Sunday, 8AM–9:15AM

SA01

CC - Room 101
Predictive Analytics for Game Theory
General Session

Session Chair
Ming Jin, Virginia Tech, Blacksburg, VA

Session Chair
Kaushik Harshal, Virginia Tech, Balcksburg, VA

1 Game Theory for Shielding Personal Data Against Privacy Attacks on Anonymity

Zhiyu Wan, Vanderbilt University Medical Center, Nashville, TN, Contact: zhiyu.wan@vanderbilt.edu

Person-specific biomedical data are now widely collected, but its sharing raises privacy concerns, specifically about the re-identification of seemingly anonymous records. Formal re-identification risk assessment frameworks can inform decisions about whether and how to share data; current techniques, however, focus on scenarios where the adversaries use only one resource. This matters because recent attacks show that adversaries can access multiple resources, combining them in a stage-wise manner, to enhance the chance of an attack's success. In this work, we represent a re-identification game that can be applied to assess risk and suggest an optimal data sharing strategy based on a privacy-utility tradeoff. We report on experiments with genomic datasets to show that most data can be effectively shared with low re-identification risk using game-theoretic models.

2 A Partially Observable Stochastic Game Model of Entry and Exit for Fast Food Industry

Yanling Chang, Texas A&M University, College Station, TX, Contact: yanling.chang@tamu.edu

Business cycle describes the periodic growth and decline of a nation's economy and has huge impact on investment decisions of corporations. However, business cycle cannot be directly observed and companies have to make their decisions based on their beliefs about economy state from various indicators such as GDP, unemployment rate. We develop a partially observable stochastic game model for the market entry and exit problem and design an estimation procedure to examine how companies make investment according to partially observed business cycle. The method is illustrated with the data of hamburger market in Canada (1970-2005) for fast food industry.

3 A Game and Control Framework for Modeling and Mitigating Advanced Persistent Threats

Shana Moothedath, Iowa State University, Ames, IA, Contact: mshana@iastate.edu

Advanced Persistent Threats (APTs) are sophisticated attacks mounted by intelligent and resourceful adversaries who gain access to a targeted system and gather critical information over an extended period of time. APTs consist of multiple stages each of which involves strategic interaction between the APT and the targeted system. While this strategic interaction can be viewed as a game, the stealthiness, adaptiveness, and unpredictability of APTs imply that the information structure of the game and the strategies of the APT are not readily available. In this talk, we will present a game-theoretic approach to characterize the trade-off between effectiveness for detecting APTs and resource efficiency. Our model is grounded on APT data gathered using the Refinable Attack Investigation (RAIN) flow-tracking framework.

Sunday, 8AM–9:15AM

SA02

CC - Room 102
Matrix/Tensor Valued Data Mining Methods and Applications
General Session

Session Chair
Yang Chen, University of Michigan, Ann Arbor, MI

1 Statistics Inferences on Image Data via Deep Neural Networks

Jian Kang, University of Michigan, Ann Arbor, MI

Regression models for matrix or tensor values have been developed to study the associations between the image data and other variables of interests. In this talk, I will present a series of regression models for image data analysis where the model parameters are constructed through deep neural networks (DNN). Compared with the existing solutions, our methods are more flexible in capturing the complex patterns among the images, of which the noise level and the spatial dependence appear to be heterogeneous across different regions of the images. I will discuss the parameter estimation and inference procedures along with the theoretical properties of our proposed methods. I will show that the new methods outperform the existing ones through both simulations and different image data examples.

2 Multi-linear Tensor Autoregressive Models

Zebang Li, Han Xiao, Rutgers University, Piscataway, NJ, Contact: hxiao@stat.rutgers.edu

Contemporary time series analysis has seen more and more tensor type data from many fields. In the first part of the talk, we propose a multi-linear autoregressive model for tensor-valued time series (TenAR). Comparing with the traditional VAR approach, the TenAR model preserves the tensor structure and has advantages in terms of interpretability, dimension reduction and computation. We propose to use the alternating algorithms to obtain the LSE and MLE. The performance of the models and methods is demonstrated by theoretical studies and simulated and real examples.
In the second part of the talk, we consider the TenAR model under co-integration. We investigate the MLE under a separable error covariance structure and provide asymptotic results for the co-integration vectors, as well as the projection onto the co-integration space.

3 Two-sample Hypothesis Testing for Multiple-Network Data

Yinqiu He, University of Wisconsin-Madison, Madison, WI

Multiple-network data has attracted increasing attention recently, where the data are recorded as symmetric matrices, and each matrix encodes an individual network structure. Such data arises frequently in various scientific fields such as the analyses of brain connectivity and gene interactions. In these studies, it is of great interest to compare the means of two populations of networks. In this work, we propose a hypothesis testing procedure when we are interested in a given area of networks that may have multiple signals functioning together. We establish asymptotic results for the proposed test under general moment conditions and validate the test under a variety of popular network models. We further demonstrate the efficacy of the proposed test under simulation studies and the analysis of a brain dataset.

4 Local Spatio-temporal Analysis of Global Climate Data from Argo Profiling Floats

Mikael Kuusela, Carnegie Mellon University, Pittsburgh, PA, Contact: mkuusela@andrew.cmu.edu

Statistical analysis of modern observational climate data is challenging due to their complex spatio-temporal structure and large size. Analyzing these data using local statistical models has proved to be a successful strategy for handling both the complexity and computational challenges.
For example, climatological anomalies can be mapped using locally stationary Gaussian processes, which yields computationally tractable nonstationary fields without the need to explicitly model the nonstationary covariance structure. In this talk, I will first introduce the relevant local modeling and analysis techniques and then describe our recent work on using these methods to produce new data-driven estimates of various key properties of the global climate system based on temperature and salinity profiles observed by Argo floats in the upper 2,000 m of the global ocean.

Sunday, 8AM–9:15AM

SA03

CC - Room 103

Advances in Time series Modeling and Forecasting Using Deep Learning Methods

General Session

Session Chair

Jie Han, University of Texas, Arlington, TX

Session Chair

Shouyi Wang, University of Texas at Arlington, Arlington, TX

1 Long-term Forecasting of Time Series with Graph Convolutional Networks

Ali Sarabi, Arizona State University, Tempe, AZ, Contact: asarabi1@asu.edu

Time series forecasting has long been a challenging task that has piqued the interest of academics in various fields. This problem becomes more difficult as model predictions become less accurate over time. Furthermore, we frequently see hierarchical structures between different time series in real-world applications, which cannot be overlooked. Graph Neural Network (GNN) has demonstrated strong capability in dealing with these relational dependencies. In this paper, we propose a generic deep neural network to improve the accuracy of time-series forecasting in the long term. Our model employs graph convolution to extract the inter-series temporal correlation properties and Long Short-Term Memory (LSTM) cells to extract intra-temporal relationships and make both short-term and long-term predictions.

2 Deep Learning-based Anomaly Detection in Multivariate Time Series Data

Yeseul Choi, Soomin Lee, Dongil Kim, Chungnam National University, Daejeon, Korea, Republic of.

Anomaly detection system aims to identify unusual events that do not conform to expected distribution. The system is one of the important tasks for several domains such as industries and network securities. We propose a method to detect anomalous data in multivariate time series data. The proposed method employs CNN-based autoencoder structures and uses 2-dimensional input shape. We used several open datasets and a real-world dataset for empirical studies. In experiments, we compared the performance of the proposed method with the performance of several models for anomaly detection as baselines. The experimental results showed that the proposed method had better performance than benchmark methods

3 The Explainable Neural Networks for Nowcasting

Wonkeun Jo, Dongil Kim, Chungnam National University, Daejeon, Korea, Republic of. Contact: jowonkun@naver.com

Nowcasting is one of the major issues in machine learning. The useful non-linear combination of the neural network that helps extract the feature vectors make it hard to explain the model. The neural additive model that was recently researched shows the possibility of the explain the reason for how to predict the nowcasting target. Since NAM-NC is conducted based on GAM, we can explain why the model nowcasts the target value. According to the pilot experiment, NAM-NC can predict the next step in the time series and also explain the reasonable contribution of the feature net. Also, we apply the hard-sharing to NAM-NC, decreasing the memory complex cost of our model. The hard-tied feature net of NAM-NC still extracts the meaningful vector from the real-world time series. NAM-NC shows competive performance as much as than other SOTA neural networks in real-world problems.

Sunday, 8AM–9:15AM

SA04

CC - Room 104

Advances in Predictive and Forecasting Techniques with Healthcare and Business Applications

General Session

Session Chair

Neta Rabin, Tel-Aviv University, Tel-Aviv, Israel.

Session Chair

Gonen Singer, Bar-Ilan University, Ramat Gan, Israel.

1 Adaptive Cost-sensitive Learning Approach in Neural Networks for Medical Applications

Gonen Singer, Ohad Volk, Bar-Ilan University, Ramat Gan, Israel. Contact: gonen.singer@biu.ac.il

We design a new Adaptive Cost-Sensitive Learning (AdaCSL) algorithm for binary classification problems. Our algorithm adaptively adjusts the loss function such that the classifier bridges the difference between the class distributions of subgroups of samples in the training and test data sets with similar predicted probabilities (i.e., local training-test class distribution mismatch). We present empirical evidence that a deep neural network used with the proposed AdaCSL algorithm yields better results on several medical data sets compared to other alternative approaches. The proposed AdaCSL algorithm can be used for medical applications, in which large variability may occur between subjects in training and test data sets.

2 Employee Retention: What is the Value of Turnover Contagion? A Bilevel Optimization Approach

Iris Forma[1], Hila Chalutz Ben-Gal[2], Gonen Singer[3], [1]Afeka Tel-Aviv College of Engineering, Tel-Aviv, Israel; [2]Afeka Tel-Aviv College of Engineering, Tel-Aviv, Israel; [3]Bar-Ilan University, Ramat Gan, Israel. Contact: irisf@afeka.ac.il

The growing practice of flexible work following the COVID-19 pandemic is likely to have a significant impact on management and human resource (HR) practices. We propose a novel bi-level mathematical programming model that can serve as a decision support tool for firms in real-life settings to address employee retention challenges via hybrid and flexible work plans, in the context of turnover contagion. We show that the model provides an exact solution based on a mixed integer formulation. We present a computational analysis based on changing candidate behaviors in response to firm's strategy, then we demonstrate its applicability to a real-world dataset and we present initial results.

3 Innovative Mathematical Tools for Post-traumatic Epilepsy Using Multimodal Data

Dominique Duncan, University of Southern California, Los Angeles, CA

The Epilepsy Bioinformatics Study for Antiepileptogenic Therapy (EpiBioS4Rx), is a multisite collaboration collecting MRI, EEG, and blood samples. The development of epilepsy after a traumatic brain injury is a multifactorial process and crosses multiple modalities. Before these data can be analyzed, a central platform is needed to standardize these data and provide tools for searching, viewing, annotating, and analyzing them. We have built a centralized data archive that will allow the broader research community to access these shared data in addition to mathematical tools to identify and validate biomarkers of epileptogenesis in imaging and electrophysiology data.

4 An Application to Optimize the Schedule of MRI

David Freud, Amir Elalouf, Bar Ilan University, Ramat Gan, Israel.

The Magnetic Resonance Imaging (MRI) is a vital diagnostic tool, yet MRI scanners are in short supply and are utilized around the clock. The MRI scheduling problem is a single-machine scheduling NP-hard problem. Our proposal is to address this problem using a novel application of a pseudo-polynomial algorithm. We assume the scanner to have required periodic maintenance time, and that each patient can be allocated to an alternative facility with a differential allocation cost, limited by a fixed budget constraint.

Sunday, 8AM–9:15AM

SA05

CC - Room 105

Efficient Statistical Methods for Uncertainty Quantification

General Session

Session Chair

Ozge Surer, Northwestern University, Evanston, IL

1 Efficient Gaussian Process Regression with Kernel Packets

Haoyuan Chen, Liang Ding, Rui Tuo, Texas A&M University, College Station, TX, Contact: ruituo@tamu.edu

We develop an exact and scalable algorithm for one-dimensional Gaussian process regression with Matern correlations whose smoothness parameter is a half-integer. The proposed algorithm only requires operations and storage both linear in the sample size. The proposed method is based on a novel theory for Matern correlation functions. We find that a suitable rearrangement of these correlation functions can produce a compactly supported function, called a "kernel packet". Using a set of kernel packets as basis functions leads to a sparse representation of the covariance matrix that results in the proposed algorithm. Simulation studies show that the proposed algorithm, when applicable, is significantly superior to the existing alternatives in both the computational time and predictive accuracy.

2 Bayesian Uncertainty Quantification for Low-rank Matrix Recovery

Simon Mak, Duke University, Durham, NC, Contact: sm769@duke.edu

We consider the problem of uncertainty quantification for an unknown low-rank matrix X, given a partial and noisy observation of its entries. This quantification of uncertainty is essential for many real-world problems, including image processing, satellite imaging, and seismology, providing a principled framework for validating scientific conclusions and guiding decision-making. We propose a new Bayesian modeling framework, called BayeSMG, which parametrizes the unknown matrix via its underlying row and column subspaces. This Bayesian subspace parametrization enables efficient posterior inference on matrix subspaces, which represents interpretable phenomena in many applications. We demonstrate the effectiveness of BayeSMG over existing methods in numerical experiments, image inpainting, and a seismic sensor network application.

3 Model Mixing with Bayesian Additive Regression Trees

John Yannotty[1], Matthew Pratola[2], Thomas Santner[3], [1]The Ohio State University, Columbus, OH, [2]The Ohio State University, New Albany, OH, [3]The Ohio State University, Columbus, OH

In modern computer experiments, one often encounters the situation where many plausible models of a physical system are considered, each implemented as a simulator. An important question in such a setting is determining the best simulator, or best combination of simulators, to use for prediction or inference. Bayesian model averaging (BMA) and stacking are relevant statistical modeling approaches typically used to account for model uncertainty. In the context of multi-simulator computer experiments, BMA or stacking can be used to combine a set of plausible simulators using a weighted average, where the weights are independent of the input space. Bayesian model mixing (BMM) extends these ideas to capture the localized behavior of each simulator by allowing the weights to depend on the inputs. In our approach, we propose a BMM model using Bayesian Additive Regression Trees.

4 Batch Sequential Calibration of a Computationally Intensive Simulation Model Using Parallel Computing

Ozge Surer[1], Matthew Plumlee[1], Stefan Wild[2], [1]Northwestern University, Evanston, IL, [2]Argonne National Laboratory, Lemont, IL, Contact: ozgesurer2019@u.northwestern.edu

In a standard Bayesian calibration, one builds a cheaper emulator as a proxy to an expensive-to-evaluate simulator using data from simulation experiments, and then leverages Markov chain Monte Carlo sampling algorithms to obtain draws from the posterior distribution of unknown/uncertain parameters. To train an emulator, one needs a design of parameters and their corresponding simulation outputs. Space-filling designs are widely used in the literature to generate designs. The region occupied by a density of parameters inside a hypercube can be very small in higher dimensions, and space-filling designs can miss the high probability regions. In this study, we propose a sequential Bayesian experimental design that can be used to provide more precise inference by better selecting the design points.

Sunday, 8AM–9:15AM

SA06

CC - Room 106

Data Analytics in Developing Quality Management Theory and Practices

General Session

Session Chair

Heng (John) Xie, California State University, Sacramento, CA

Session Chair

Xinyu Wei, California State University, Chico, Chico, CA

1 **Applying Text Mining Methods to Identify Health Perceptions of College Students**

Heng (John) Xie[1], Xiaoni Zhang[2], [1]California State University, Sacramento, Sacramento, CA, [2]University of Alabama at Birmingham, Birmingham, AL, Contact: heng.xie@csus.edu

Developing a healthy lifestyle is important at a young age as it impacts a person's future health and well-being. A habit could also be a risk factor for developing chronic disease. However, behavior change is not easy. We use text mining methods to examine published papers on healthy behaviors in college students and synthesize prior findings. Our goals are to identify effective interventions that could produce long-term benefits for a person and has the potential to be accepted and adopted by others. We want to raise awareness of the detrimental effect of chronic disease and educate college students about well-being, disease prevention, and a healthy lifestyle. We summarize prior interventions and propose suggestions and strategies for health promotion for college students.

2 **Relationships Among Healthcare Operations Measurements and Patient Satisfaction**

Xinyu Wei[1], Xianghui (Richard) Peng[2], Victor R. Prybutok[3], [1]California State University, Chico, Chico, CA, [2]Penn State Erie The Behrend College, Fairview, PA, [3]University of North Texas, Denton, TX, Contact: xwei1@csuchico.edu

Effective measurement of healthcare outcomes remains of interest to healthcare professionals, healthcare executives, and academics. This study examines and compares different healthcare operations measurements provided by regulatory agencies and healthcare associations. This research examines the relationships between these measurements and patient satisfaction. The findings contribute to the health care operations literature and reveal the need for a structured and consistent measurement because such consistency can enhance temporal and organizational comparisons.

3 **A Sustainability Focused Organizational Framework**

Lu Xu[1], Ying Cao[2], Xinyu Wei[3], Xianghui Peng[2], Victor Prybutok[4], [1]University of North Georgia, Oakwood, GA, [2]Penn State Erie The Behrend College, Erie, PA, [3]California State University, Chico, Chico, CA, [4]University of North Texas, Denton, TX, Contact: lu.xu@ung.edu

This study integrates quality management (QM) and supply chain management (SCM) to create a sustainable organizational framework. The literature review on QM, SCM, and sustainable SCM allowed identifying research gaps. One outcome from integration of theory was proposal of a testable research model and a survey to test that model. This study contributes to theory development and provides managerial insights.

4 **Customers' Perceptions of Quality Management in Electric Vehicle Rental Business in The USA**

Edwin (Yuchen) Wang[1], Richard (Xianghui) Peng[2], Adeela Gulzari[3], Victor R. Prybutok[4], [1]Kean University, Union, NJ, [2]Penn State Erie, Erie, PA, [3]University of North Texas, Denton, TX, [4]University of North Texas, Denton, TX

To limit household energy consumption and carbon emissions, the promotion of clean and fuel-efficient vehicles, such as electric vehicles (EV), especially in the surge of international gasoline prices, is thriving. Along with the upward trend of EV, the quality of this type of automobile, the service before & after the purchase or rental, and the infrastructure become the concerns of many consumers.

This research centers on the relationship between perceived service quality, perceived functional quality, willingness to pay, and the rental intention of EV with the partial least squares method, using the survey data collected in the southern USA. The results provide information about the preferences of customers that can be used in the implementation of a proper quality management approach, thereby ensuring that customers receive the quality they expect when renting EV.

Sunday, 8AM–9:15AM

SA07

CC - Room 107
Risk Analysis
Contributed Session

Session Chair
Mehdi Dadfarnia, National Institute of Standards & Technology, Bethesda, MD

1 Reliability Inference of Spacecraft Power Systems with Imperfect Information

Marc Eskew[1], M. Elisabeth Pate-Cornell[2], Victoria Li[1], Donovan Tokuyama[1], Ashten Prechtel[1], [1]Stanford University, Stanford, CA, [2]Stanford University, Stanford, CA, Contact: esq601@gmail.com

The objective of this work is to model the reliability of a critical component in spacecraft power systems with no direct observations of the individual component performance. Based on data from NASA/JPL missions, Markov Chain Monte Carlo modeling is used to infer probability distributions of reliability parameters of interest. Using these estimates, this model provides credible intervals of reliability and probability of failure of power systems for future missions and allows updating from continued missions or testing.

2 Project Control Looking Forward: Making Sense of Project Performance Indicators Under Uncertainty and Ambiguity

Byung-Cheol Kim, Penn State Behrend, Erie, PA, Contact: buk70@psu.edu

Project managers need to look forward, not backward, in order to drive a project forward. This presentation discusses the predictive performance tracking problem (PPTP) in the context of project control. Tracking bias arises when a project backtracks (digging into visible numbers), rather than embracing the uncertain future, creating a consistent tendency of overshooting or undershooting the true project position at completion. The PPTP is framed as a signal-noise separation problem and a risk-driven debiasing simulation model is used to investigate the nature, characteristics, and implications of the tracking biases of standard key performance indicators (KPIs) in project control. Results from the predictive tracking simulation are integrated into a set of decision support tools for real-time adjustment of the KPIs as a predictive measure.

3 Discrete Approximations for Large Scale Markov Systems

Zhengqi Lin, Rutgers University, Newark, NJ, Contact: zhengqi.lin@rutgers.edu

We consider the construction of finite-state approximations of continuous state-space Markov systems. When the dimension of the state space increases, the amount of data required for numerical analysis grows exponentially. We introduce a state discretization method using particle generation and selection to overcome this issue. The method uses the dynamics equation to generate new particles and probability metrics for the selection of a suitable subset of particles. Furthermore, we demonstrate the approximation errors are kept small for the estimation of the dynamic measure of risk and associated control problems, without the exponential growth of the number of particles.

4 A Systematic Review of Approaches to Evaluate the Operational Risks and Benefits of Condition Monitoring

Mehdi Dadfarnia, National Institute of Standards & Technology, Gaithersburg, MD, Contact: mehdi.dadfarnia@nist.gov

Industrial users increasingly use condition monitoring systems (CMSs) to detect, diagnose, or prognosticate asset faults and failures. Such capabilities mitigate operational risks and enhance asset reliability but come at a cost. Pinpointing a CMS's benefits to a particular industrial asset is not trivial. A prior successful implementation does not imply future success, as monitoring depends on the asset's structure, operating conditions, and often closed-box machine learning algorithms that the CMS utilizes. Many studies have considered decision-making approaches for CMS-related investments and balancing their risks and benefits, though no widely accepted procedures exist. This talk surveys CMS evaluation approaches, yields definitions for terms relevant to their evaluation, and elucidates the existing approaches' possibilities, gaps, and limitations.

Sunday, 8AM–9:15AM

SA09

CC - Room 109

Data Mining Flash Session I

Flash Session

Session Chair

Margret V. Bjarnadottir, University of Maryland, College Park, MD

1 Mode Melding in Misspecified Gaussian Mixtures

Xumei Xi, Cornell University, Ithaca, NY, Contact: xx269@cornell.edu

We study Gaussian mixture models where the number of components may be misspecified. We focus on the special case of fitting a 2-Gaussian mixture to a single Gaussian. We reveal an intriguing phenomenon called Mode Melding, where the two modes of the likelihood function merge and attain an error rate faster than the minimax bound. On the algorithmic side, we study a quasi-Newton algorithm suitable for optimizing the ill-conditioned likelihood. Perhaps unexpectedly, a naive implementation fails spectacularly, precisely in the event of Mode Melding. Leveraging a fine-grained characterization of Mode Melding, we design an improved algorithm that is guaranteed to converge linearly and robustly.

2 Missing Data? Four Imputation Strategies and How They Impact Model Performance

Jennifer Priestley[1], Martin Brown[2], Duleep Don[1], [1]Kennesaw State university, Kennesaw, GA, [2]Kennesaw State University, Kennesaw, GA

We present our study which evaluates differences in model performance using 4 imputation techniques across 3 levels of missingness among predictor variables in logistic regression. Imputation techniques include median imputation, multiple imputation by chained equations (MICE), single center imputation from multiple chained equations (SICE), and denoising autoencoder (DAE). The dataset comes from a global credit bureau and includes firmographic information and payment performance for 6 million commercial entities. Results indicate that risk modeling is heavily impacted by imputation technique across varying levels of missingness. Model performance is evaluated using AUC and K-S test.

3 Big Data Analytics Adoption: An Extension of UTAUT Model

Vatsal Paghadal, Md Golam Kibria, University of Toledo, Toledo, OH

Grounded in the UTAUT model, management fads and fashions and social learning theory/neo institutional theory this study proposes a model determining the role of Performance expectancy, effort expectancy, social influence and facilitating conditions on of organizational big data analytics intention and firm performance. It also explores the moderating role of Mindfulness in effect of UTAUT model constructs on behavioral intention and role of voluntariness in effect of behavioral intention on quality of innovation. Measurements have been developed based on literature review and Q-sorting and the proposed model is ready to be tested utilizing a structural equation modeling (SEM).

4 A Graphical Multi-fidelity Gaussian Process Model, with Application to Emulation of Expensive Computer Simulations

Yi Ji[1], Simon Mak[2], Derek Soeder[3], J-F Paquet[3], Steffen A. Bass[3], [1]Duke University, Durham, NC, [2]Duke University, Durham, NC, [3]Duke University, Durham, NC, Contact: yi.ji@duke.edu

We present a novel Graphical Multi-fidelity Gaussian Process (GMGP) model that uses a directed acyclic graph to model dependencies between multi-fidelity simulation codes. It is an extension to the Kennedy-O'Hagan model for problems where different codes cannot be ranked in a sequence from lowest to highest fidelity. We also present a scalable recursive formulation and a non-linear extension to the GMGP model. The advantages of the GMGP model over existing methods are demonstrated via an application to heavy-ion collisions emulation, which shed light on the origins of the Universe shortly after the Big Bang.

5 A Data-driven Approach to Modeling Assortment Optimization: The Tractable Case of Similar Substitutes

Nanxi Zhang, Shanghai University of Finance and Economics, Shanghai, China. Contact: sufenanxizhang@163.sufe.edu.cn

We propose a data-driven approach to model assortment optimization problem. Two empirical observations from Taobao data motivate our work: one is that most customers browse very few items before they make a purchase; the second is that customers consideration sets are small intervals in a sorting of items. We build a choice model framework with these observations which subsumes some popular choice models as special cases. To justify our framework, we use hotel transaction data to fit different models and compare their performance. Finally, we give algorithms for assortment planning problems under our framework and implement our data-to-model-to-optimization approach on customer data on JD.com.

6 Improving Conversation Analytics Through Hyperparameter Tuning with and Without Labels

Cecilia Ying, Stephen Thomas, Queen's University, Kingston, ON, Canada. Contact: 18yly@queensu.ca

Conversation Analytics (CA) is used for extracting insights from chatbot logs to help companies understand their customers' frequent concerns and trending topics. Many human-annotated messages used for training CA tools are incorrectly and inconsistently labelled, resulting in unreliable metrics for model evaluation. We propose a hybrid hyperparameter tuning approach to address this. We leverage the Cophenetic Correlation, a performance metric for unsupervised hierarchical clustering, with the Adjusted Mutual Information when labels are available. We conclude that this hybrid approach is more effective than using just one of the two methods for model evaluations.

7 Knot Selection for B-spline Regression via Trimmed Regularizer

Shotaro Yagishita[1], Jun-ya Gotoh[2], [1]Chuo university, Bunkyo-ku, Tokyo, Japan; [2]Chuo University, Bunkyo-ku, Tokyo, Japan.

We propose a nonconvex regularizer and an algorithm for selecting knots at the same time as estimating the B-spline regression model. More specifically, starting with the constraint to directly designate the number of knots to be used, we present an (unconstrained) regularized least square reformulation, which is equivalent to the cardinality-constrained formulation. The obtained formulation is further modified so that we can employ a proximal gradient-type algorithm. Numerical experiment demonstrates how our approach performs on several data sets.

8 Scalable Distributed Computing Systems for Incremental Machine Learning in Big Data Applications

Dhaval Salwala[1], Seshu Tirupathi[1], Brian Quanz[2], Wesley Gifford[2], Stuart Siegel[2], [1]IBM Research Europe, Dublin, Ireland; [2]IBM Thomas J. Watson Research Center, Yorktown Heights, NY, Contact: dhaval.vinodbhai.salwala@ibm.com

Terabytes of daily raw data generated by IoT sensors are indispensable for investigating time-series problems like short-term forecasting of the target variable, and failure predictions. Pure batch learning algorithms can be challenging with this high frequency and high-volume data as concept drifts would require frequent retraining of the deployed models leading to significant downtimes. Therefore, incremental models or coupled batch-incremental models are gaining increasing importance to handle these problems. In this talk, we will present a distributed computing system that can scale to perform incremental learning for big data and efficiently perform a parameter search in big data applications to dynamically generate the most efficient incremental modelling pipelines with every stream of new incoming data, followed by synthetic and real world use cases.

9 Flash Paper

Shulei Wang, 1</sup

Self-supervised metric learning has been a successful approach for learning a distance from an unlabeled dataset. The resulting distance is broadly useful for improving various distance-based downstream tasks, even when no information from downstream tasks is utilized in the metric learning stage. To gain insights into this approach, we develop a statistical framework to theoretically study how self-supervised metric learning can benefit downstream tasks in the context of multi-view data.

10 Closing Demographic Pay Gaps

Margret V. Bjarnadottir[1], David Anderson[2], David Gaddis Ross[3], [1]University of Maryland, College Park, MD, [2]Villanova University, Villanova, PA, [3]University of Florida, GAINESVILLE, FL, Contact: mbjarnad@umd.edu

Employers are under increasing pressure to address pay inequity, however, managers have few tools at their disposal to help them. We design and implement an algorithm that measures whether an employer has a pay gap, suggests salary adjustments to close it, and establishes a quantitative framework for determining whether a pay gap is "statistically closed," all while supporting the employer's own goals with respect to equity, culture, and incentives in its pay structure. Our work not provides a solution to management personnel for a problem of growing social and practical importance, and demonstrates how the OM toolkit may be applied to improve human resources management.

Sunday, 8AM–9:15AM

SA10

CC - Room 110

Applications and Implications of AI in Social Interactions

Joint Session

Session Chair

Yifan Yu, University of Washington, Seattle, WA

1 Covid-19 Pandemic Heard Disproportionate Female Voices in News

Zhihan Li[1], Juan Wang[2], Wendao Xue[3], Yifan Yu[3], Yong Tan[3], [1]Cornell University (Cornell Tech Campus), New York, NY, [2]Chongqing University, Chongqing, China; [3]University of Washington, Seattle, WA, Contact: zl629@cornell.edu

Studies on gender inequality during the COVID-19 pandemic have found women's burden and contribution in the crisis. The long-lasting gender gap in media coverage, therefore, is expected to narrow. However, we find that the gender gap enlarged, by analyzing 146,203 online news on the coronavirus from January 20, to April 30, 2020. Gender gap is measure by both coverage gap, the difference between number of times males and females are mentioned in news, and source gap, the difference between number of times males and females are quoted. We observe a jump in both coverage gap and source gap on March 11, when the COVID-19 cases in the U.S. has reached 1000. We utilize Synthetic Control Method and Regression Discontinuity in Time to identify such effects and mechanisms.

2 Whose Words to Believe? The Polarity of Customer Reviews on Apparel Rental Platforms

Yu Kan, Uttara Ananthakrishnan, University of Washington, Seattle, WA

Customer reviews make a difference. This is especially true for online fashion retailers. Countless research has shown that positive reviews can increase sales. However, due to the heterogeneity among customers, their opinions inevitably differ from each other. If the reviews contain positive and negative emotions, how will they affect the sales? Will the extent of polarity in reviews affect sales? In this paper, we partner with a subscription-based apparel rental platform and leverage large-scale customer and product level data to investigate these questions. We employ Bidirectional Encoder Representations from Transformers (BERT) to identify entities mentioned in each review and corresponding sentiment. We show that the contradictory opinions in reviews affect rentals under different circumstances.

3 How to Identify Lonely People with Social Media Data and Help Them Cope?

Chengyue Huang[1], Alice Wang[2], Weiguo (Patrick) Fan[1], [1]University of Iowa, Iowa City, IA, [2]University of Iowa, Iowa City, Contact: cyhuang@uiowa.edu

Given the unprecedent social isolation caused by the pandemic, loneliness is a growing mental health issue. However, not all lonely people respond to the undesired situations equally. Some actively cope with it, while others may cope with it negatively. Therefore, to help people cope with loneliness, it's important to identify lonely people and to analyze their optimism/pessimism attitudes towards future. In this research, we examine how loneliness and optimism jointly affect behaviors with social media data from Reddit by leveraging NLP techniques. We collected thousands of posts from loneliness-related subreddits and classified posts into four groups. With MANOVA analysis, we found the lonely and optimistic groups express stronger social motivations compared to other groups (non-lonely and optimistic, non-lonely and pessimistic, lonely and pessimistic groups)

4 How Recommender Systems Shape Online Investor Behaviors

Ruiqi Zhu[1], Yu Jeffrey Hu[2], Cheng He[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technologuy, Atlanta, GA, [3]University of Wisconsin-Madison, Madison, WI, Contact: rich.zhu@scheller.gatech.edu

The impact of recommender systems on online investors' behaviors is rarely documented. Financial products are inherently different from consumer products in terms of quality uncertainty and purchase stages. In this paper, we employ regression discontinuity design to causally examine the effect of recommender systems on online investor behaviors, more specifically in the context of mutual fund investment. The results show that (1) funds featured by recommender systems receive a significantly higher number of purchases; (2) the recommendation effect is heterogeneous across different types of mutual funds and investors with different characteristics. Furthermore, (3) the holding period of recommended and non-recommended funds is heterogeneous across diverse investors. In addition, we examine the mechanisms and implications.

Sunday, 8AM–9:15AM

SA11

CC - Room 111

AI in Operations Management

General Session

Session Chair

Huihui Chi, ESCP Europe, paris, France.

1 On-line Order Batching for Robot-based Order Picking Systems Using Deep Reinforcement Learning

Bhoomica Mysore Nataraja, Zumbul Atan, Ivo Adan, Eindhoven University of Technology, Eindhoven,

Netherlands. Contact: b.m.nataraja@tue.nl
Recent advancements in robotics and automation have enabled warehouses in the e-commerce era to adopt new ways to cope with highly volatile customer demands with shorter deadlines. Uniquely, we consider an autonomous robot-based order picking system that fulfils orders from a multi-deep gravity flow rack in an online environment. For such a system, we study the online order batching problem with an objective to minimize the weighted earliness and tardiness. We formulate a Semi-Markov decision process to represent the problem that allows us to create a deep reinforcement learning (DRL) agent. The DRL agent can produce feasible solutions superior to the benchmark heuristics in most tested cases. We demonstrate that the learning agent shows potential performance under fluctuating order environments making it suitable for online retailing of fast-moving consumer goods.

2 Machine Learning Based Problem Space Reduction in Stochastic Programming Models: An Application in Biofuel Supply Chain Network Design

Kolton Keith[1], Krystel Castillo[2], Adel Alaeddini[1], [1]University of Texas at San Antonio, San Antonio, TX, [2]University of Texas-San Antonio, San Antonio, TX, Contact: kolton.keith@utsa.edu

Biofuels derived from feedstock offer a sustainable alternative to meeting energy needs. Stochastic programming models in this area often incur a heavy computational burden. The present work proposes a hybrid strategy that uses machine learning to reduce computational complexity of stochastic programming models via problem space reduction. First, randomly generated reduced-space versions of the problem are solved to generate a set of solution data. Next, a supervised machine learning algorithm is called to predict a potentially beneficiary problem space from which a near-optimal solution can be obtained. Finally, the mixed integer linear program will select the optimal solution from the reduced space suggested. The numerical experiments show the proposed solution procedure yields quality solutions with reduced computational burden.

Sunday, 8AM–9:15AM

SA12

CC - Room 113

Improving Healthcare One Bit at a Time: Using Data Science to Revolutionize the Industry

General Session

Session Chair

Geoffrey Fairchild, Los Alamos National Laboratory, Los Alamos, NM

1 Real-time Characterization of Emerging SARS-CoV-2 Variants Globally

Kaitlyn Johnson, The Rockefeller Foundation, DC

Understanding in real-time when, whether, and how emerging SARS-CoV-2 variants pose a threat is critical for tailoring responses. The characteristics of a novel variant can affect public health guidelines, vaccine roll-out, treatment recommendation, and individual risk assessment. The Pandemic Prevention Institute has developed a weekly report that provides scientists, decision-makers, and the public with real-time variant characterization. Using a global sequencing repository coupled with epidemiological data, we systematically assess the risk posed by a novel variant by estimating its fitness advantage, checking for bias in the lag-time of sequence submission, and assessing its impact on cases. In this talk, I will discuss some of the approaches we have taken to parse signals from noise to improve our early understanding of SARS-CoV-2 variants as they emerge.

2 The Road to Data-Centric Machine Learning in Healthcare

Jason Fries, Stanford University, Stanford, CA

The high cost of building and sharing labeled training data is one of the largest barriers to using supervised machine learning in medicine. One approach to addressing this challenge is *weakly supervised learning*, where instead of manually labeling data, domain experts create training labels programmatically using imperfect labeling rules. Programmatic labeling takes a data-centric view of machine learning, and focuses on novel methods to curate, transform, and shape training data to improve model performance. In this talk, I describe our recent successes using weakly supervised learning and other data-centric techniques to build medical applications across a range of modalities, including structured medical records, clinical text, and medical imaging.

3 Identifying Asymptomatic Spreaders of Antimicrobial Resistant Pathogens in Hospital Settings

Sen Pei, Columbia University, NY

Antimicrobial resistant organisms (AMROs) can colonize people without symptoms for long periods and spread unnoticed to other patients. Here, we study methicillin-resistant Staph. aureus (MRSA), a prevalent AMRO, in 66 Swedish hospitals using an agent-based model informed by real-world hospitalization records. We develop and validate an individual-level inference approach that estimates the colonization probability of individual hospitalized patients. For both model-simulated and historical outbreaks, the proposed method supports the more accurate identification of asymptomatic MRSA carriers than other traditional approaches. In addition, in silica control experiments indicate that interventions targeted to inpatients with a high-colonization probability outperform heuristic strategies informed by hospitalization history and contact tracing.

4 NEEDS TITLE

Sara Del Valle, Los Alamos National Laboratory, Los Alamos, NM

The COVID-19 pandemic has highlighted a need for better understanding of countries' vulnerability and resilience to not only pandemics but also disasters, climate change, and other systemic shocks. In this talk, I will present a data-driven framework for studying countries' vulnerability and resilience to incident disasters across multiple dimensions of society. To illustrate this methodology, we leverage the rich data landscape surrounding the COVID-19 pandemic to characterize observed resilience for several countries (USA, Brazil, India, Sweden, New Zealand, and Israel) as measured by pandemic impacts across a variety of social, economic, and political domains. This work also highlights key gaps in our current understanding about vulnerability and resilience and a need for data-driven, context-specific assessments of disaster vulnerability in the future.

Sunday, 8AM–9:15AM

SA13

CC - Room 114

Decision Support for Competitive Security Applications

General Session

Session Chair

William Caballero, AFIT, Air Force Academy, CO

1 A Behavioral Approach to Repeated Bayesian Security Games

William Caballero[1], Jake Cooley[1], David Banks[2], Phillip R. Jenkins[3], [1]United States Air Force Academy, Colorado Springs, CO, [2]Duke University, Durham, NC, [3]Air Force Institute of Technology, Wright-Patterson Air Force Base, OH, Contact: william.caballero@afacademy.af.edu

Security games are a potent policymaking tool however, whereas canonical models effectively allocate limited resources, they generally do not consider adaptive, boundedly rational adversaries. Thus, we develop a repeated game framework in which a boundedly rational adversary is characterized by a behavioral-economic theory of learning, i.e., experience-weighted attraction learning. Realistic uncertainty about the competition is modeled by adopting the perspective of adversarial risk analysis. Using Bayesian reasoning, these games are decomposed into multi-arm bandit problems. A collection of cost-function-approximation policies are set forth, and their effectiveness is shown via extensive empirical testing on a defense-related case study.

2 Strategic Network Inspection with Imperfect Detection Technology

J. Haden Boone, Mathieu Dahan, ISyE Georgia Tech, Atlanta, GA, Contact: jboone31@gatech.edu

We consider a two-player zero-sum network inspection game, in which a limited number of detectors are coordinated according to a probability distribution to detect multiple attacks from a strategic opponent. Detection is assumed to be imperfect and is modeled with a probability that an attack of each network component is successfully detected from each detector location. This probability is determined from the detection technology utilized and the properties of the network. We analytically characterize Nash equilibria of the game in which the defender (attacker) attempts to minimize (maximize) the number of undetected attacks under the condition that each network component is detected from one detector location. We utilize the results on the disjoint case to provide approximate solutions to the general case using a greedy partitioning strategy.

3 Information Security Investments Against Multiple Boundedly-Rational Attackers: An Adversarial Risk Analysis Approach

Ashley Peper[1], Eric B. DuBois[2], Laura Albert[1], [1]University of Wisconsin-Madison, Madison, WI, [2]CNA, Arlington, VA, Contact: apeper2@wisc.edu

We use integer programming techniques to inform defensive decision-making in mitigating the risk from multiple boundedly rational adaptive adversaries. We extend adversarial risk analysis frameworks to consider a maximum reliability path interdiction problem with a single defender and multiple attackers who have different goals and levels of strategic sophistication.

4 Rumor Propagation and Clarification on Social Media During Crisis Events

Puneet Agarwal[1], Ridwan Al Aziz[2], Kyle J. Hunt[3], Jun

Zhuang[3], [1]California Polytechnic State University, San Luis Obispo, CA, [2]State University of New York-Buffalo, Buffalo, NY, [3]University at Buffalo, Buffalo, NY, Contact: pagarw05@calpoly.edu

Online social media allow for the delivery of important information at extreme speeds. Unfortunately, due to the unmoderated nature of social media, rumors and fake news have plagued the networks of platforms such as Twitter. Rumors and fake news are spread across social media when information integrity is crucial to the safety of the public, such as during crisis events. During these events, timely and credible information is of the utmost importance to those affected by the disasters, and those following the disaster-related news. In this study, we model the strategic behaviors of the official agencies and social media users during rumor transmission using two novel game-theoretic models. The objective of this study is to analyze the impact of rumor clarification and verification strategies of the agencies on the decisions of social media users during rumor propagation.

Sunday, 8AM–9:15AM

SA14

CC - Room 115

Artificial Intelligence for Transportation Cyber-Physical Systems Analytics

General Session

Session Chair

Mohamadhossein Noruzoliaee, University of Texas Rio Grande Valley, Edinburg, TX

1 System Optimal Vehicle Platooning Control for Eco-Driving at Signalized Intersection Built upon Hybrid MPC System, Online Learning and Distributed Optimization

Hanyu Zhang, Lili Du, University of Florida, Gainesville, FL, Contact: hanyu.zhang@chem.ufl.edu

This study develops a system optimal platoon-centered control for eco-driving (PCC-eDriving) at signalized intersections, which aims to guide a mixed flow platoon to smoothly approach, split as needed, and then sequentially pass intersections, while reducing sharp deceleration and red idling. The PCC-eDriving is enabled by a hybrid model predictive control (MPC) system, including three MPC for platoon trajectory control and a mixed-integer nonlinear program for optimal platoon splitting decision. The feasibility and stability of the hybrid MPC system are mathematically proved to ensure the system performance. Besides, we design an online adaptive curve learning algorithm to learn vehicle driving uncertainties. The numerical experiments validate the merits of the PCC-eDriving in improving traffic efficiency and reducing energy consumption.

2 Detection and Mitigation of Cyber Threats in Smart Traffic Signal Control System

Yiheng Feng, Purdue University

Connected vehicle (CV) technology brings both opportunities and challenges to the traffic signal control system. The vulnerabilities in communications between vehicles and infrastructure may increase the risks of cyber threats. In this talk, I will introduce our recent work that integrates machine learning models with transportation engineering domain knowledge to analyze the cybersecurity of the smart traffic signal control system in the V2X environment, including threat modeling, mitigation solutions, and test and evaluation.

3 Learning-based Optimization of Large-scale Combinatorial Problems in Transportation

Zhongxia Yan, Massachusetts Institute of Technology, Cambridge, MA, Contact: zxyan@mit.edu

Combinatorial problems abound in transportation and cyberphysical systems. Despite recent efforts by machine learning (ML)-based methods to solve problems such as the traveling salesman problem (TSP), vehicle routing problem (VRP), and others, scalability and solution quality remains a key issue for ML-based methods. In this talk, we discuss a general learning-augmented framework for solving large-scale VRPs. The method iteratively improves the solution by identifying appropriate subproblems and obtaining improvements by calling a black box subsolver. Our method accelerates state-of-the-art VRP solvers by 10x to 100x on VRPs of sizes 500 to 3000 while generalizing to a variety of distributions, variants, and solvers. We additionally discuss recent results in lifelong multi-agent path finding (MAPF), another combinatorial problem in cyberphysical systems.

Sunday, 8AM–9:15AM

SA15

CC - Room 120

Interpretable Models in Healthcare

General Session

Session Chair

Elisa Frances Long, UCLA Anderson School of Management, Los Angeles, CA

Session Chair
Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA

1 Estimating Treatment Effects from Observational Data Using a Hidden Markov Model

Tongqing (Angelina) Chen[1], John R. Birge[2], [1]University of Chicago, Chicago, IL, [2]University of Chicago, Chicago, IL, Contact: john.birge@chicagobooth.edu

Estimating treatment effects from observational data is complicated by unobserved confounders and other selection issues. Hidden Markov models can be applied to represent these unobserved conditions. This talk will describe an approach to solve the resulting maximum likelihood estimation problem and conditions for identifiability of the underlying effects.

2 Interpretable Machine Learning: Application to Triage and Reassessment Guidelines for Ventilator Rationing

Julien Grand-Clément[1], Carri Chan[2], Vineet Goyal[3], Elizabeth H. Chuang[4], [1]ISOM Department, HEC Paris, Paris, France; [2]Columbia Business School, New York, NY, [3]Columbia University, New York, NY, [4]Albert Einstein College of Medicine, New York, NY, Contact: grand-clement@hec.fr

Algorithms for sequential decision-making in healthcare often suffer from a lack of interpretability. Decision trees have gained interest in recent years, due to their performances and their interpretability. We present a model to compute interpretable sequential policies that have a tree structure, called tree policies. We apply our model to learn triage and reassessment guidelines for ventilator allocations to patients affected by Sars-Cov-2. We find that official New York state guidelines, based on risk scores, may not outperform First-Come-First-Served guidelines, because they are not adjusted to the specifics of Sars-Cov-2. Our simple tree policies improve upon First-Come-First-Served guidelines and New York State guidelines by reducing the number of excess deaths associated with various hypothetical levels of ventilator shortage.

3 Improving Prediction of Opioid-involved Overdosed Deaths with Multivariate Spatiao-temporal Hawkes Process

Che-Yi Liao[1], Gian-Gabriel P. Garcia[2], Kamran Paynabar[3], Mohammad Jalali[4], [1]Georgia Tech, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, [3]ISyE Georgia Tech, Atlanta, GA, [4]Harvard University, Boston, MA, Contact: cliao48@gatech.edu

Public health surveillance efforts, critical to planning for policy interventions, can be enhanced by decision support tools that identify emerging trends from data. One of the most severe public health crises in US history, surveillance of the opioid crisis has been complicated by ever-changing drug overdose trends across many geographic regions and population groups. In this work, we propose an interpretable Multivariate Spatio-Temporal Hawkes Process with a dynamic network structure (D-MSTHP). D-MSTHP can model these complex interactions by quantifying the influence of each overdose on future overdoses across space, time, and substance. Using overdose death data from Massachusetts, we show that D-MSTHP outperforms popular predictive models applied in this field, with the additional interpretable structure to facilitate inference of emerging trends.

4 Waiting Time Prediction with Invisible Customers

Yoav Kerner[1], Ricky Roet-Green[2], Arik Senderovich[3], Yaron Shaposhnik[2], Yuting Yuan[2], [1]Ben Gurion University of the Negev, Beer Sheva, Israel; [2]University of Rochester, Rochester, NY, [3]University of Toronto, Toronto, ON, Canada.

We study the problem of predicting in real time customers' expected waiting time in partially visible service systems. We apply a theoretical analysis to a novel queueing model that highlights the technical challenge in obtaining an analytical solution. Subsequently, we use the solution as an element of a data-driven machine learning approach to solve the problem in general. We conduct extensive numerical experiments using the simulated data inspired by the literature and real data from a large outpatient hospital.

Sunday, 8AM–9:15AM

SA16

CC - Room 121
Empirical Research in Health Care Operations
General Session

Session Chair
Austin McCandlish, 1</sup

Session Chair
Bilal Gokpinar, UCL School of Management, London, United Kingdom.

1 In-group Bias in Treatment: Does RAS Play a Role?

Jianing Ding, Susan F. Lu, Karthik Kannan, Purdue University, West Lafayette, IN, Contact: ding246@purdue.edu

More than surging clinical performance, robotic-assisted surgery (RAS) tends to increase objectivity in treatment process. In this work, we examine RAS's effect on ameliorating treatment bias induced by patient-physician concordance, which is identified as one of priorities to alleviate surgical disparities. We first examine the effect of RAS on clinical outcomes, controlling physician's self-selection behavior in choosing treatment methods. Then we investigate the patient-physician concordance bias in clinical outcomes and reveal the synergy of RAS implementation on alleviating such bias. Ultimately, we focus on the access to RAS and explore how physician and patient heterogeneity affect the adoption of RAS. As our study suggests RAS reduces treatment bias in clinical performance, future healthcare management might leverage RAS on alleviating treament bias.

2 Primary Care, Health Screenings, and Disease Management Outcomes: An Empirical Investigation

Yingchao Lan[1], Aravind Chandrasekaran[2], Jane Iversen[3], [1]University of Nebraska-Lincoln, Lincoln, NE, [2]The Ohio State University, Columbus, OH, [3]The Ohio State University, columbus, OH, Contact: yingchao.lan@unl.edu

Overuse of resource-intensive services such as unplanned hospitalization and emergency room (ER) visits and underuse of primary care and health screenings contributes to soaring healthcare expenditures in the United States. Despite calls for more investments in primary care, there is lack of empirical evidence on how levels of access to primary care and preventive health screenings can affect patient's use of resource-intensive healthcare services. Leverating a unique diabetic patient claim dataset across United States and implementation of accountable care organizations initiative, we created a quasi-experiment with a difference-in-difference identification strategy to study the impact of primary care access through ACOs. We find that improved access to primary care is associated with more diabetes screening and better disease management performance.

3 Continuity of Care Increases Physician Productivity in Primary Care

Harshita Kajaria-Montag[1], Michael Freeman[2], Stefan Scholtes[1], [1]University of Cambridge, Cambridge, United Kingdom; [2]INSEAD, Singapore, Singapore. Contact: hk437@cam.ac.uk

To date, much research effort has been spent on establishing the impact of continuity of care (COC) in the primary care setting on patient outcomes and secondary care utilization. However, no work has looked at how reductions in COC can also have a detrimental effect on the productivity of primary care service provision itself. In this paper, we show causally that patients who are seen by their regular primary care provider (i.e., who receive COC), return for a subsequent primary care visit on average 15% later than a patient who does not. This effect increases for older patients and patients with comorbidities. A counterfactual analysis suggests that an increase in COC to the top decile would have led to a 5.2% reduction in consultations.

4 The Effect of Episode-based Payments on Cost and Quality: An Empirical Investigation

Austin McCandlish[1], Turgay Ayer[2], Bilal Gokpinar[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, [3]UCL School of Management, London, United Kingdom.

Unlike fee-for-service (FFS) payments which reward volume, episode-based payments (EBPs) are designed to encourage efficient use of resources by issuing a single payment for an entire episode of care. There is, however, limited empirical research on whether and to what extent EBPs lower costs or improve quality of care, particularly in the private insurance market where FFS dominates. We examine a statewide all-payer EBP program implemented in Arkansas using a large claims database of privately insured patients. We evaluate the effect of the EBPs on episode-level costs across different clinical episodes with a difference-in-difference approach. We also explore operational implications of EBPs in terms of cost-savings and quality improvements.

Sunday, 8AM–9:15AM

SA17

CC - Room 122

Data-driven Research in Health Care

General Session

Session Chair

Paola Martin, University of Texas at Austin, Austin, TX

Session Chair

Jingyao Huang, the University of Texas at Austin, Autsin, TX

1 **Combining Pre-approval Clinical Trials and Post-approval Spontaneous Adverse Event Reporting for Improved Safety Signaling**
John M. Silberholz[1], Fernanda Bravo[2], Yunliang Chen[3], [1]University of Michigan Ross School of Business, Ann Arbor, MI, [2]UCLA Anderson School of Management, Los Angeles, CA, [3]UC Berkeley, Berkeley, CA
A classical question in pharmacovigilance is how to combine pre-approval RCTs and post-approval surveillance data to increase the power for side effect detection. A key step is to learn the degree to which the observational data is biased before one can combine it with unbiased clinical trial data. In this work, we propose a model that uses information about common toxicities to help de-bias the observational data on rare toxicities through the correlation of bias among different toxicities (e.g., correlation due to co-reported drugs, indications, and patient health). Using Bayesian statistics, we analyze the benefit of "cross"-debiasing and identify the situation where such benefit is largest. Numerical experiments using real data from the FDA Adverse Event Reporting System (FAERS) suggest significant values of using cross-debiasing to improve drug safety signaling.

2 **Impact of the Kidney Transplant Risk Index on Kidney Accept/Decline Decisions**
Paola Martin[1], Diwakar Gupta[2], Jingyao Huang[3], [1]University of Texas at Austin, Austin, TX, [2]University of Texas, Austin, TX, [3]the University of Texas at Austin, Autsin, TX, Contact: jingyao.huang@mccombs.utexas.edu
The Kidney Donor Risk Index (KDRI) plays a key role in determining transplant surgeons' accept/decline (A/D) decisions for deceased-donor kidneys. However, the KDRI only includes donor characteristics but does not consider candidates' features. In this talk, we propose a new measure of transplant risk, coined the Kidney Transplant Risk Index (KTRI), which considers both donors' and recipients' characteristics. Using historical national transplant data, we develop a highly-accurate A/D model and quantify the impact of using KTRI, instead of KDRI, on the number of kidneys that will be accepted by transplant surgeons and candidates. Moreover, we evaluate the potential societal benefits of using KTRI instead of KDRI.

3 **A Comparison Between Process-flow Simulators and Black-box Prediction Models in Health Care**
Yao Li[1], Simrita Singh[2], Jan A. Van Mieghem[3], [1]Kellogg School of Management, EVANSTON, IL, [2]Kellogg School of Management at Northwestern University, San Jose, CA, [3]Northwestern University, Evanston, IL, Contact: yao.li@kellogg.northwestern.edu
In health care systems, length of stay (LOS) is an important operation measure. Two methods are commonly used to predict LOS: a detailed process-flow simulator and a black-box prediction model. The authors compare the two types of predictors and investigate the value added from knowledge of process flows and time distributions. The authors also investigate how to mine process knowledge from current EHR data.

4 **A Supply Chain Look at Opioid Crisis**
Iman Attari, Jorge Mejia, Jonathan Eugene Helm, Indiana University, Bloomington, IN, Contact: iattari@iu.edu
Over the past two decades, the opioid crisis has escalated into a national public health emergency by claiming the lives of more than 400,000 people, exceeding those attributed to guns or car accidents during the same period. While much of the current research has addressed the opioid epidemic from the perspective of prescription monitoring and end-point distributions, little is known about how structural characteristics in the broader pharmaceutical industry environment, in terms of supply chain structure and market contribute to or mitigate the prevalence of opioid addiction. This study examines supply chain levels above the providers to determine deeper, supply chain-based connections with opioid abuse.

Sunday, 8AM–9:15AM

SA18

CC - Room 123
HAS/DEIC/MIF: DEI in Health Applications
Panel Session

1 **Examining Ethics and Considerations of ORMs Health Disparities Research**
Karen T. Hicklin, University of Florida, Gainesville, FL
Health disparities research promotes the conduct of research to understand inequities in health care to ultimately lead to increased health equity. In this panel we examine the ethics, responsibilities, and special considerations needed to properly conduct health disparities research effectively. Panelists conduct health disparities research spanning areas of engineering, public health, and public policy.

Session Chair
Karen T. Hicklin, University of Florida, Gainesville, FL

2 **Panelist**
Jennifer Mason Lobo, University of Virginia,

Charlottesville, VA

3 Panelist

Julie Simmons Ivy, North Carolina State University, Raleigh, NC

4 Panelist

Toyya Pujol, 1</sup

5 Panelist

Jonathan Welburn, 1</sup

Sunday, 8AM–9:15AM

SA19

CC - Room 124

Advances in Empirical Healthcare Operations

General Session

Session Chair

Song-Hee Kim, Seoul National University, Gwanak-gu, Korea, Republic of.

Session Chair

Wilson Lin, University of Southern California, Arcadia, CA

1 Impact of Telehealth on Appointment Adherence in Ambulatory Care

Masoud Kamalahmadi, Christos Zacharias, Howard Gitlow, University of Miami, Coral Gables, FL, Contact: mkamalahmadi@miami.edu

Telehealth services grew massively popular amid the COVID-19 pandemic, but their operational implications for healthcare organizations are not well-understood. We study the effect of telehealth on patients' adherence to medical appointments in ambulatory care. Using data from a large medical system, we find that telehealth improves appointment adherence. We discuss the mechanisms of the effect and its implications for managers and policy makers.

2 The Impact of Online Self-scheduling on Patient Access to Hospital Services

Lesley Meng[1], Hummy Song[2], Christian Terwiesch[2], [1]Yale School of Management, Yale University, New Haven, CT, [2]University of Pennsylvania, Philadelphia, PA, Contact: lesley.meng@yale.edu

Recent innovation in healthcare access has led to the launch of online patient platforms where patients are now able to digitally schedule and manage their own medical appointments within a health system. In many large academic medical centers, digital scheduling has become the default method for patients to request and schedule appointments, and many medical appointments are now made this way. In this study, we examine the impact of online self-scheduling access on patient scheduling and visit behavior at a large academic medical center.

3 The Role of Physician Integration in Alternative Payment Models: The Case of the Comprehensive Joint Replacement Program

Christopher J. Chen[1], Kraig Delana[2], [1]Indiana University Kelley School of Business, Bloomington, IN, [2]University of Oregon, Eugene, OR, Contact: kdelana@uoregon.edu

In this paper, we empirically examine the role of both horizontal and vertical integration of orthopaedic surgeons in driving heterogeneity in the impact of the Comprehensive Joint Replacement (CJR) alternative payment program. Using a quasi-experimental difference-in-differences approach, we find hospitals with high horizontal and vertical integration see an increase in both hospital costs and complication rates of 3.17% and 1.18, respectively, while others see either a decrease or no-change in these measures. Moreover, we present evidence that these changes in performance measures are driven by changes in physician care decisions regarding length-of-stay and discharge disposition. Our findings provide novel insights into hospital-physician relationships, which are relevant for policymakers, payors, and healthcare providers.

4 Does Telehealth Reduce Rural-urban Care-access Disparities? Evidence from Covid-19 Telehealth Expansion

Shujing Sun, Guihua Wang, The University of Texas at Dallas, Richardson, TX

Using a unique set of national healthcare claims data, we investigate the effect of telehealth expansion policy on rural-urban healthcare-access disparities. Leveraging a difference-in-differences design, we compare the total number of visits to urban and rural providers before and after telehealth expansion. We find an enlarged disparity in rural-urban healthcare access, with the rural-urban gap in total patient visits increasing by 3.9% due to telehealth expansion. We then examine the underlying mechanisms that drive the enlarged disparity. Our findings are important to policy makers, healthcare providers, and researchers seeking to understand the broad implications of telehealth expansion on rural-urban disparities and further promoting and integrating remote care delivery into the healthcare system.

Sunday, 8AM–9:15AM

SA20

CC - Room 125

Delegated Sequential Search

General Session

Session Chair

Shouqiang Wang, 1</sup

1 To Whom the Offer Prioritizes? A Joint Optimization of Offer Sequence and Offer Deadline

Wenjie Tang[1], Zhenyu Hu[2], [1]University of Vienna, Vienna, Austria; [2]National University of Singapore, Singapore, Singapore. Contact: wenjie.tang@univie.ac.at

We consider a setting where a proposer makes an offer to a sequence of responders, each of whom concurrently searches for alternative offers and has to respond to the proposer's offer by the respective deadline. Taking into account responders' reactions, the proposer needs to maximize her value-to-go through the choice of sequence of responders and corresponding deadlines. We provide a full characterization of the optimal deadlines. Moreover, we solve for the optimal sequence in two special cases. Finally, we investigate the efficiency of a greedy policy that always prioritizes the highest-utility responder, and provide a lower bound for the proposer's expected payoff when the size of alternative offers is deterministic.

2 The when and How of Delegated Search

Sasa Zorc[1], Ilia Tsetlin[2], Sameer Hasija[3], Stephen E. Chick[4], [1]University of Virginia, Darden School of Business, Charlottesville, VA, [2]INSEAD, Singapore, Singapore; [3]Insead, Singapore, Singapore; [4]INSEAD, Fontainebleau, France. Contact: zorcs@darden.virginia.edu

Firms often outsource search processes such as the acquisition of real estate, technologies, or talent, which then involves designing contracts to attenuate the ill effects of agency. We model this problem via the dynamic principal-agent framework, embedding the standard sequential search model. The optimal contract pays a fixed per-period fee, plus a bonus for finding a suitable alternative. The bonus size is defined a priori and decreases over time, while the range of values deemed suitable expands over time. We also consider the choice between searching in-house and outsourcing. This decision is shown to hinge on the speed-quality tradeoff. The age-old aphorism "if you want it done right, do it yourself" holds, as in-house search is optimal if quality is prioritized. Yet, in the context of our model, we establish an addendum: "if you want it done fast, hire someone else."

3 Information Design of a Delegated Search

Zhenyu Hu[1], Shouqiang Wang[2], Yangge Xiao[1], [1]National University of Singapore, Singapore, Singapore; [2]The University of Texas at Dallas, Richardson, TX

We study a delegated sequential search problem, where an agent is in charge of the search but only a principal can observe and evaluate each search result. Once the search ends, the principal and agent split the payoff. The principal designs an information policy to strategically provide some information about the search results over time. We show that the optimal policy makes a binary recommendation in each period, which the agent will voluntarily follow. Specifically, the principal specifies a threshold in each period, decreasing over time, such that the agent is recommended to continue the search if and only if the payoff from the search is below that threshold. These thresholds are higher than those that would be used if the agent has full access to the search results, suggesting that the principal can induce a higher search intensity by leveraging her informational advantage.

4 Optimal Presentation of Alternatives

Zeya Wang, Morvarid Rahmani, Karthik Ramachandran, Georgia Institute of Technology, Atlanta, GA, Contact: zeya.wang@scheller.gatech.edu

In many contexts such as technology and management consulting, clients seek the expertise of providers to find solutions for their problems. When there are multiple alternatives that could potentially solve the client's problem, providers can lead the client's exploration by choosing which alternative(s) to present and in what sequence. In this paper, we develop a dynamic game-theoretic model where the provider chooses how to present alternative solutions, and the client chooses which solution to try. Our analysis reveals that it is generally optimal for the provider to offer alternatives sequentially. Following a failed trial, the provider should readily offer a new alternative if the client's capability is either very high or very low. Otherwise, the provider should allow the client to try the same solution multiple times, especially when the project duration is long.

Sunday, 8AM–9:15AM

SA21

CC - Room 126

Qualitative Value of Information: Theory and Applications
General Session

Session Chair
Michael C. Runge, USGS Eastern Ecological Science Center, Laurel, MD

1 Developing a Qualitative Measure of the Value of Information
Michael C. Runge[1], Clark S. Rushing[2], James E. Lyons[1], Madeleine A. Rubenstein[3], [1]USGS Eastern Ecological Science Center, Laurel, MD, [2]University of Georgia, Athens, GA, [3]USGS National Climate Adaptation Science Center, Reston, VA, Contact: mrunge@usgs.gov
The value of information is a central concept in decision analysis, used to quantify how much the expected outcome of a decision would be improved if epistemic uncertainty could be resolved prior to committing to a course of action. Quantitative analysis of the value of information demands predictions as a function of actions and sources of uncertainty, but what if such predictive tools are not available? In this presentation, we propose a novel qualitative measure of the value of information (QVOI), grounded in the algebra of the expected value of perfect information (EVPI), but requiring less of experts and analysts. The QVOI calculation decomposes EVPI into a contribution representing the relevance of the uncertainty to the decision and a contribution representing the magnitude of uncertainty; qualitative constructed scales are then proposed for each contribution.

2 Prioritizing Research Needs for Migratory Bird Management Under Climate Change Using Qualitative Value of Information
Clark Rushing[1], Madeleine Rubenstein[2], James Lyons[3], Michael C. Runge[3], [1]University of Georgia, Athens, GA, [2]USGS National Climate Adaptation Science Center, Reston, VA, [3]USGS Eastern Ecological Science Center, Laurel, MD, Contact: clark.rushing@uga.edu
We demonstrate how qualitative value of information (QVoI) can be used to prioritize research in decision contexts characterized by high degrees of complexity and uncertainty. We used QVoI to evaluate 11 hypotheses about the effects of climate change on migratory birds and prioritize research needs to improve land acquisition decisions to protect these species. Reducing uncertainty about how climate change will influence the spatial distribution of priority species was identified as the highest priority for future research due to both the value of this information for improving decisions and the feasibility of reducing uncertainty. By providing a rigorous and transparent approach to prioritizing research, QVoI is a valuable tool for prioritizing research and improving management decisions in settings where quantitative value of information is not possible.

3 Qualitative Value of Information Provides a Transparent and Repeatable Method for Identifying Critical Uncertainty Regarding the use of Prescribed Fire
Michelle L. Stantial[1], Abby Lawson[2], Auriel Fournier[3], Peter Kappes[4], Chelsea Kross[3], Michael C. Runge[1], Mark Woodrey[4], James Lyons[1], [1]USGS Eastern Ecological Science Center, Laurel, MD, [2]USGS New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University, Las Cruces, NM, [3]Forbes Biological Station–Bellrose Waterfowl Research Center, Illinois Natural History Survey, Prairie Research Institute, University of Illinois at Urbana-Champaign, Havana, IL, [4]Coastal Research and Extension Center, Mississippi State University, Biloxi, MS, Contact: mstantial@usgs.gov
Conservation decisions are often made under uncertainty, and adaptive management can balance achieving conservation objectives with reducing epistemic uncertainty. However, quantitative evaluation of uncertainty may require more resources than are available in the early stages of conservation planning. We demonstrate a qualitative value of information (QVoI) analysis requiring few resources to efficiently prioritize uncertainty for adaptive management. We developed conceptual models to identify sources of uncertainty and articulate hypotheses about prescribed fire to benefit marshbirds in the Gulf of Mexico. We used QVoI to prioritize the sources of uncertainty based on their magnitude, relevance for decision making, and reducibility. We found that uncertainties related to fire return intervals and burn season were the highest priorities for managers.

4 Value Added Conservation: Prioritizing Critical Uncertainties for Rosy-finch Conservation in a Warming World
Abby Lawson[1], Janice Gardner[2], Michelle Stantial[3], Clark Rushing[4], [1]US Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, Las Cruces, NM, [2]Sageland Collaborative, Salt Lake City, UT, [3]US Geological Survey Eastern Ecological Science Center, Laurel, MD, [4]University of Georgia, Athens, GA, Contact: ajlawson@nmsu.edu
While nearly all wildlife management decisions involve some degree of uncertainty, those involving data-deficient species pose unique challenges. For imperiled species in particular, data deficiency can prevent managers from knowing

how to direct limited resources to provide the maximum conservation benefit. Rosy-finches are a group of three cold-adapted passerine species that breed in alpine ecosystems that are difficult to access and monitor, resulting in extreme data deficiency. Here we describe the use of qualitative value of information (QVoI) to identify research priorities to improve conservation planning for Rosy Finches. Results are being implemented by an interagency Rosy-Finch working group and will help streamline research and monitoring, avoid duplication, and reduce uncertainties related to conservation interventions.

Sunday, 8AM–9:15AM

SA22

CC - Room 127

AI for Cybersecurity

General Session

Session Chair

Soumyadeep Hore, Tampa, FL

Session Chair

Ankit Shah, University of South Florida, Tampa, FL

1 A Machine Learning and Optimization Approach to Optimal Alert Investigation

Jalal Ghadermazi, Ankit Shah, University of South Florida, Tampa, FL

A Cyber Security Operations Center (CSOC) is tasked with investigating alerts generated from the Intrusion Detection Systems (IDS) in a timely manner. CSOCs often fall short of alert handling expectations due to two main reasons. First, the rule-based triage mechanism of the IDS does not comprehensively consider the organization-specific factors such as asset and mission criticality. Second, the analyst expertise is not matched with the alert type for efficient investigation. In this talk, we address the above shortcomings with an intelligent approach to achieving optimal alert investigation that considers organization-specific factors and analysts' capabilities. Experimental results show that with our approach, which combines machine learning and optimization, alerts are investigated in a timelier manner when compared to the current practices at the CSOCs.

2 The Potential of AI in Cybersecurity

Soumyo D. Moitra, Pittsburgh, PA

This paper discusses potential applications of AI for enhancing cybersecurity. AI is a good fit to cybersecurity problems as AI is ideally suited to analyze big data, complex decision-making spaces, and situations where there is ambiguity. High level algorithms for some examples are presented including cost modeling of cybersecurity systems and the evaluation of the effectiveness of security systems. The perspective is that of decision support through expert systems.

3 Cyber-physical System Monitoring Using Explainable Artificial Intelligence

Iida Haghnegahdar, SUNY, Binghamton, NY

Manufacturing systems are increasingly faced with attacks not only by traditional malicious actors such as hackers and cyber-criminals but also by some competitors and nations engaged in corporate espionage. Artificial intelligence (AI) as one of the new approaches has emerged to overcome the increasing complexity and sophistication of cybersecurity attacks in manufacturing. These defensive and control-based AI method implements various machine learning algorithms for different types of controls, such as intrusion detection and malware detection. However, the growing adoption of advanced deep learning algorithms is turning these AI-based controls into black box systems. In this study, the authors propose an action for the explainability of the AI-based cybersecurity controls in research and practice for Additive manufacturing.

4 A Reinforcement Learning Approach to Maintaining the Level of Operational Effectiveness of a Cyber Security Operations Center Under Adverse Conditions

Ankit Shah[1], Rajesh Ganesan[2], [1]University of South Florida, Tampa, FL, [2]George Mason University, Fairfax, VA

The level of operational effectiveness (LOE) is a color-coded performance metric that is monitored by the Cyber Security Operations Center (CSOC). It is determined using the average time to analyze alerts in every hour of shift operation. Adverse events can cause low LOE as the alert arrival rate exceeds the investigation rate. Upon exhausting all the analyst resources, the only option available to a CSOC manager is to discard alerts for restoring the LOE of the CSOC. This talk presents an intelligent strategy, powered by reinforcement learning (RL), to maintain the LOE under adverse conditions. The RL-based strategy, which is developed using a dynamic optimization model, has the following desiderata: (i) maximize utilization of analysts and (ii) minimize the number of alerts to discard. Our experiment results show that the RL strategy outperforms the other strategies.

Sunday, 8AM–9:15AM

SA23

CC - Room 128

Global and Planetary Health

Joint Session

Session Chair

Rebecca Alcock, Madison, WI

Session Chair

Justin J. Boutilier, University of Wisconsin - Madison, Fitchburg, WI

1 Cost-effectiveness of Seroprevalence Based Covid-19 Vaccination Strategies in India

Sripad K. Devalkar[1], Sarang Deo[1], Abhishek Reddy[1], Nimalan Arinaminpathy[2], Sandip Mandal[3], Hiral Shah[4], [1]Indian School of Business, Hyderabad, India; [2]Imperial College London, London, United Kingdom; [3]Independent Consultant with ICMR, New Delhi, India; [4]Imperial College London, London, United Kingdom.

Given the considerable heterogeneity and uncertainty in the transmission of COVID-19 in urban and rural areas of India, identifying and prioritising vaccination strategies based on cost-effectiveness evidence can aid in understanding how to allocate limited supply and resources. In this work, we determine the cost-effectiveness of seroprevalence-based vaccination strategies by combining epidemiological and supply chain modeling. We develop a supply chain model based on the resources available to support COVID-19 vaccination and determine the appropriate allocation of these resources to support different seroprevalence-based vaccination strategies to estimate the cost of vaccine administration. We use an epidemiological model of transmission dynamics to determine health outcomes for the vaccination strategies and estimate their cost-effectiveness.

2 Health Clinic Electrification in LMICs via a Novel Renewable Energy Network

Rebecca Alcock[1], Justin J. Boutilier[2], [1]University of Wisconsin–Madison, Madison, WI, [2]University of Wisconsin - Madison, Fitchburg, WI, Contact: ralcock@wisc.edu

More than one billion people worldwide receive healthcare in a facility without electricity. Energy inequities in healthcare have many consequences, including increased mortality and higher incidence of disease. To address this, we are investigating a vehicle-to-grid system that will equip resource-limited health clinics with the electricity needed to keep them running, while enabling mobile health services via access to electric bicycles. This talk will focus on the pilot project at a community garden in Madison, WI, and the current state of the mathematical frameworks used for sizing the system.

3 Designing a Personalized Community-based Approach to Diabetes Care

Katherine B. Adams[1], Justin J. Boutilier[2], Yonatan Mintz[3], Sarang Deo[4], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin - Madison, Fitchburg, WI, [3]University of Wisconsin Madison, Madison, WI, [4]Indian School of Business, Hyderabad, India. Contact: kbadams@wisc.edu

Diabetes is a global health priority, especially in lower-middle-income countries, where over 50% of premature deaths are attributed to high blood glucose. Several studies have demonstrated the feasibility of using Community Health Worker (CHW) programs to provide affordable and culturally tailored solutions for early detection and management of diabetes. We propose an optimization framework to personalize CHW visits to maximize glycemic control at a community-level. We present structural and computation results using real data from India.

4 Ensemble Machine Learning Methods to Improve Burden Estimates for Wasting

Mayukh Ghosh[1], Zohreh Raziei[2], Chintan Amrit[1], Ozlem Ergun[2], Srinivasan Radhakrishnan[3], [1]University of Amsterdam, Amsterdam, Netherlands; [2]Northeastern University, Boston, MA, [3]Northeastern University, Amsterdam, Netherlands.

Wasting, an acute form of malnutrition, increases a child's risk of infection and death and reduces their ability to learn and be productive. Reliable estimates of annual severe acute malnutrition (SAM) are required for policy decisions and planning. In the absence of incidence data, the SAM burden is estimated as a function of only prevalent cases and the incidence correction factor for which a single factor (1.6) is recommended globally. However, obtaining a reliable estimate is challenging as the incidence varies among sites thereby often leading to underestimation of the SAM burden. In this study, in collaboration with UN WFP, we propose novel multivariate ensemble classification models to predict and validate the burden of SAM in the Sahel region of Africa. We then present a comparative evaluation of the performance of our chosen algorithms.

Sunday, 8AM–9:15AM

SA25

CC - Wabash 2

Epidemic Modeling, Prediction, and Control

Tutorial Session

Session Chair

Pradeep Kumar Pendem, University of Oregon, Eugene, OR

1 **Epidemic Modeling, Prediction and Control**

Ujjal Kumar Mukherjee[1], Sridhar Seshadri[2], [1]University of Illinois, Urbana-Champaign, Champaign, IL, [2]University of Illinois, Champaign, IL

The COVID-19 pandemic has disrupted almost every facet of life globally and has posed new challenges to policymakers and questions to researchers. In this article, we discuss some of the key considerations and challenges in modeling epidemics, predicting their diffusion within and across populations and evaluating their control policies. Epidemic prediction is challenging due to the uncertain nature of its spatial and temporal diffusion, co-evolution of latent confounding factors, sparsity of signals particularly during the initial stages of a pandemic and the complex interactions of the individual- and group-level behaviors with mitigating policy interventions. We explain, illustrate and comment on the strengths and weaknesses of the commonly used epidemic models. We classify the existing models on methodologies used such as compartmental models versus agent-based models, nature of model uncertainties considered such as deterministic versus stochastic models and factors included in the models such as network effects, disease characteristics and control actions. We highlight some of the common behavioral traits exhibited by individuals and discuss the theoretical sources of such behavior. Based on our work, we illustrate the formulation of a specific compartmental model that accounts for asymptomatic spread of COVID-19 and the effect of control actions such as testing and lockdowns. We also demonstrate the nature of optimal actions based on analytical and agent-based simulation methodology. Finally, we conclude by discussing lessons learned from the COVID-19 pandemic to better manage any future pandemic.

Sunday, 8AM–9:15AM

SA26

CC - Wabash 3

Airline Network Design on STEAM and OR Education Contents

Joint Session

Session Chair

Shio Kawagoe, 1</sup

Session Chair

Yudai Honma, The University of Tokyo, Meguro-Ku, Japan.

1 **Workshop Design for STEAM Education by Cooperating with Industry**

Shio Kawagoe, The University of Tokyo, Tokyo, Japan.

In response to the drastically changing society, the practice of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education is being promoted internationally. The Office for the Next Generation (ONG) has organized various STEAM education programs based on engineering research. In this study, we designed workshops by cooperating with the airline for junior and senior high school students to learn the relationship between science and technology and society. The questionnaire survey results indicate that the workshops efficiently make the students understand "each STEAM subject" and "the social roles and the significance of science and technology."

2 **Development of an Evaluation Method for STEAM Education-based Learning in High School**

Mizuki Yamada, The University of Tokyo, Japan.

According to the recent curriculum guideline, the importance of cross-curricular learning has been addressed in Japan. With establishment of project-based learning activities in high schools, there is a need to develop lesson designs for project-based learning with STEM (Science, Technology, Engineering, and Mathematics) approaches and their evaluation methods to enhance STEAM Education.

The present study aims to develop a lesson design and evaluation method for project-based learning with STEAM approaches that is introduced into schools through the project UTokyoGSC conducted by the University of Tokyo. UTokyoGSC has been developing education programs, which utilizes a science and technology human resource development program for high school students initiated by Office for the Next Generation at the University of Tokyo.

3 **Development of Excel Materials for or Education Through Airline Network Design**

Yudai Honma[1], Saori Nakai[2], Hiroko Watanabe[2], [1]The University of Tokyo, Meguro-Ku, Japan; [2]The University of Tokyo, Tokyo, Japan. Contact: hiroko@iis.u-tokyo.ac.jp

Airline network design is considered a network optimization while considering various conflicting objectives, so it is an excellent educational theme for OR. In this study, we have developed an Excel education material that delivers the essence of this topic to junior and senior high school students.

4 Importance of STEAm and or Educations for Airline Companies

Taito Sato, Saki Inohata, Yuta Watari, Hiroshi Iseki, Hiroshi Ohata, Hideki Ochiai, Japan Airlines Co., Ltd., Tokyo, Japan.

Sustainability is an important issue shared by society as a whole. It is no different for airline companies that connect cities around the world. We are continuously examining how to balance economic activities and environmental protection, and how to deliver appropriate messages to society. With this background, Japan Airlines actively promotes educational activities for junior and senior high school students, who are the future leaders of the next generation. In particular, we have focused on STEAM and OR educations to acquire a broad perspective and have developed both educational materials and workshop events on the theme of "aviation" in cooperation with the University of Tokyo. This presentation will introduce the content and motivation of such efforts.

Sunday, 8AM–9:15AM

SA27

CC - Room 138

Digital Platforms

General Session

Session Chair

Christopher S. Tang, University of California-Los Angeles

Session Chair

Yiting Deng, University College London, London, United Kingdom.

1 The Effects of Driver Supply on Demand in the Ride-sharing Market: A Field Experiment

Zack Wang[1], Qiyuan Wang[2], Song Yao[3], Tat Y. Chan[1], [1]Washington University, St. Louis, MO, [2]The Hong Kong Polytechnic University, Hong Kong, China; [3]Washington University in St. Louis, St. Louis, MO, Contact: chongbo.wang@wustl.edu

We study the effects of driver supply on demand in the ride-sharing market by running a natural field experiment for a platform. We manipulate drivers' subsidies to influence the supply, and use subsidies as an instrument to identify the impacts on demand. We find that increasing the number of drivers at work by 1% will increase the number of customer orders by 2.0% and, conditional on the orders, reduce the cancellation rate by 0.5%. These results also imply a long-term impact on customers' repeating orders and churns. We find that, for a 1% increase in the number of drivers working in afternoon or night, the aggregate customer lifetime value of the platform will increase by 1.6% or 0.5%, respectively. The findings suggest that, to improve the revenue, the platform can focus on hiring drivers or incentivizing current drivers work for longer hours.

2 Planogram Design in the Presence of Store Brands and Shelf Display Fees

Yasin Alan[1], Mumin Kurtulus[2], Alper Nakkas[3], [1]Vanderbilt University - Owen Graduate School of Management, Nashville, TN, [2]Vanderbilt University, Nashville, TN, [3]University of Texas at Arlington, Arlington, TX, Contact: yasin.alan@vanderbilt.edu

We examine how store brands (SBs) and display fees, which manufacturers pay retailers for prime shelf space, affect retailers' planogram decisions (i.e., placement of products on shelves). We consider a game-theoretic model with one retailer and two national brand (NB) manufacturers. The NB manufacturers determine their wholesale prices and how much they are willing to pay for the prime shelf space, while the retailer makes assortment and planogram decisions and sets retail prices. Our study generates three insights. First, the common practice of giving the prime shelf space to a high sales volume product can be suboptimal for the retailer. Second, the retailer can carry the SB in its assortment to increase its display revenue. Third, display fees can increase the NB manufacturers' profits.

3 Informal Payments and Doctor Engagement in Online Health Community: An Empirical Investigation Using Generalized Synthetic Control

Qili Wang[1], Liangfei Qiu[1], Wei Xu[2], [1]University of Florida, Gainesville, FL, [2]Renmin University of China, Beijing, China. Contact: qili.wang@warrington.ufl.edu

Online health communities are growing rapidly as more individuals seek health information online. Given the importance of doctor engagement, some online health communities have introduced informal payments to doctors to encourage knowledge sharing. We leverage the launch of a gifting feature by a leading online health community as a natural experiment that exogenously provides doctors with extra monetary incentives. We find that the introduction of the gifting feature negatively affects doctors' responses to medical consultations. Our results indicate a crowding-out effect of informal payments on doctors' intrinsic motivation to engage in such consultations. Moreover, our consultation-level analysis suggests that monetary and nonmonetary gifts play distinct roles in motivating doctors' responses.

4 The Effect of Surge Pricing on Driver Behavior in the Ride-sharing Market: Evidence from a Quasi-experiment

Wei Miao[1], Yiting Deng[1], Wei Wang[2], Yongdong Liu[3], Christopher S. Tang[4], [1]University College London, London, United Kingdom; [2]University of International Business and Economics, Beijing, China; [3]UCL School of Management, University College London, London, United Kingdom; [4]University of California-Los Angeles, Los Angeles, CA, Contact: yiting.deng@ucl.ac.uk

Surge pricing has been used to coordinate supply and demand in the ride-sharing industry; however, its causal effects on driver behavior remain unclear. This motivates us to examine how surge pricing causally affects driver earnings and labor supply by leveraging a unique quasi-experiment, in which a leading ride-sharing company in China introduced surge pricing in two cities at different times. Using a difference-in-differences design with the causal forest method, we find that surge pricing increased a driver's weekly revenue. We then decompose the driver's weekly revenue into "intensive margin" and "extensive margin" factors, and identify two countervailing effects at play: a cherry-pickingeffect and a competition effect. Finally, we find considerable heterogeneity across drivers, and that the benefit of surge pricing was unevenly distributed across drivers.

Sunday, 8AM–9:15AM

SA28

CC - Room 139

Operations Management and Social Development

General Session

Session Chair

Andre Du Pin Calmon, Scheller College of Business, Georgia Institute of Technology, Atlanta, GA

Session Chair

Christopher Dalton Parker, American University, Washington

1 Improving Cash-constrained Smallholder Farmers' Revenue: The Role of Government Loans

Wen Hong (Kenneth) Pay[1], Somya Singhvi[2], Yanchong (Karen) Zheng[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]USC Marshall School of Business, Los Angeles, CA, Contact: yanchong@mit.edu

The need for immediate cash inhibits smallholder farmers from maximizing their revenue by forcing them to sell their produce at suboptimal times. This paper develops a model to examine how cash constraints influence farmers' selling decisions, as well as to analyze the efficacy of loan programs in improving revenue outcomes. The model results are validated with field data from agricultural markets in India.

2 The Operational Origins of Child Labor in Cocoa Production

Andre Du Pin Calmon[1], Andreas Gernert[2], Dan Andrei Iancu[3], Luk N. Van Wassenhove[4], [1]Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, [2]Kühne Logistics University, Hamburg, Germany; [3]Stanford University, Stanford, CA, [4]INSEAD, Fontainebleau Cedex, France. Contact: andre.calmon@gatech.edu

Child labor is a major issue in chocolate value chains. In Ghana and Ivory Coast, most farmers employ child labor in cocoa production. Our work examines, both empirically and analytically, how several aspects of cocoa farmers' operations, such as production decisions, farmer wealth, and access to loans, can exacerbate (or mitigate) child labor use. Our empirical approach leverages detailed surveys of cocoa farmers. We find, for example, that the availability of loans does not increase the use of child labor in very low-income farmers. Conversely, the availability of loans for higher-income (but still poor) farmers might increase the use of child labor. Based on our empirical findings, we build an analytical model that describes the various tradeoffs cocoa farmers face. We use this model to investigate the value of different interventions that aim to mitigate child labor.

3 Blockpower: Using Compensated Relational Voting to Increase Black Voter Turnout

Karthik Balasubramanian[1], Chris Parker[2], [1]Howard University School of Business, Washington, [2]American University, Washington, DC, Contact: chris.parker@american.edu

BlockPower is a non-profit that pays citizens of majority-Black neighborhoods up to $500 to train people they already know to increase voter turnout. We describe BlockPower and explain how we are testing for increases in voter turnout. We also describe other opportunities to collaborate on research.

4 The Impact of Streak-based Performance Evaluation in Crowdsourcing Contests for Skilled Microtasks

Olumurejiwa A. Fatunde[1], Joann de Zegher[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Sloan, Cambridge, MA

Crowdsourcing is increasingly used to organize distributed work, including skilled tasks. This paper explores incentive design for distributed-task platforms by studying a platform which serves as an intermediary in the supply chain for medical knowledge. Using data on 5,418 crowdsourcing contests for medical diagnosis, we examine how evaluation metrics shape participants' decisions and performance. We assess the impact of evaluating participants using the longest "streak" of correct answers, rather than an accuracy-based metric. Streak evaluation increases volume of quality responses and speed of achieving consensus, largely through dramatically increased engagement. These findings are relevant in settings where rewards for performance streaks are used to boost motivation; we find that they also boost performance.

Sunday, 8AM–9:15AM

SA29

CC - Room 140

Operational Decision-making for Effective Mitigation of COVID-19

General Session

Session Chair

Ebru Korular Bish, University of Alabama, Tuscaloosa, AL

Session Chair

Sait Tunc, Virginia Tech, Blacksburg, VA

1 Correlation Improves Group Testing

Yujia Zhang[1], Jiayue Wan[2], Peter Frazier[3], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, [3]Cornell University, Ithaca, NY

Large-scale screening enabled by group testing is a powerful tool for controlling infectious diseases like COVID-19. While past analyses of group testing typically assume samples in a pool are independent, we observe that placing samples from a social group into the same pool correlates a pool's samples, so that a positive pool likely contains multiple positive samples. We show that, under the classic two-stage Dorfman procedure, correlated pooling increases sensitivity and also tends to require fewer tests per positive identified. Such improvement in sensitivity and efficiency in turn improves group testing's power in achieving epidemic control. Thus, correlation is an important consideration for policy-makers: it makes screening more attractive for epidemic control (as opposed to lockdown) and it suggests that sample collection should maximize correlation.

2 Presenter

Sait Tunc, Virginia Tech, Blacksburg, VA

3 Optimal COVID-19 Vaccination Facility Location

Jingyuan Hu, Elisa Frances Long, Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, Contact: jingyuan.hu.phd@anderson.ucla.edu

Socioeconomic disparities in COVID-19 vaccination rates are partially attributable to poor vaccination site selection. We formulate a COVID-19 vaccination location problem as a large-scale mixed-integer program, selecting from >58,000 pharmacies and >30,000 dollar stores nationwide. The optimal solution allocates 37% of vaccinations to dollar stores, achieving a 62% reduction in travel distance, and reduces racial disparities as measured by a newly constructed Gini coefficient.

4 Presenter

Robert Shumsky, Dartmouth College, Hanover, NH

Sunday, 8AM–9:15AM

SA30

CC - Room 141

Supply Chain Financing and Operational Decisions

General Session

Session Chair

Karca D. Aral, Syracuse University, Syracuse, NY

1 Effects of Financial Constraint Relaxation on Supply Chain Financing Choices and Operational Decisions

Sridhar Seshadri, UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN, IL

Aggregate planning in supply chain management enables firms to make operational investments subject to financial constraints, to resolve the trade-off between capacity and inventory. Limited research empirically examines the how financial constraints affect these decisions. In this study, we bridge the gap and investigate how firms plan on their capacity and inventory when financial constraints are relaxed. To alleviate the endogeneity stemming from unobserved factors driving the relation and to identify a causal link, we leverage staggered state-wise implementations of interstate branching deregulation across U.S. as quasi-experiments. We find that banking deregulation improves firms' access to credit market and generates heterogenous effects on financing choices and operational decisions across firms.

2 Shareholder Scrutiny, Managerial Flexibility, and Inventory Management

Karca D. Aral, Syracuse University, Syracuse, NY

We study how shareholder scrutiny may affect key operations decisions pertaining to inventory. For identification, we exploit the quasi-natural experiment provided by the staggered adoption of constituency statutes which provided executives the flexibility to invest in building long-term operational capacity. Using a staggered difference-in-differences approach, we find that, after the reforms, firms incorporated in constituency states increased inventory by 5.2% relative to firms not incorporated in constituency states. We also find that the increase in inventory is gradual and persists over time, suggesting a strategic shift in long-term service levels. These changes are associated with a positive increase in firm value. A battery of validity and robustness tests strongly mitigates the concern that alternative channels could explain our findings.

Sunday, 8AM–9:15AM

SA31

CC - Room 142

Service Systems and Customer Behaviour

General Session

Session Chair

Tingliang Huang, Carroll School of Management, Boston College, Newton, MA

1 Order Ahead for Pickup: Promise or Peril?

Luyi Yang[1], Yunan Liu[2], Ke Sun[3], [1]University of California, Berkeley, Berkeley, CA, [2]North Carolina State University, Raleigh, NC, [3]Beijing University of Chemical Technology, Beijing, China.

Mobile technologies have increasingly enabled customers to order ahead at quick-service restaurants. As customers who order ahead travel to the service facility to pick up their order, their order also advances in the food-preparation queue. It is widely believed that the order-ahead scheme reduces customers' total wait time and therefore attracts more orders (i.e., yields higher throughput) than if customers must order onsite. We build queueing-game theoretic models to study the throughput implications of the order-ahead scheme.

2 The Impact of Consumer Complaint Relevance on Product Recalls: An Empirical Investigation of the Automobile Industry

Weihan Jia[1], Yufei Huang[1], Xingjie Wei[2], [1]Trinity Business School, Trinity College Dublin, Dublin, Ireland; [2]University of Leeds, Leeds, United Kingdom. Contact: yufei.huang@tcd.ie

This paper studies the impact of consumer complaint relevance on the timing of product recall decisions. Using a car recall data set from NHTSA (National Highway Traffic Safety Administration) in the USA, we first implement text mining methods to analyze consumer complaint relevance by measuring the similarity between the car defects and the content in consumer complaints. We then examine how consumer complaint relevance impacts the timing of recall decisions. We find that when the level of consumer complaint relevance is higher, a recall decision is made faster. Such a relationship becomes stronger when a defected component is used in different car models or when the car models are older.

3 Whether and when Grocery Stores Should Adopt Time-based Pricing: Competition and Negative Congestion Externality

Christopher S. Tang[1], Onesun Steve Yoo[2], Dongyuan Zhan[3], [1]University of California-Los Angeles, Los Angeles, CA, [2]UCL School Of Management, University College London, London, United Kingdom; [3]University College London, London, United Kingdom. Contact: d.zhan@ucl.ac.uk

Considering consumer's congestion aversion, we examine "whether and when" brick-and-mortar grocery stores should adopt intra-day time-based pricing. We develop a two-stage dynamic duopoly game in which each store can make sequential adoption timing and pricing decisions pricing. Our equilibrium analysis reveals that both stores should eventually adopt time-based pricing in equilibrium. Additionally, despite the fact that cautious adoption offers an "informational advantage" by postponing the adoption time, at most one store will adopt the cautious approach in equilibrium.

Interestingly, we find that adoption of time-based pricing can soften the intensity of the competition to raise prices and boost retailer profits. We examine the implications of the equilibrium transition to time-based pricing on demand smoothing, consumer welfare, and social welfare.

4 Service Networks with Open Routing and Procedurally Rational Customers

Tingliang Huang[1], Andrew E. Frazelle[2], Yehua Wei[3], [1]BC, Boston, MA, [2]The University of Texas at Dallas, Richardson, TX, [3]Duke University, CHAPEL HILL, NC

We investigate the implications of procedurally rational customers on service networks where customers visit multiple stations but can choose the order in which to visit the stations. Self-interested customers populate various service systems, and these customers may not be fully rational. Customers' form of reasoning and its consequences for system performance affect the planning decisions of service providers.

Sunday, 8AM–9:15AM

SA32

CC - Room 143

Analytics of Operations Management

General Session

Session Chair

Lei Li, Purdue University, West Lafayette, IN

Session Chair

Qi Annabelle Feng, Purdue University, West Lafayette, IN

1 Assortment and Price Optimization Under MNL Model with Price Range Effect

Stefanus Jasin[1], Chengyi Lyu[2], Andrew Vakhutinsky[3], Huanan Zhang[2], [1]University of Michigan, Ann Arbor, [2]University of Colorado Boulder, Boulder, CO, [3]Oracle Labs, Burlington, Contact: huanan.zhang@colorado.edu

In this paper, we study the assortment and price optimization problems under the MNL model with price range effect, where the utility of a product is affected by the relative position of its price with respect to the highest and the lowest prices in the offer set. This model is motivated by the so-called Range Theory popularized in the behavioral economics and psychology literature. It addresses the limitation of a single-point interpretation of reference price, which ignores the impact of all other distributional information. We investigate the pure assortment problem, the pure pricing problem, and the joint assortment and pricing problem under the MNL model with price range effect. For each model, we first identify the structure of the optimal policy, and then we propose tractable algorithms that either output the optimal solution in polynomial time or admit an FPTAS.

2 Offline Personalized Pricing with Censored Demand

Zhengling Qi[1], Jingwen Tang[2], Ethan Xingyuan Fang[3], Cong Shi[2], [1]The George Washington University, Potomac, MD, [2]University of Michigan, Ann Arbor, MI, [3]Duke University, Durham, NC, Contact: xingyuan.fang@duke.edu

We study a personalized pricing problem with demand censoring in an offline data-driven setting. In this problem, a firm is endowed with a finite amount of inventory, and faces a random demand that is dependent on the offered price and the covariates (from products, customers, or both). Any unsatisfied demand that exceeds the inventory level is lost and unobservable. Our objective is to use the offline dataset to find the optimal personalized pricing rule so as to maximize the expected revenue. Through the lens of causal inference, we propose a novel data-driven algorithm that is motivated from survival analysis and doubly robust estimation. We derive a finite sample regret bound to justify the proposed offline learning algorithm and prove its robustness. Thorough numerical experiments demonstrate the value of factoring in demand censoring for personalized pricing.

3 Learning Fair Machine Learning Models with ROC Constraints by Semi-infinite Programing

Qihang Lin[1], Yao Yao[2], [1]University of Iowa, Iowa City, IA, [2]The University of Iowa, Iowa City, IA

Machine learning technologies have been increasingly used in high-stakes decision making, which raises a new challenge of avoiding unfair and discriminatory decisions for protected classes. Among various criteria of fairness, the one based on ROC curve is the strongest as it requires the model to generate the same distribution of prediction scores on the protected classes and the entire population. Using the ROC-based fairness metric as a constraint, training a fair machine learning model can be formulated as a semi-infinite program. We propose a new first-order method for this problem and establish its convergence analysis. The applications of our methods include the fairness-aware learning problems arising from health care and operations management.

4 Transfer Learning, Cross Learning, and Co-learning of Unknown Product Demands

Lei Li[1], Qi Annabelle Feng[1], George George

Shanthikumar[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, WEST LAFAYETTE, IN, Contact: li2851@purdue.edu
Making inventory decision under limited demand data can be challenge. We apply operational data analytics (ODA) framework to develop prescriptive solutions under transfer learning, cross learning and co-learning of the demands. This approach features data integration model and validation model, and demonstrates superior performance for small samples.

Sunday, 8AM–9:15AM

SA33

CC - Room 144

Closed Loop SCM

General Session

Session Chair

Paolo Letizia, University of Tennessee

1 Impact of Competitor Store Closures on a Major Retailer

M. Serkan Akturk[1], Michael Ketzenberg[2], [1]Clemson University, Clemson, SC, [2]Texas A&M University, College Station, TX, Contact: makturk@clemson.edu
We use a proprietary data set from a national US department store chain to investigate the impact of competitor store closures on a major retailer. We find that store sales increase with respect to a store's proximity to closed competitor locations. More interestingly, we find that online channel sales also increase in geographic locations where competitors close stores and where our focal retailer has store locations in close proximity to the markets it serves. This latter finding highlights the important role that stores play in the online channel. Stores provide a level of shopping assurance generally not available online and support customer webrooming and showrooming to mitigate purchase uncertainty. Stores are also integral to omnichannel services like return-to-store wherein stores provide a convenient nearby location to make a free return.

2 Input Material Reduction Incentives vs. Scrap Recycling for Closed Loop Supply Chains

Tolga Aydinliyim[1], Eren Basar Cil[2], Nagesh N. Murthy[2], [1]Baruch College, CUNY, New York, NY, [2]University of Oregon, Eugene, OR, Contact: erencil@uoregon.edu
In this paper, we consider a setting wherein a buyer procures standard-sized forgings from a supplier, and performs machining, which yields final components and significant scrap. Adopting a principal-agent framework, we investigate coordination implications while accounting for potential information asymmetry issues, and find that improved recycling may or may not mitigate decentralization cost.

3 Pricing and Returns in the Era of Big Tech: Implications of Information Asymmetry Reversal

Kiarash M. Hassani, Murray Lei, Anton Ovchinnikov, Queen's University, Kingston, ON, Canada. Contact: 18kmh4@queensu.ca
We present a model to optimize the return policy of a monopolistic seller, who may have better information about consumers' tastes than the customers themselves. We analyze how return policy, tech-enabled superior information, and return hassle cost affect the firm's profit and consumer surplus. The results show that without returns, collecting information up to the consumer's information doubles the profit compared with the case that the firm has no information, but being fully-informed brings no additional value. When costless returns are allowed, more information results in more profit, but the value of information is decreasing in salvage value, and when the firm is fully informed, it is always profitable to allow returns. Finally, in some situations, Pareto-improvement exists.

4 How Does Product Customization Affect Consumer Returns? An Empirical Analysis

Anupam Agrawal[1], Christoph Fuchs[2], Paolo Letizia[3], [1]Texas A&M University, College Station, TX, [2]University of Vienna, Vienna, Austria; [3]University of Tennessee, Knoxville, TN, Contact: pletizia@utk.edu
Product customization has been shown to reduce returns. However, there are different types of customization: horizontal, which involves the change of color or shape of a product component, vertical, which is related to the selection of a quality level for a product component, and personalization, which consists of the engraving of a text on the product. In this work, we empirically study how the different types of customization affect product returns.

Sunday, 8AM–9:15AM

SA34

CC - Room 145

Behavior in Services

General Session

Session Chair
Pnina Feldman, Boston University, Boston, MA

1 Cooperation in Heterogeneous Teams

Mouli Modak[1], Yaroslav Rosokha[2], Masha Shunko[3], [1]Chapman University, Orange, CA, [2]Purdue University, West Lafayette, IN, [3]University of Washington, Seattle, WA, Contact: modak@chapman.edu

We study a project management system in which heterogeneous tasks arrive stochastically and are processed by a team of heterogeneous workers. In particular, workers specialize in one type of task, which, in our model, translates into a lower cost of effort while processing that type of task. The effort chosen by the servers determines the payoff after the task is processed. Our paper compares the behavior of workers when the sequence of tasks are visible versus not visible.

2 Not All Lines are Skipped Equally: An Experimental Investigation of Line-sitting and Express Lines

Abdullah Althenayyan[1], Sezer Ulku[2], Shiliang Cui[2], Luyi Yang[3], [1]Columbia University, Columbia Business School, New York, NY, [2]Georgetown University, McDonough School of Business, Washington, DC, [3]University of California, Berkeley, Orinda, CA, Contact: aalthenayyan27@gsb.columbia.edu

We study how customers respond to priority in queues. In addition to express lines, the most common forms of priority schemes, we also consider line-sitting which is the practice of hiring others (line-sitters) to wait in line and has become more prevalent in a variety of contexts.

3 Evaluating Experienced and Prospective Queues: A Behavioral Investigation

Sera Linardi, Jing Luo, Leon Valdes, University of Pittsburgh, Pittsburgh, PA, Contact: lvaldes@katz.pitt.edu

Contrary to rational queuing predictions, empirical evidence suggests that waiting disutility does not decrease neatly over time. However, it remains unclear whether and how the experience of wait impacts such disutility. Similarly, how queue characteristics such as speed, length, and total waiting time affect waiting disutility remains unclear. In this paper, we conduct a controlled experiment to study, in observable queues, how do (i) the experience of wait and (ii) the characteristics of the residual queue affect the estimated cost of obtaining service. Our results show that the effect of experienced wait depends on the characteristics of both the queue and the individual. We also find that, in contrast to rational models, the length and service speed of the residual queue affect individuals' costs additively, not multiplicatively.

4 Exploring Consumer Responses to Time Limits

Pnina Feldman[1], Ella Segev[2], Michelle A. Shell[3], [1]Boston University, Boston, MA, [2]Ben-Gurion University of the Negev, Beer Sheva, Israel; [3]Boston University, Dover, MA, Contact: pninaf@bu.edu

Service providers often request that customers limit their consumption of experiential goods - particularly during periods of congestion. This research seeks to shed light on trade-offs between customer satisfaction, desired operational efficiencies, and general welfare by improving our understanding of how customers respond to voluntary time limits in discretionary service environments.

Sunday, 8AM–9:15AM

SA35

CC - Sagamore 1
Global Optimization
General Session

Session Chair
Shima Dezfulian, Northwestern University, Evanston, IL

1 An Adaptive Superfast Inexact Proximal Augmented Lagrangian Method for Smooth Nonconvex Composite Optimization Problems

Arnesh Sujanani, Renato Monteiro, Georgia Institute of Technology, Atlanta, GA, Contact: asujanani6@gatech.edu

This work presents an adaptive superfast proximal augmented Lagrangian (AS-PAL) method for solving linearly-constrained smooth nonconvex composite optimization problems. At each iteration, AS-PAL inexactly solves a possibly nonconvex proximal augmented Lagrangian subproblem with prox stepsize chosen aggressively large so as to speed up its termination. An adaptive ACG variant of FISTA, namely R-FISTA, is then used to possibly solve the above subproblem. AS-PAL then adaptively updates the prox stepsizes based off the possible failures of R-FISTA. An interesting feature of AS-PAL is that it does not require knowledge of the parameters underlying the problem. We demonstrate the speed and efficiency of our method through extensive computational experiments which show that AS-PAL can be more than 10 times faster than all the other state-of-the-art codes.

2 Equilibrium Computation of Generalized Nash Games: A New Lagrangian-based Approach

Jong Gwang Kim, Purdue university, West Lafayette, IN, Contact: kim2133@purdue.edu

This paper presents a primal-dual method, based on a new form of Lagrangian, for computing an equilibrium of generalized Nash equilibrium problem (GNEP) where each player's feasible strategy set depends on the other players' strategies. We establish the equivalence between a saddle point of the Lagrangian and an equilibrium of the GNEP. We then propose a simple algorithm that is globally convergent to the saddle point. Our method has novel features over existing approaches; it does not require any boundedness assumptions and is the first development of an algorithm to solve a general class of GNEPs in a distributed manner. Numerical experiments on test problems demonstrate the effectiveness of the proposed method.

3 An Interior Point Method for Nonlinear Optimization Problems with Noise

Shima Dezfulian, Jorge Nocedal, Andreas Waechter, Northwestern University, Evanston, IL, Contact: shimadezfulian2023@u.northwestern.edu

We propose an interior-point algorithm for solving nonlinear constrained optimization problems in which the objective and constraints values and gradients are contaminated by non-diminishing noise. We identify the key components of the classical algorithm that should be modified to achieve noise-tolerance. We establish that the iterates converge into a neighborhood of stationary points and demonstrate the efficiency of the method with numerical experiments.

Sunday, 8AM–9:15AM

SA37

CC - Sagamore 6

Robust Decision-making in Healthcare

General Session

Session Chair

Arkajyoti Roy, The University of Texas at San Antonio, San Antonio, TX

1 Equitable Anesthesiologist Scheduling Under Demand Uncertainty Using Multi-objective Programming

Kai Sun[1,2], Minghe Sun[1], Deepak Agrawal[3], Ronald Dravenstott[4], Frank Rosinia[2], Arkajyoti Roy[1], [1]The University of Texas at San Antonio, San Antonio, TX, [2]The University of Texas Health Science Center at San Antonio, San Antonio, TX, [3]American Airlines, Fort Worth, TX, [4]The University of Texas Health Science Center at San Antonio, San ANtonio, TX, Contact: kasun@syr.edu

This work addresses an anesthesiologist scheduling (AS) problem under uncertainty. The goal is to plan and deploy providers to meet clinical demand and institutional protocols. A data-driven two-step sequential AS framework is developed using a mixed-integer multi-objective program. Step 1 designs shifts to minimize excessive clinical time using conditional value-at-risk constraints to account for demand uncertainty. Step 2 assigns shifts to providers considering optimal and equitable workload distribution and the number of required providers. An ⍰-constraint solution method is applied for multi-objective optimization, and an iterative solution method is developed to improve workload equity in clinical applications. Two case studies, the budget and hiring planning and the monthly AS, are addressed in a large anesthesiology department via the AS framework.

2 Risk-averse Radiotherapy Planning to Account for Auto-segmentation Errors

Ruiqi Li[1], Justin J. Boutilier[2], Niko Papanikolaou[1], Neil Kirby[1], Arkajyoti Roy[3], [1]UT Health San Antonio, San Antonio, TX, [2]University of Wisconsin - Madison, Fitchburg, WI, [3]The University of Texas at San Antonio, San Antonio, TX

To incorporate uncertainty in deep learning (DL) based auto-segmentation models into radiotherapy planning, we propose a data-driven conditional value-at-risk (CVaR) framework. First, we apply hybrid techniques, including Monte Carlo dropout and deep ensemble to estimate uncertainty in the segmentation model. Second, we propose an optimization model that employs an expected linear-quadratic objective and multiple CVaR constraints on the predicted tumor and organ contours and the prediction uncertainties. Preliminary results on a set of clinical lung cancer patients show improvements in target dose coverage and healthy organ sparing, reducing the toxicity caused by errors in auto-segmentation models.

3 Value of Intermediate Imaging in Adaptive Robust Radiotherapy Planning to Manage Radioresistance

Arkajyoti Roy[1], Shaunak Dabadghao[2], Ahmadreza Marandi[3], [1]The University of Texas at San Antonio, San Antonio, TX, [2]Eindhoven University of Technology, Eindhoven, Netherlands; [3]Eindhoven University of Technology, Tilburg, Netherlands. Contact: arkajyoti.roy@utsa.edu

In radiotherapy, uncertainties in tumor radioresistance and its progression can degrade deterministic treatments. While a robust methodology can overcome this, it often produces overly conservative or suboptimal decisions, especially when there are changes in time. We develop an adaptive radiotherapy planning framework that reduces over-conservatism yet remains robust to uncertainties. Intermediate imaging is used to update the uncertainty at each stage. While additional imaging reduces uncertainty, it accrues costs such as extra radiation to organs, which deters continuous imaging. We probe this trade-off in uncertainty and observation cost by computing and comparing two-stage, three-stage, and four-stage robust models, as well as deterministic approaches. All models are evaluated on a clinical prostate case.

4 Optimal Interventions in Robust Optimization with Time-dependent Uncertainties

Shaunak Dabadghao[1], Arkajyoti Roy[2], Ahmadreza Marandi[3], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]The University of Texas at San Antonio, San Antonio, TX, [3]Eindhoven University of Technology, Tilburg, Netherlands.

Uncertainties can be time-dependent, particularly in areas such as cancer radiotherapy planning, where the condition of the patient can change during the course of the treatment. It is crucial to intervene and observe the condition of the system prior to adapting the decisions. But observations are costly, and the timing of observations is directly impacted by time-dependent uncertainties. We develop optimal intervention policies for robust optimization models that employ time-dependent uncertainty sets. We provide heuristic procedures to compute adaptive robust solutions from the models. We evaluate practicality of the developed results and show that they perform better than naive models. The proposed methodology is generic and can be applied to other time-dependent uncertain processes.

Sunday, 8AM–9:15AM

SA38

CC - Sagamore 7

Learning and Optimization in Dynamic Environments

General Session

Session Chair

Apurv Shukla, Columbia University, New York, NY

1 Is Separately Modeling Subpopulations Beneficial for Sequential Decision-making?

Ilbin Lee, University of Alberta, School of Business, Edmonton, AB, Canada.

In recent applications of Markov decision processes (MDPs), it is common to estimate model parameters from data. In healthcare and other applications, data are collected from different entities, such as patients. Thus, one faces the question of whether to model subpopulations separately. For instance, there may be a subpopulation whose disease status progresses faster than others, and for such a group, estimating a separate model and applying the resulting treatment plan can improve their outcomes, which aligns with the precision medicine paradigm. This work provides theoretical results and empirical methods for deciding whether to model subpopulations separately. We also present how to use our results to select the best stratification among many. We illustrate our results and methods using random instances and a medical decision-making problem from the literature.

2 Lower Bounds for Reinforcement Learning in Non-ergodic MDPs

Apurv Shukla, Columbia University, New York, NY

We derive instance-dependent lower bounds for learning average-cost criterion, non-ergodic tabular Markov Decision Processes (MDPs). The lower-bound is established in both asymptotic and non-asymptotic regimes. The results are characterized through a series of examples illustrating how structurally-different MDPs have significantly different complexity.

3 Sampling-based Safe Reinforcement Learning for Dynamic Systems

Westley Suttle[1], Krishna Kosaraju[2], Sivaranjani Seetharaman[3], Vijay Gupta[4], Ji Liu[1], [1]Stony Brook University, New York, IN, [2]Clemson University, Clemson, IN, [3]Purdue University, West Lafayette, IN, [4]Purdue university, West Lafayette, IN, Contact: gupta869@purdue.edu

Designing controllers that guarantee properties like safety and stability in complex systems when the dynamics are unknown is a challenging problem. Recent advances in control theory and reinforcement learning (RL) incorporate hard constraints on the controls proposed by RL algorithms to assure safety or stability in such systems, but lose the convergence guarantees enjoyed by classical RL and suffer increased computational burdens. In this talk, we describe a sampling-based approach to constraint satisfaction that allows us to learn RL controllers that enjoy classical convergence guarantees while maintaining desirable properties like stability, robustness, or safety of the system under disturbances. Our approach naturally integrates with the notion of control barrier functions to guarantee such properties, but applies to more general constraints as well.

Sunday, 8AM–9:15AM

SA39

CC - Room 201

Robust and Stochastic Decision Making

General Session

Session Chair

Chen Li, Singapore.

1 Robust Explainable Prescriptive Analytics

Li Chen[1], Melvyn Sim[1], Xun Zhang[2], Minglong Zhou[1], [1]National University of Singapore, Singapore, Singapore; [2]Shanghai Jiao Tong University, Shanghai, China. Contact: chen_l@u.nus.edu

We propose a new robust explainable prescriptive analytics framework that minimizes a risk-based objective function under distributional ambiguity by leveraging the data of the uncertain parameters affecting the decision model and the side information that have some predictive power on those uncertainties. The framework solves for an explainable response policy that transforms the side information directly to implementable decisions. We adopt the data-driven robust satisficing framework to address the issue of overfitting when the empirical distribution is used for evaluating the risk-based objective function. We introduce a new tractable safe approximation when the constraints are biaffine in the outcome variables and the side information. We provide a simulation study on allocating taxis to different demand regions in response to the weather information.

2 Single-scenario Facet Preservation for Stochastic Mixed-integer Programs

Aysenur Karagoz, David Mildebrath, Andrew J. Schaefer, Rice University, Houston, TX

When solving the extensive form of a two-stage stochastic mixed-integer linear program (SMIP), valid inequalities for a single-scenario polyhedron can provide significant improvements. However, it is important to assess the strength of a single-scenario valid-inequality for the extensive form. To this end, we introduce a class of two-stage SMIPs where the single-scenario facets are facet-defining for the extensive form. Particularly, we study when a SMIP preserves single-scenario facet-defining inequalities. To answer this question, we examine the matrix and recourse structures and provide examples illustrating the necessity and sufficiency relation between recourse structures and preserving single-scenario facets. We further show that under mild assumptions some matrix and recourse structures are sufficient for preserving single-scenario facets.

3 Quantum Control Pulse Optimization with Uncertain Hamiltonian Controllers

Xinyu Fei[1], Lucas Brady[2], Jeffrey Larson[3], Sven Leyffer[4], Siqian Shen[1], [1]University of Michigan, Ann Arbor, MI, [2]NASA Ames Quantum Artificial Intelligence Laboratory, Mountain View, CA, [3]Argonne National Laboratory, Argonne, IL, [4]Argonne National Laboratory, Lemont, IL, Contact: xinyuf@umich.edu

Quantum control aims to manipulate quantum systems toward desired states or operations. We consider binary optimal quantum control under uncertain Hamiltonian controllers. We propose a chance-constrained formulation to guarantee high fidelity of the control performance and solve the CVaR approximation via two approaches. One is an interpolated approximation for the non-differentiable objective function, and the other is a two-step minimization algorithm. We apply sum-up-rounding techniques to obtain binary controls and extend the model by introducing an exact penalty function to handle the additional SOS1 property. We conduct numerical studies on examples in quantum pulse optimization. The results demonstrate that (i) our algorithms can obtain high-quality control results; (ii) the CVaR model improves solution robustness under controller uncertainty.

4 Data Driven Bunker Refueling Under Price Uncertainty

Qinghe Sun[1], Ying Chen[2], Mabel Chou[1], [1]National University of Singapore, Singapore, Singapore; [2]National University of Singapore, Singapore, Singapore.

Bunker refueling decisions in international shipping are high-stake operational decisions. Each ship is analogous to a mobile storage facility rotating among different markets, procuring bunker fuels at different ports to propel itself throughout its voyage, while grappling with fluctuating bunker fuel prices over time and geographical locations. In this paper, we propose a set of data-driven structure prescriptive (SP) approaches to address this problem, marrying the strength of modern machine learning, with the structural insights obtained from traditional OR modeling and optimization.

Sunday, 8AM–9:15AM

SA40

CC - Room 202
Optimization Under Uncertainty II
Contributed Session

Session Chair
Mohsen Mohammadi, Northwestern University, Evanston, IL

1 **Efficient Algorithm for Solving Robust Counterparts of LP Problems Under Budgeted Uncertainty**
Odellia Boni, Evgeny Shindin, Harold Ship, IBM Research, Haifa, Israel. Contact: odelliab@il.ibm.com
We consider the case of an uncertain linear optimization problem subject to budgeted uncertainty, meaning the uncertain parameters are dependent. Such uncertainty occurs in many real-life scenarios. Moreover, it is used in a standard approximation of scalar chance constraints. To create a tractable robust counterpart for the case of budgeted uncertainty we need to introduce many additional variables and constraints to the original problem, which may render it too large. However, many of these are typically inactive at the optimal robust solution. We present a simplex based algorithm that finds an optimal robust solution with minimal number of additional variables and constraints.

2 ***MSPLib*: A Library of Problems for Benchmarking SDDP**
Bonn Kleiford Seranilla[1], Nils Loehndorf[2], [1]University of Luxembourg, Esch-sur-Alzette, Luxembourg; [2]University of Luxembourg, Luxembourg, Luxembourg. Contact: bonn-kleiford.seranilla@uni.lu
We present MSPLib - a library of multistage stochastic programming problems to measure the computational performance of different implementations of stochastic dual dynamic programming (SDDP). MSPLib contains various instances of large real-world problems as well as synthetic problems ranging from easy to difficult variations. We use the library to test prevailing implementations - including QUASAR, SDDP.jl, and MSPPy.

3 **A New Tool for Solving Uni-parametric Linear Programs, Convex Quadratic Programs, and Linear Complementarity Problems**
Nathan Adelgren, Princeton University, Princeton, NJ, Contact: na4592@princeton.edu
We introduce a new technique for solving uni-parametric versions of linear programs, convex quadratic programs, and linear complementarity problems in which a single parameter is permitted to be present in any of the input data. We demonstrate the use of our method on a small, motivating example and present the results of a small number of computational tests demonstrating its utility for larger scale problems.

4 **Interval Linear Programming: An Additional Function of Interest**
Mohsen Mohammadi[1], Monica Gentili[2], Milan Hladik[3], Raffaele Cerulli[4], [1]Northwestern University, Evanston, IL, [2]University of Louisville, Louisville, KY, [3]Charles University, Prague, Czech Republic; [4]University of Salerno, Fisciano, Italy.
In this talk, we consider the problem of finding the range of an additional function over the set of all possible optimal solutions of a linear program with interval right-hand sides. We show the relevance of the problem in practice, address its computational complexity, and discuss some of its theoretical properties. Moreover, we propose several heuristics to solve the problem and analyze their quality and efficiency.

Sunday, 8AM–9:15AM

SA41

CC - Room 203
OPT/Linear and Conic Optimization Flash Session
Flash Session

Session Chair
Farouk Harb, University of Illinois Urbana-Champaign (UIUC), Champaign, IL

1 **Layer VQE: A Variational Approach for Combinatorial Optimization on Noisy Quantum Computers**
Xiaoyuan Liu[1], Anthony Angone[2], Ruslan Shaydulin[3], Ilya Safro[4], Yuri Alexeev[5], Lukasz Cincio[6], [1]Fujitsu Research of America, Inc., Sunnyvale, CA, [2]Clemson University, Clemson, SC, [3]JPMorgan Chase & Co., Lemont, IL, [4]University of Delaware, Newark, DE, [5]Argonne National Lab, Chicago, IL, [6]LANL, Los Alamos, NM
Combinatorial optimization on near-term quantum devices is a promising path to demonstrating quantum advantage. In this paper, we propose an iterative Layer VQE (L-VQE) approach, inspired by the Variational Quantum Eigensolver (VQE). We evaluate quantum optimization heuristics on the

problem of detecting multiple communities in networks, for which we introduce a novel qubit-frugal formulation. We show that L-VQE is more robust to finite sampling errors and has a higher chance of finding the solution as compared with standard VQE approaches. Our simulation results show that L-VQE performs well under realistic hardware noise.

2 Polyhedral Structure of Exact Penalty Constants in Quadratic Unconstrained Binary Optimisation

Rodolfo Quintero Ospina, Lehigh University, Bethlehem, PA

In recent years, the study of Quadratic Unconstrained Binary Optimization (QUBO) problems has regained importance because it provides a unified framework to model and solve many combinatorial optimization problems (COPT); in particular, several quantum computing algorithms can be used to solve QUBO models. In this flash talk, we propose a polyhedral characterization of the penalty constants that arise when exact penalization methods are used to reformulate linear and quadratic integer programs as a QUBO problem. We obtain new general existence results and explicit constructions that allow recovering previous reformulations and techniques used in the literature.

3 Preconditioned Inexact Infeasible Quantum Interior Point Method for Linear Optimization

Zeguan Wu, Mohammadhossein Mohammadisiahroudi, Xiu Yang, Tamás Terlaky, Lehigh University, Bethlehem, PA, Contact: zew220@lehigh.edu

Quantum Interior Point Methods (QIPMs), due to its potential to solve optimization problems significantly faster, attracted significant interest recently. Generally, QIPMs use Quantum Linear System Algorithms (QLSAs) as a replacement for classical linear system solvers. However, the performance of QLSAs depend on the condition number of the linear systems arising from QIPM, which are typically $O(1/\mu^2)$. To improve conditioning, a preconditioned QIPM based on the optimal partition estimation is developed. We improve the condition number of the linear systems to be solved to $O(1/\mu)$ and improve the preconditioned QIPM's dependence on the duality gap by $O(1/\mu^{.5})$.

4 A Faster Interior-point Method for Semidefinite Programming

Swati Padmanabhan, University of Washington, Seattle, WA, Contact: pswati@uw.edu

Semidefinite programs (SDPs) are a fundamental class of optimization problems with important recent applications in approximation algorithms, quantum complexity, robust learning, algorithmic rounding, and adversarial deep learning. This paper presents a faster interior point method to solve generic SDPs with variable size n x n and m constraints in time $O(\sqrt{n}\cdot (mn^2 + m^\omega + n^\omega) \cdot \log (1/\epsilon))$, where ω is the exponent of matrix multiplication and ϵ is the relative accuracy. In the predominant case of m≥n, our runtime outperforms that of the previous fastest SDP solver, which is based on a cutting plane method.

5 Cost Optimization of Smart Manufacturing Systems by Charging and Discharging Scheduling of Electric Trucks

Lata Pandurang Karmali[1], Nasim Nezamoddini[2], Amirhosein Gholami[3], [1]Oakland University, Rochester, MI, [2]Oakland University, Rochester, MI, [3]NULL, Binghamton, NY, Contact: lkarmali@oakland.edu

Majority of supply chains in any manufacturing industry relies on heavy trucks for transportation that leads to greenhouse gas emissions and cost fluctuation. Electric vehicles are a key component in transportation to reduce these challenges. This paper proposes a deterministic model that optimizes cost in manufacturing plants while reducing emissions caused by their transportation systems. This is enabled by utilizing electric trucks and scheduling of their charging and discharging activities in a smart manufacturing. The results show that the proposed framework not only supports penetration of renewable energy resources in manufacturing, but also saves transportation costs.

6 PAC Reinforcement Learning for Predictive State Representations

Wenhao Zhan, Princeton University, Princeton, NJ

In this paper we study online Reinforcement Learning (RL) in partially observable dynamical systems. We focus on the Predictive State Representations (PSRs) model, which is an expressive model that captures other well-known models such as Partially Observable Markov Decision Processes (POMDP). PSR represents the states using a set of predictions of future observations and is defined entirely using observable quantities. We develop a novel model-based algorithm for PSRs that can learn a near optimal policy in sample complexity scaling polynomially with respect to all the relevant parameters of the systems. Our algorithm naturally works with function approximation to extend to systems with potentially large state and observation spaces. We show that given a realizable model class, the sample complexity of learning the near optimal policy only scales polynomially with respect to the statistical complexity of the model class, without any explicit polynomial dependence on the size of the state and observation spaces. Notably, our work is the first work that shows polynomial sample complexities to compete with the globally optimal policy in PSRs. Finally, we demonstrate how our general theorem can be directly used to derive sample complexity bounds for special models including m-step weakly revealing and m-step decodable tabular POMDPs, POMDPs with low-rank latent transition, and POMDPs with linear emission and latent transition.

7 Stochastic Inverse Optimization

John R. Birge[1], Xiaocheng Li[2], Chunlin Sun[3], [1]University of Chicago, Chicago, IL, [2]Imperial College Business School, London, United Kingdom; [3]Stanford University, Stanford, CA, Contact: xiaocheng.li@imperial.ac.uk

The inverse linear optimization considers the problem of inferring the objective coefficient of a linear program through the observation(s) of the constraints and the optimal solution. We consider a stochastic setting where the objective coefficient follows some unknown distribution and the goal becomes to infer the distribution from observations of constraints and the optimal solution. We consider two settings for the stochastic inverse optimization: a Gaussian setting where the objective coefficient follows von Mises-Fisher distribution, and a delta-corruption setting where the objective coefficient distribution concentrates on one vector with high probability and is arbitrarily corrupted otherwise. We devise Bayesian algorithms for parameter estimation and develop theoretical guarantees for the recovery of the true parameter.

8 Scalable Algorithms for Densest Subgraph

Farouk Harb, University of Illinois at Urbana Champaign, Champaign, IL, Contact: eyfmharb@gmail.com

In this talk, we'll briefly recap some recent results on the densest subgraph problem for large scale graphs. The problem has a classical max-flow reduction and an LP. However, for large scale graphs, simple iterative algorithms perform much better in practice than theoretically fast algorithms based on network-flow or LP solvers. We will reference some of the iterative algorithms available like Greedy++, the Frank-Wolfe-based algorithm, and quickly introduce our new scalable iterative algorithm.

Sunday, 8AM–9:15AM

SA42

CC - Room 204

Advanced Capabilities in Algebraic Modeling Languages

General Session

Session Chair

Carl Laird, Carnegie Mellon University, Fayetteville, AR

Session Chair

Joshua Pulsipher, Carnegie Mellon University, Pittsburgh, PA

1 Pyros: A Generalized Robust Cutting-Set Algorithm for Nonlinear Two-Stage Adjustable Robust Optimization

Jason Sherman[1], Natalie Isenberg[2], John Siirola[3], Carl Laird[4], Chrysanthos Gounaris[5], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Brookhaven National Laboratory, Upton, NY, [3]Sandia National Laboratories, Albuquerque, NM, [4]Carnegie Mellon University, Pittsburgh, PA, [5]Carnegie Mellon University, Pittsburgh, PA, Contact: jasherma@andrew.cmu.edu

We present PyROS, a Python-based meta-solver for nonlinear, nonconvex two-stage adjustable robust optimization problems. Based on a generalized robust cutting-set algorithm, PyROS may be accessed through the open-source algebraic modeling language Pyomo. PyROS supports recourse decisions via various types of decision rules, and user-defined or a multitude of pre-implemented uncertainty set classes. We report latest advances in the implementation of PyROS and computational results for a two-stage optimal power flow problem—with uncertain renewable energy generation capacities—to demonstrate the utility of PyROS for systems of practical relevance.

2 Performance Evaluation of Algebraic Modeling Languages Under Practical use Cases

Merve Merakli[1], Carl Laird[2], Kevin C. Furman[3], Bashar L. Ammari[4], Sai Kompali[4], Yufeng Qian[4], [1]ExxonMobil, Spring, TX, [2]Carnegie Mellon University, Fayetteville, AR, [3]ExxonMobil, Houston, TX, [4]Carnegie Mellon University, Pittsburgh, PA

Increased interest in high level algebraic modeling languages (AMLs) has resulted in extensible open-source tools. However, this extensibility and implementation in high-level languages can raise performance concerns. While AML performance comparisons exist in the literature, most of the work does not address common meta-algorithmic use cases - for example, repeated resolves with different parameter values, cut additions, and sub-model solves frequently utilized in matheuristics and exact solution algorithms. In this presentation, we compare the performance of several AMLs under common use cases with large-scale problems. The case studies selected for comparison include, for example, a maritime inventory routing problem, a modified facility location problem, a linear-quadratic control problem, and optimization of trained neural networks.

3 Pyomo.doe: An Open-source Package for Model-based Design of Experiments in Python

Jialu Wang[1], Alexander Dowling[2], [1]Notre Dame University, Notre Dame, IN, [2]University of Notre Dame, Notre Dame, IN, Contact: jwang44@nd.edu

Selecting, calibrating, and validating predictive science-based models often remain an art in practice. Model-based design of experiments (MBDoE) leverages science-based models to maximize information gain from experiments while minimizing time and resource costs. We introduce Pyomo. DOE, an open-source package for MBDoE. Pyomo.DOE uses a nonlinear sensitivity analysis code k_aug to quickly approximate the Fisher information matrix, improving the computational time by more than one order of magnitude. In addition, Pyomo.DOE leverages a new two-stage stochastic program to facilitate the gradient-based optimization framework. Two case studies show how MBDoE formalism quickly identifies model identifiability challenges, and the power of Pyomo.DOE to estimate the value of experimental modifications a priori for large-scale partial PDAE models.

4 PAO: A Python Library for Adversarial Optimization

William E. Hart, Sandia National Laboratories, Berlin, MA

We describe PAO, a Python-based package for Adversarial Optimization. The goal of PAO is to provide a general modeling and analysis capability for bilevel, trilevel and other multilevel optimization forms that express adversarial dynamics. PAO integrates two different modeling abstractions. First, PAO algebraic models extend the modeling concepts in the Pyomo algebraic modeling language to express problems with an intuitive algebraic syntax. Second, PAO compact models express objective and constraints in a manner that is typically used to express the mathematical form of these problems (e.g. using vector and matrix data types). PAO defines custom Multilevel Problem Representations (MPRs) that simplify the implementation of solvers for bilevel, trilevel and other multilevel optimization problems.

Sunday, 8AM–9:15AM

SA43

CC - Room 205

Methods for Large Scale, Nonlinear and Stochastic Optimization

General Session

Session Chair

Albert Solomon Berahas, University of Michigan, Ann Arbor, MI

Session Chair

Raghu Bollapragada, The University of Texas at Austin, Austin, TX

1 High Probability Iteration and Sample Complexity Bounds for Adaptive Optimization Algorithms via Stochastic Oracles

Billy Jin, Katya Scheinberg, Miaolan Xie, Cornell University, Ithaca, NY, Contact: mx229@cornell.edu

We consider an adaptive step-size algorithm for continuous optimization under a stochastic setting where the function values and gradients are available only through inexact probabilistic zeroth and first-order oracles. Unlike the stochastic gradient method and its many variants, the algorithm does not use a pre-specified sequence of step sizes but adjusts the step size adaptively according to the estimated progress. The probabilistic oracles capture standard settings including expected loss minimization and zeroth-order optimization. Moreover, our framework allows the function and gradient estimates to be biased. The proposed algorithm is simple to describe, easy to implement and is close in spirit to standard line search. Under reasonable conditions on the oracles, we derive high probability tail bounds on the iteration and sample complexity of the algorithm.

2 Global Convergence of Sub-gradient Method for Low-rank Matrix Factorization

Jianhao Ma, Salar Fattahi, University of Michigan, Ann Arbor, MI, Contact: fattahi@umich.edu

We study the performance of sub-gradient method (SubGM) on a nonconvex formulation of low-rank matrix recovery, where the goal is to recover a low-rank matrix from a limited number of measurements, a subset of which may be grossly corrupted with noise. We study a scenario where the rank of the true solution is unknown and over-parameterized instead. Such over-parameterization may lead to overfitting, or adversely affect the performance of the algorithm. We prove that SubGM with small initialization is agnostic to both over-parameterization and noise in the measurements. In particular, we show that small initialization nullifies the effect of over-parameterization on the performance

of SubGM, leading to an exponential improvement in its convergence rate, even under arbitrarily large and arbitrarily dense noise values.

3 SQP Methods for Inequality Constrained Stochastic Optimization

Baoyu Zhou[1], Frank E. Curtis[2], Daniel Robinson[1], [1]Lehigh University, Bethlehem, PA, [2]lehigh university, Bethlehem, PA

We introduce an algorithm for minimizing a stochastic objective function subject to deterministic nonlinear equality and inequality constraints. Such problems arise in various important applications including machine learning and data science. Under common assumptions, we prove the convergence in expectation from remote starting points for the proposed algorithm. The results of numerical experiments demonstrate the practical performance of our proposed method.

4 Adaptable Businesses: A Mixed Integer Approach for Modeling the Food Service Sectors' Resilience Tactics in Face of Disruptions

Grace Jia[1], Xiangyang Guan[2], Chaoyue Zhao[3], Cynthia Chen[3], [1]UNIVERSITY OF WASHINGTON, SEATTLE, WA, [2]University of Washington, Seattle, WA, [3]UNIVERSITY OF WASHINGTON, Seattle, WA, Contact: gracejia@uw.edu

The food services sector, i.e., restaurants, grocery stores, and convenience stores, brings the community together, participates in economic activities, and satisfies human needs. As COVID-19 shows, food-related businesses are vulnerable to disruptions such as labor shock, supply shock, demand shock, infrastructure damage, regulations, etc. This work develops a mixed-integer nonlinear programming model with scenario designs to study how the businesses adapt to different disruptions, identify bottlenecks in current operations, and develop adaptation strategies.

Sunday, 8AM–9:15AM

SA44

CC - Room 206

Nonconvex Constrained Optimization

General Session

Session Chair

Andy Sun, MIT, Catonsville, MD

Session Chair

Jiawei Zhang, MIT, Cambridge, MA

1 Dual Descent ALm and ADMM

Kaizhao Sun[1], Andy Sun[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]MIT, Catonsville, MD, Contact: ksun46@gatech.edu

We investigate a new class of dual updates within the augmented Lagrangian framework, where the key feature is to reverse the update direction in the traditional dual ascent. When the dual variable is further scaled by a fractional number, we name the resulting scheme scaled dual descent (SDD), and otherwise, unscaled dual descent (UDD). We propose SDD-ADMM for nonlinear equality-constrained multi-block problems, and contribute to the literature by establishing O(□$^{-4}$), O(□$^{-3}$), and O(□$^{-2}$) *first-order* iteration complexities for SDD-ADMM under different assumptions. We also propose UDD-ALM for weakly convex minimization over affine constraints, which complements the best-known results for the class of problems considered.

2 Global Complexity Bound of a Proximal ADMm for Linearly-Constrained Non-Separable Nonconvex Composite Programming

Weiwei Kong, U.T. Battelle, LLC (ORNL), Oak Ridge, TN, Contact: wwkong92@gmail.com

In this talk, we present a dampened proximal alternating direction method of multipliers (DP.ADMM) for solving linearly-constrained nonconvex optimization problems where the smooth part of the objective function is nonseparable. Each iteration of DP.ADMM consists of: (ii) a sequence of partial proximal augmented Lagrangian (AL) updates, (ii) an under-relaxed Lagrange multiplier update, and (iii) a novel test to check whether the penalty parameter of the AL function should be updated. Under some mild regularity conditions, we describe how DP.ADMM obtains a first-order stationary point of the constrained problem in O(□^{-3}) iterations for a given numerical tolerance □>0. One of the main novelties of the method is that the convergence of the method is obtained without requiring any rank assumptions on the constraint matrices.

3 Proximal-primal-dual Algorithms for Nonconvex Optimization Problems

Jiawei Zhang[1], Zhi-quan Luo[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Shenzhen Research Institute of Big Data, The Chinese University of Hong Kong, Shenzhen, China. Contact: jwzhang@mit.edu

In this talk, we first answer the open problem of how to design an algorithm achieving the benchmark iteration complexity *O*(1/□^{2}) for constrained nonconvex problems with linear equality constraints and convex inequality constraints. To this aim, we propose a smoothed proximal augmented Lagrangian method and its multi-block version. Using a proximal-primal-dual framework and some novel error bounds, we prove that our algorithm can converge with an $O(1/\square^2)$ iteration complexity for the problems with polyhedral constraints and compact, convex constraints. In addition, we introduce the extension of our algorithm to distributed optimization and minimax problems, achieving the $O(1/\square^2)$ iteration complexity for decentralized training over distributed samples and features and robust optimization.

4 Low-order Methods for Nonlinear Constrained Nonconvex Optimization

Yangyang Xu, Rensselaer Polytechnic Institute, Troy, NY

Many applications involve nonlinear functional constraints that prohibit easy projections. These problems are often high dimensional. Traditional methods such as the Newton's method are usually too expensive. In this talk, I will present low-order optimization methods. For applications where function values and first-order derivatives are accessible, we propose first-order methods; for problems where only function values are available, we propose zeroth-order methods. Oracle complexity results will be shown under certain regularity conditions. Numerical results will also be shown on solving classical optimization problems and machine learning problems.

Sunday, 8AM–9:15AM

SA45

CC - Room 207

Topics in Sequential Models Under Uncertainty

General Session

Session Chair

Sebastian Perez Salazar, Georgia Institute of Technology, Atlanta, GA

1 Tightness Without Counterexamples: A New Approach and New Results for Prophet Inequalities

Jiashuo Jiang[1], Will Ma[2], Jiawei Zhang[3], [1]New York Uniersity, New York, NY, [2]Columbia University, New York, NY, [3]New York University, New York, NY, Contact: jzhang@stern.nyu.edu

Prophet inequalities consist of many beautiful statements that establish tight performance ratios between online and offline allocation algorithms. Typically, tightness is established by constructing an algorithmic guarantee and a worst-case instance separately, whose bounds match as a result of some "ingenuity". In this paper, we instead formulate the construction of the worst-case instance as an optimization problem, which directly finds the tight ratio without needing to construct two bounds separately. Through this analysis, our paper provides a unified framework that derives new results and recovers many existing ones. For example, we show that the "oblivious" method of setting a static threshold due to Chawla, Devanur, and Lykouris (2021) is, surprisingly, best-possible among all static threshold algorithms, for any number k of starting units.

2 Icu Management with Proactive Patient Transfer

Chia-Hao Chang, Vineet Goyal, Columbia University, New York, NY, Contact: cc4626@columbia.edu

Managing patient flow in hospitals has always been a crucial subject for hospital operation. In hospitals, regular patients stay in wards whereas severely ill ones are treated in the Intensive Care Units (ICUs). However, recent evidence from machine learning shows that proactive patient transfer to the ICU may increase overall patients' well-being. Due to the scarcity of ICUs and uncertainties of patient dynamics, nonetheless, effective management of the ICUs is paramount. In this work, we consider a discrete-time Markov model where a central planner decides the number of patients to be proactively transferred. We propose a state-dependent threshold policy and compare it with other heuristics by several numerical simulations.

3 Non-Adaptive Stochastic Score Classification

Rohan Ghuge[1], Anupam Gupta[2], Viswanath Nagarajan[3], [1]University of Michigan, Ann Arbor, MI, [2]Carnegie Mellon University, Pittsburgh, PA, [3]University of Michigan, Ann Arbor, MI

In the stochastic score classification problem, there are several binary tests, where each test i is associated with a probability p_i of being positive and a cost c_i. The score of an outcome is a weighted sum of all positive tests, and the range of possible scores is partitioned into intervals corresponding to different classes. The goal is to perform tests sequentially so as to identify the class at the minimum expected cost. We provide the first constant-factor approximation algorithm for this problem, improving over a previous logarithmic approximation ratio. Moreover, our algorithm is non adaptive: it just involves performing tests in a fixed order until the class is identified. We also perform computational experiments on random instances, and observe that the cost of our algorithm is typically within 50% of an information-theoretic lower bound on the optimal value.

4 **Online Resource Allocation for Electric Vehicle Battery Swapping Service**

Ziyang Liu, Rajan Udwani, UC Berkeley, Berkeley, CA, Contact: ziyang_liu@berkeley.edu

We study the online decision making in electric vehicle battery swapping service. When adversarial customers arrive at the service facility sequentially, the facility determines whether to provide a battery for swapping to save customer's time or provide the regular charging service. Moreover, the matching eligibility depends on both the battery resources and the customers. We propose novel algorithms that address the heterogeneity of battery resources and the uncertainty in future arrivals.

Sunday, 8AM–9:15AM

SA46

CC - Room 208

Transportation-enabled Services

General Session

Session Chair

Hai Wang, Singapore Management University, Singapore, Singapore.

Session Chair

Hao Hao, Carnegie Mellon University, Pittsburgh, PA

1 **Commuting Service Platform: Concept and Analysis**

Xuegang Ban, University of Washington, Seattle, WA

Platform (app)-based ride-hailing services have recently transformed urban mobility by connecting drivers (supply) directly with travelers (demand). For commuting to work or school, however, individual travelers' travel decision making can be heavily influenced by employers or work places. In this talk, we propose the commuting service platform (CSP) to serve urban commuting, which also connects commuters and their employers, thus revealing their interactions when commuting decisions are concerned. We present CSP as a two-sided market, its conceptual service modes, and the analysis methods. We also model the impact of the locations of homes and worksites to the analysis of CSP, and summarize major factors that may impact the performance of a CSP.

2 **Optimization of Customer Service Area and Driver Dispatch Area for On-demand Food Delivery Services**

Jingfeng Yang, Singapore Management University, Singapore.

Recently, on-demand food delivery platforms have connect drivers, restaurants, and customers in real time and are drastically changing food delivery services. In this paper, we focus on the area size optimization problem, in which the platform dynamically coordinates the balance between supply and demand by adjusting the radius of its customer service and driver dispatch areas. Leveraging a real dataset from a food delivery platform, we propose a data-driven optimization framework that combines machine learning methods for order delivery time estimation and mathematical programming for the optimization of the two areas at the same time. The objective is to maximize the total number of orders served with minimal impact on the average order delivery time. Experiments using real-world data show that our framework outperforms several benchmarks in current practice.

3 **Prescriptive Analytics for Wildfire Suppression**

Jacob Wachspress[1], Alexandre Jacquillat[2], [1]Operations Research Center, MIT, Cambridge, MA, [2]MIT Sloan School of Management, Cambridge, MA, Contact: jacobwac@mit.edu

We propose an optimization approach to support wildfire suppression operations. The model brings together prioritization and routing decisions to minimize future fire damage as well as crew assignment costs. Accordingly, the model is formalized via a double set partitioning formulation over time-space networks, with linking constraints ensuring that crew supply meets wildfire suppression demand. To solve it, we develop a double column generation algorithm with tailored stabilization strategies. Our algorithm can scale to realistic instances faced in practice, and can thus guide wildfire suppression efforts at the regional and national levels. Results show that out optimization approach can outperform several benchmarks—in particular, they show the benefits of integrating the endogeneity of wildfire growth and crew assignments decisions.

4 **Multimodal Transportation Alliance Design with Endogenous Demand: Large-scale Optimization for Rapid Gains**

Kayla Spring Cummings[1], Vikrant Vaze[2], Ozlem Ergun[3], Cynthia Barnhart[4], [1]Massachusetts Institute of Technology, Allston, MA, [2]Dartmouth College, Hanover, NH, [3]Northeastern University, Boston, MA, [4]Massachusetts Institute of Technology, Cambridge, MA, Contact: vikrant.s.vaze@dartmouth.edu

We design a prescriptive pricing alliance to power collaborations between fixed-route transit agencies and on-demand mobility providers. We formulate a fare-setting model to jointly optimize discounted fares across both networks under endogenous traveler route choice resulting in a large-scale, non-convex, mixed integer program. We develop a new solution heuristic combining tailored coordinate descent, parsimonious anchor point selection, and non-convex piecewise linear interpolation. Computationally, our approach significantly outperforms state-of-the-art benchmarks. Practically, our pricing alliance improves outcomes over non-cooperative counterfactuals from both operators' self-interested perspectives while also improving system utilization and lowering prices for low-income residents and long-distance commuters.

Sunday, 8AM–9:15AM

SA47

CC - Room 209
RAS Student Paper Competition
Award Session

Session Chair
Stefano Rieppi, Norfolk Southern Railway, Roswell, GA

Session Chair
Andrea D'Ariano, Universita degli Studi Roma Tre, University Park

1 **Award Presenter**
Stefano Rieppi, Norfolk Southern Railway, GA

UNREGISTERED Award Presenter
Andrea D'Ariano, Universita degli Studi Roma Tre, University Park

Sunday, 8AM–9:15AM

SA48

CC - Room 210
Facility Management in the Era of eCommerce and Analytics
General Session

Session Chair
Amir Gharehgozli, California State University Northridge, Northridge, CA

1 **A Simulation Model for the Railcar Retrieval Problem**
Atefe Sedaghat[1], Amir Gharehgozli[2], Maryam Hamidi[3], Roger William Baugher[4], [1]Lamar University, Beaumont, TX, [2]California State University Northridge, Northridge, CA, [3]Lamar University, Beaumont, TX, [4]TrAnalytics, LLC, Johns Creek, GA, Contact: asedaghat@lamar.edu
This paper develops an AnyLogic simulation model to study the railcar retrieval problem (RRT) that focuses on retrieving the railcars required for the next train. The railcars are stored in several tracks and retrieving some of them needs reshuffling. The objective function is to minimize the total time and the performances of different policies are evaluated using a real-world case study.

2 **How Blockchain and Uber Freight Services Can Help Disrupted Logistics Network**
Lanqing Du[1], Jinwook Lee[2], [1]Drexel University, Philadelphia, PA, [2]Drexel University, Philadelphia, PA, Contact: ld695@drexel.edu
Since COVID, labor shortages have substantially influenced conventional transportation and supply chain management activities. When faced with interruption and its associated ripple impact, third-party logistics (3PL) services are critical logistical fulfillment options. And blockchain-enabled information transparency will aid in the development of information resilience. In this research, we investigate related decision-making problems in a disrupted logistics network, where nodes represent facilities with varying degrees of disruption and edges indicate a shipment volume between two nodes. Key findings from numerical experiments on real-world data will be presented.

Sunday, 8AM–9:15AM

SA49

CC - Room 211
Transportation Logistics for Social Good
General Session

Session Chair
Sara Reed, University of Kansas, Lawrence, KS

1 **The Dynamic Pickup and Allocation with Fairness Problem**
Gal Neria, Michal Tzur, Tel Aviv University, Tel Aviv, Israel.

We consider the problem of determining a vehicle route that visits pickup points (PPs), from which the vehicle collects supplies, and demand points (DPs) to which these supplies are delivered. The supply quantities at the PPs are uncertain, and the information on their value arrives gradually over time. We model it as a stochastic dynamic routing and resource allocation problem, with the aim of delivering as many goods as possible while obtaining equitable allocations to the DPs. We present a Markov decision process formulation, however, it suffers from the curse of dimensionality. Therefore, we develop a solution framework that presents a novel combination of operations research and machine learning. A numerical experiment with 11 to 100 site instances, based on data from the Berlin Foodbank and random datasets, confirms that our solution method performs very well.

2 Diversion and Treatment Policies for Opioid use Disorder: A Discrete Event Simulation Approach

Veronica M. White[1], Laura Albert[2], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Middleton, WI, Contact: vmwhite@wisc.edu

The opioid crisis has led to a rapid increase of opioid-related deaths, overdoses, and arrests, that have strained many organizations, systems, and personnel in hospitals, treatment facilities, and police departments. We introduce a discrete event simulation to evaluate various intervention policies to estimate a community's opioid-related outcomes over time by modeling opioid users' pathways. We use public and community-sourced data to populate the case study based in Dane County, Wisconsin. We then compare our case study's simulated outcomes of implementing various community interventions. The analysis sheds light on the combination of policies that has the best potential to lower opioid-related deaths, overdoses, and arrests.

3 Revisiting School District Design: A Stream-based Approach

Aysu Ozel[1], Karen Smilowitz[2], Lila K. S. Goldstein[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: aysuozel@u.northwestern.edu

We revisit the school districting problem, introducing a new stream-based approach that can incorporate multiple assignment decisions simultaneously. In particular, the students in small geographic units are assigned to a set of schools (e.g., elementary, middle, high school, specialized education programs) with a single composite variable. This leads to a compact optimization model that considers metrics such as transportation cost and equitable access while meeting community-driven needs. The formulation builds on decades of advancements in such models, while allowing flexibility to adapt to local conditions. We present a case study from a partnership with a community redesigning student assignment to address historic inequities.

Sunday, 8AM–9:30AM

SA50

CC - Room 212

Societal and Welfare Impacts of Information Systems

General Session

Session Chair

Abhishek Ray, George Mason University, West Lafayette

1 The Advertising Big Picture: Analyzing The Cross-platform Synergies Between Tv and Online Advertising

Ilango Guru Muniasamy[1], Mohammed Alyakoob[2], Hossein Ghasemkhani[1], [1]Purdue University, West Lafayette, IN, [2]University of Southern California, New York, CA, Contact: igurumun@purdue.edu

We study the interaction effects between TV advertising and online advertising in driving consumers' decisions to make online purchases. We match a rich dataset of an automobile company's online advertising and activities of users on the company's website, with a granular dataset of TV ad spending by the company and its competitors in the users' geographical locations. Our findings suggest that TV advertisements amplify the probability of an online purchase by users who are exposed to online advertisements of the company.

2 Brand Mentions and News Engagement: An Empirical Investigation of The Roles of News Format and Narrativity

Debashish Ghose[1], Susan Mudambi[1], Subodha Kumar[2], [1]Temple University, Philadelphia, PA, [2]Fox School of Business, Temple University, Philadelphia, PA, Contact: dghose@temple.edu

Social media continues to grow into a major provider of news but competition for user attention is intense, encouraging the use of attractive headlines. News editors need to carefully choose which brands to feature and how to talk about them. We investigate the roles of brand mentions, news format (traditional or satirical), and news narrativity in garnering engagement. Endogeneity corrected analyses of a curated dataset comprised of 50k traditional and satirical stories that originated from the same newsroom reveal that while brand mentions in headlines do encourage engagement, human brand mentions have a stronger effect than product brands. This effect is stronger for satirical news than traditional news. Narrative structures of staging, plot progression, and cognitive tension encourage engagement for satirical news but not traditional news.

3 Does Pre-login Search Matter? Evidence from a Mobile Commerce Platform

Jordan He[1], Luna Zhang[2], David Zhang[1], Yuliang Yao[1], [1]Lehigh University, Bethlehem, PA, [2]University of Washington Tacoma, Tacoma, WA, Contact: qih320@lehigh.edu

An increasing number of consumers enjoy shopping in mobile commerce. When consumers use a mobile app, they can choose whether to log in with their accounts or not. In this paper, we argue that pre-login search can play a critical role in affecting consumers' purchase decisions, although it has largely been overlooked in the Information Systems literature. Using clickstream data, we examine whether and how pre-login search effort affects the likelihood of purchase. Our results show that pre-login search behaviors are as important as post-login search behaviors to consumers' purchase decisions. We also demonstrate that consumers purchase probability increases at a diminishing rate with an increasing search effort during both pre- and post-login periods.

Sunday, 8AM–9:15AM

SA51

M - Santa Fe

George Nicholson Student Paper Competition I

Award Session

Session Chair

Jing Dong, Columbia University, New York, NY

Session Chair

Paul Grigas, UC Berkeley, Berkeley, CA

Testing Network Correlation Efficiently via Counting Trees

Sophie Yu, Duke University, Durham, NC

We propose a new procedurefor testing whether two networks are edge-correlated through some latent vertexcorrespondence. The test statistic is based on counting the co-occurrences ofsigned trees for a family of non-isomorphic trees. Our algorithms significantlyimprove the prior work in terms of statistical accuracy, running time, andgraph sparsity.

Tight Guarantees for Multi-unit Prophet Inequalities and Online Stochastic Knapsack

Jiashuo Jiang, Hong Kong University of Science and Technology, Hong Kong.

Prophet inequalities are a useful tool for designing online allocation procedures, with widespread adoption in mechanism design and general online allocation problems in online advertising, healthcare scheduling, and revenue management. In this paper, we characterize the optimal procedure to obtain tight LP bounds and consequently improve the best-known guarantee for k-unit prophet inequalities for all k>1. We also consider the more general online stochastic knapsack problem. We introduce a new ``best-fit'' procedure with an improved guarantee which we also show is tight over LP upper bound.

The Fragility of Optimized Bandit Algorithms

Lin Fan, Stanford University, Stanford, CA

Much of the literature on optimal design of bandit algorithms is based on minimization of expected regret. It is well known that designs that are optimal over certain exponential families can achieve expected regret that grows logarithmically in the number of arm plays, at a rate governed by the Lai-Robbins lower bound. We show that when one uses such optimized designs, the regret distribution necessarily has a very heavy tail, specifically, that of a truncated Cauchy distribution. This makes such designs highly fragile from a statistical viewpoint, the consequences of which we explore.

Sunday, 8AM–9:15AM

SA52

M - Lincoln

Case Competition

Award Session

Session Chair

Stefan Creemers, Catholic University Leuven, Lille, France.

Digitizing Spare Parts Supply Chain via 3D Printing - An Operational Cost Analysis

Yue Zhang[1], William McCall[2], Jing-Sheng Jeannette Song[3], [1]Pennsylvania State University, University Park, PA, [2]Xerox, Chapel Hill, NC, [3]Duke University, Durham, NC

The case includes a sourcing problem and a manufacturing problem for an original equipment manufacturer, demanding sourcing recommendations for a variety of parts used in high voltage equipment, and decisions on the manufacturing strategy for a part used in a water monitoring system. The case promotes qualitative and quantitative understanding of 3D printing vs. traditional manufacturing via the lens of operational cost. It can be used for discussing the impact of 3D printing on supply chains, and for graduate/undergraduate course to introduce make-to-stock/order, queueing, lifecycle analysis.

Moneyball for Murderball: Using Analytics to Construct Lineups in Wheelchair Rugby

Craig Fernandes[1], Timothy Chan[1], Albert Loa[1], Nathan Sandholtz[2], [1]University of Toronto, Toronto, ON, Canada; [2]Brigham Young University, Provo, UT

This case follows a new assistant coach of Canada's national wheelchair rugby team who is tasked with optimizing their lineups using descriptive (data analysis), predictive (regression) and prescriptive (optimization) techniques. It was developed from discussions with the national team coach and sport scientists. Students build proficiency in developing an end-to-end solution approach using appropriate software for a complex real-world problem. This case can be utilized in both OR and statistics courses, with material that covers both introductory and advanced modeling topics.

To Catch a Thief: Explainable AI in Insurance Fraud Detection

Antoine Desir[1], Ville Satopaa[1], Eric Sibony[2], Laura Heely[3], [1]INSEAD, Fontainebleau, France; [2]Shift Technology, Paris, France; [3]Atypical Partner, London, United Kingdom.

This case introduces the concept of explainable artificial intelligence through the lens of InsurTech unicorn Shift. Students are asked to take the position of a senior operations professional, whose algorithm is used by leading global insurers such as Generali France and Mitsui Sumitomo to fight fraudulent claims. The case focuses on company-level strategic decisions and algorithm-level decisions. With an anonymized dataset of more than 10,000 claims and a guided coding exercise in statistical computing softwares R and Python, students are able to backtest their strategies on historical data.

Elections Management: Exploring the Complexity of Polling Place Consolidation

Adam Schmidt, UW-Madison, Madison, WI

Every election, officials plan for unpredictable election conditions, which requires inter-related decisions. This case has students study the impact of polling place consolidation on voter participation, equity, and cost effectiveness by predicting the performance of polling places using a mathematical queueing model. The case will improve students ability to study queueing systems and assess decisions from the viewpoint of multiple stakeholders. The case is presented in three parts and is to be completed by small student groups coupled with larger group discussions over one course period.

Sunday, 8AM–9:15AM

SA53

M - Denver

Empirical Research in Operations Management

General Session

Session Chair

Kejia Hu, Vanderbilt University, Nashville, TN

Session Chair

Simin Li, Tulane University

1 Going The Distance: The Impact of Commute on Gender Diversity in Public Service Positions

Dawson Kaaua[1], Vanitha Virudachalam[2], [1]Georgetown University, Washington, DC, [2]Gies College of Business, UIUC, Champaign, IL, Contact: dawson.kaaua@georgetown.edu

Women have been shown to prefer jobs with a better work-life balance across many fields. Given that serving as a state political representative requires a significant amount of travel between one's home district and the state capitol, this suggests that long commute times may reduce the number of women that seek political office in the United States. We investigate whether this is true and, if so, potential policies to mitigate this effect.

2 A Data-driven Approach to Routing Images in a Virtual Radiology Network

Vijay Mehrotra[1], Shivani Shukla[1], Theo Mefford[2], [1]University of San Francisco, San Francisco, CA, [2]University of San Francisco, San Francisco, CA, Contact: vmehrotra@usfca.edu

In a virtual radiology network, images are captured in many different medical facilities and then routed to radiologists in a variety of remote locations. From an operations management perspective, there are two primary factors that make the design and control of such networks challenging. First of all, there are typically several hundred unique types of images and several hundred different radiologists, each of whom is eligible to handle a unique subset of image types. Secondly, images can be queued to multiple radiologists in parallel even though it will ultimately be handled by the first radiologist who begins working on it. In this paper, we propose logic to route images to radiologists to optimize system performance, and demonstrate how our method outperforms current practices.

3 The Psychology of Virtual Queue: When Waiting Feels Less like Waiting

Kejia Hu[1], Xun Xu[2], Ao Qu[3], [1]Vanderbilt University, Nashville, TN, [2]California State University, Dominguez Hills, Carson, CA, [3]Massachusetts Institute of Technology, Cambridge, MA

In this study, we examine the impact of the practice of virtual queue (VQ) on customer complaints and satisfaction via empirical evidence from 0.72 million online customer reviews of U.S. major casual-dining chain restaurants. Using difference-in-difference regressions facilitated by propensity score matching, we find that VQ significantly reduces customers' complaints about pre-process waiting and increases their overall satisfaction but does not increase their in-process waiting complaints. In addition, we find that when the providers adopt VQ, the positive effects are relatively immediate, rather than lagged. Further, the VQ effects are amplified if the providers are perceived to offer low value or have high substitutability.

4 Cents of Urgency: How Opening An Urgent Care Center Affects Emergency Department Arrivals?

Simin Li[1], Achal Bassamboo[2], Martin Lariviere[2], [1]Tulane University, New Orleans, LA, [2]Northwestern University, Evanston, IL

How a nearby urgent care center (UCC) affect emergency department arrivals is inconclusive in literature. In this project, we use a clean quasi-experiment setting to show that: 1) 21% semi to nonurgent patients, 5% urgent patients are diverted to UCC; 2) diverted urgent patients requires no hospitalization, which indicates a sophisticated self-selection of healthcare facilities among the patients; 3) the provider to disposition time among urgent and semi-urgent patients decrease by 13%, which improves hospital's throughput measures; 4) these effects are mostly persistent.

Sunday, 8AM–9:15AM

SA54

M - Marriott 1
Stochastic Systems
General Session

Session Chair
Mark S. Squillante, IBM Research, Yorktown Heights, NY

1 Distributionally Robust Time Series Analysis with Martingale Constraints

Jose Blanchet[1,2,2], [1]Columbia University, Dallas, [2]Stanford, Palo Alto, CA

We optimal min-max linear prediction for linear time series (including ARMA(p,q)). We generalize the prediction equations by considering adversarial perturbations in a Wasserstein neighborhood of a baseline model but adding martingale constraints. We show the existence of a Nash equilibrium, strong duality, and provide efficient algorithms for computing it. If the baseline model is Gaussian, we show that the optimal adversarial martingale is also Gaussian. The min-max non-parametric prediction / estimation problem can be efficiently computed within a Wasserstein ball subject to martingale constraints.

2 Load Balancing on Truly Sparse Graphs

Kavita Ramanan, Brown University, Providence, RI, Contact: kavita_ramanan@brown.edu

We will consider the behavior of load balancing networks on truly sparse networks, developing tractable approximations for their hydrodynamic limits and using them to provide insight into performance analysis.

3 On Quantum Algorithms for Random Walks in the Nonnegative Quarter Plane

Mark S. Squillante[1], Vasileios Kalantzis[1], Shashanka Ubaru[1], Lior Horesh[2], [1]IBM Research, Yorktown Heights, NY, [2]IBM TJ Watson, Ossining, NY, Contact: mss@us.ibm.com

We consider the problem of computing the stationary distribution of a general class of random walks in the nonnegative quarter plane, with a focus on efficient quantum computing solutions. We devise quantum algorithms for computing the stationary distribution and establish significant speedups under different conditions, including quadratic speedup over the classical cyclic reduction algorithm, exponential improvement over so-called quantum walk algorithms, and addressing for the first time a well-known computational bottleneck of quantum walk algorithms.

4 Square-Root Voting: Related Stochastic Processes and Limiting Regimes

David D. Yao, Wenpin Tang, Columbia University, New York, NY

The square-root voting rule was first proposed by Lionel Penrose, that each member country of a world assembly (such as UN) be given a number of votes equal to the square root of its population. The idea has become newly relevant in the POS (proof of stake) scheme of digital currency (e.g., Ethereum) and other decentralized voting mechanisms. Focusing on the processes representing the total wealth over time and each participant's share, we derive their limiting distributions and related concentration inequalities.

Sunday, 8AM–9:15AM

SA55

M - Marriott 2
Learning, Control and Stochastic Models
General Session

Session Chair
Harsha Honnappa, 1</sup

1 Optimal Dividend Strategy Under Model Uncertainty

Prakash Chakraborty, Pennsylvania State University, State College, PA, Contact: prakashc@psu.edu

We consider a diffusive model for optimally distributing dividends, while allowing for Knightian model ambiguity concerning the drift of the surplus process. We show that the value function is the unique solution of a non-linear Hamilton-Jacobi-Bellman variational inequality. In addition, this value function embodies a unique optimal threshold strategy for the insurer's surplus, thereby making it the smooth pasting of a non-linear and linear part at the location of the threshold. Furthermore, we obtain continuity and monotonicity of the value function in addition to continuity of the threshold strategy with respect to the parameter that measures ambiguity of our model.

2 Presenter

Imon Banerjee, Purdue University

Markov decision processes (MDPs) have wide applications in engineering and machine learning, forming a key component in many reinforcement learning problems. In this work, we consider the estimation of the transition probabilities of finite-state finite-action MDPs, and develop a minimax sample complexity bounds for nonparametric estimation of these transition probability matrices. Unlike most studies, which have been in the online setup, we consider offline MDPs. Our results are quite general since we do not assume anything specific about the logging policy. Instead, the dependence of our statistical bounds on the logging policy comes out in form of a natural mixing coefficient. We finally demonstrate the validity of our results under various known policies like stationary, Markov, and episodic policies.

3 Adopting to Changing Environment: Dynamic Bandits with Stochastic Structure

Poyraz Bozkurt[1], Harsha Honnappa[2], Ruihao Zhu[3], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN, [3]Purdue Krannert School of Management, Chicago, IL, Contact: pbozkurt@purdue.edu

Motivated by the dynamic/non-stationary nature of many real-world market settings, we study dynamic multi-armed bandit (MAB) problem with stochastic temporal structures that satisfies: (i) the amount of changes is linear in T time periods; (ii) the expected reward of an arm follows a stochastic process. Many existing MAB algorithms fail to perform well in the dynamic settings, where the expected reward of each arm changes over time. In our formulation, the expected reward of each arm follows a Reflected Brownian Motion (RBM) model that governs the temporal structure of the reward distributions. Due to the dynamic nature of rewards, an agent has to continuously keep exploring in order to adapt to the changing environment. Our formulation is a special case of the restless MAB problem.

4 Generalized Regret Analysis of Thompson Sampling Using Fractional Posteriors

Prateek Jaiswal, Texas A&M University, College Station, TX, Contact: jaiswalp@tamu.edu

Thompson sampling (TS) is one of the most popular and earliest algorithms to solve stochastic multi-armed bandit problems. We consider a variant of TS, named □-TS, where we use a fractional or □-posterior (□ (0,1)) instead of the standard posterior distribution. For □-TS we compute near-optimal problem-dependent and problem-independent frequentist regret bounds for general prior and reward distributions (with bounded support). Our key contribution is to deliver the near-optimal frequentist regret bounds under a very mild regularity condition on the prior distribution that only requires the prior to place positive mass in an appropriate Rényi neighborhood of the true reward distribution. Moreover, our analysis does not require additional structural properties such as closed-form posteriors or conjugate priors.

Sunday, 8AM–9:15AM

SA56

M - Marriott 3

Causal Inference, Robustness, and Reinforcement Learning

General Session

Session Chair

Shuangning Li, 1</sup

1 Sensitivity Analysis of Individual Treatment Effects: A Robust Conformal Inference Approach

Ying Jin, Stanford University, Stanford, CA, Contact: ying531@stanford.edu

We propose a model-free framework for sensitivity analysis of individual treatment effects (ITEs). For any unit, our procedure reports a number that quantifies the minimum strength of confounding needed to explain away the evidence for ITE.Under the marginal sensitivity model, we characterize the distributional shift between the observations and the counterfactuals. We first develop a general method for predictive inference under distributional shifts; we then leverage this to construct covariate-dependent prediction sets for counterfactuals. These prediction sets (resp. approximately) achieve marginal coverage if the propensity score is known (resp. estimated). We devise another procedure attaining coverage conditional on the training data that is sharp in certain problems. We verify the new methods via simulation studies and apply them to real datasets.

2 Empirical Gateaux Derivatives for Causal Inference

Angela Zhou, University of Southern California, Los Angeles, CA, Contact: angela-zhou@berkeley.edu

We study a constructive procedure for estimating Gateaux derivatives for statistical functionals, with attention to causal inference. We study a statistical setting where probability distributions need also to be estimated from data. We begin with a case study of counterfactual mean estimation. This helps concretize by allowing us to study rates of numerical approximation that preserve statistical performance; our concretizations improve facial validity of numerical derivative approaches and highlight tradeoffs for researchers and practitioners. Next we study applications to optimization functionals, : we can evaluate influence function bias corrections by evaluation of the functional at valid (perturbed) distributions. We show how this approach is relevant to constrained off-policy evaluation in infinite-horizon settings.

3 Distributionally Robust Q-learning: Formulation, Algorithm, and Sample Complexity

Shengbo Wang, Stanford University, Stanford, CA, Contact: shengbo.wang@stanford.edu

We consider a reinforcement learning setting in which the deployment environment is different from the training environment. We propose a synchronous distributionally robust (DR) tabular Q-learning algorithm that learns the DR Q function under the worst distributional perturbation of the environment within a relative entropy uncertainty set. We utilize the strong duality theory for the DR Q function and design an unbiased randomized multi-level Monte-Carlo scheme to estimate the distributionally robust error using this dual formulation. Assuming access to a generative model, we prove that the worst-case sample complexity to achieve ⍰ algorithmic error is upper bounded by Õ(|S||A|(1-⍰)^{-5}⍰^{-2}). Simulation studies further validate our theoretical results.

4 Optimal Policy Evaluation Using Kernel-Based Temporal Difference Methods

Yaqi Duan, Massachusetts Institute of Technology, Cambridge, MA, Contact: yaqid22@gmail.com

We study kernel methods for value function estimation of an infinite-horizon discounted Markov reward process (MRP). We use empirical process theory to derive a non-asymptotic upper bound on the estimation error with explicit dependence on the eigenvalues of the kernel operator, as well as the instance-dependent variance of the Bellman residual error. In addition, we prove minimax lower bounds over sub-classes of MRPs, which shows that our rate is optimal in terms of sample size n and effective horizon $H=(1-⍰)^{-1}$. Whereas existing worst-case theory predicts cubic scaling (H^3) in the effective horizon, our theory reveals that there is in fact a much wider range of scalings, depending on the kernel, the stationary distribution, and the variance of the Bellman residual error. Notably, it is only (near-)parametric problems that can ever achieve the worst-case cubic scaling.

Sunday, 8AM–9:15AM

SA57

M - Marriott 4

Statistical Process Monitoring, Reliability, Bayesian Methods

General Session

Session Chair

Arda Vanli, FAMU-FSU College of Engineering, Tallahassee, FL

1 RCA Knowledge Transferring for Machine Learning Based Multiclass Compressor Anomaly Classification

Pooyan Mobtahej, Sadra Naddaf-Sh, Maryam Hamidi, Hassan Zargarzadeh, Xinyu Liu, José M. Vega-Guzmán, Lamar University, Beaumont, TX, Contact: pmobtahej@lamar.edu

A gas compressor system consists of different components, where any defects in components could cause a costly system failure. Therefore, early diagnosis of failures in a compressor is essential to reduce the risk of system shutdown and increase reliability. This research proposes a hybrid anomaly detection approach by leveraging both Root Cause Analysis (RCA) and supervised Machine Learning based algorithms for feature selection, component failure detection, and unseen anomalies classification captured in historical multivariate time-series records of components. Ten-fold cross-validation is conducted to evaluate the performance of trained models. Best performance is achieved through A decision tree-based approach with a 99.99% AUC score in the multiclass anomaly detection setting on the test set.

2 Bridging Reliability and Operations Management for New Product Introduction in Nonstationary Condition

Tongdan Jin, Texas State University, San Marcos, TX

Nowadays many firms have handled the manufacturing, maintenance, and repair of capital goods under an integrated product-service paradigm. However, in literature reliability-redundancy, maintenance planning, and spares logistics are often optimized separately, resulting in local optimality. We discuss the challenges and opportunities of consolidating these decisions for attaining superior system availability. Specific interest is focused on the new product introduction phase in which firms face a variety of uncertainties, such as installed base, usage, reliability, and intermittent demand. The goal is to call for tackling the reliability-maintenance-inventory allocation problem under a nonstationary condition.

3 Extracting Failed Equipment Taxonomy from Unstructured Maintenance Records with Confidence

Abhijeet Sandeep Bhardwaj[1], Dharmaraj Veeramani[2], [1]University of Wisconsin Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI

Maintenance records generated while inspection of breakdown event contain rich information in unstructured free-text format. The effort for manual review and analysis of voluminous maintenance records is prohibitive, and hence, in real-world industrial practice, the unstructured data are typically not leveraged in systematic ways to support failure diagnosis. An important facet of failure diagnosis is the ability to identify the complete equipment taxonomy of sub-components that malfunctioned during a breakdown event. To address this opportunity, in this work we propose a comprehensive methodology to automatically analyze unstructured maintenance records in an unsupervised manner to extract the complete equipment taxonomy corresponding to each maintenance event along with a confidence score for each predicted result.

4 Predictive Models for Covid-19 Survival Analysis from Blood Test Data

Seyedreza Abazari[1], Arda Vanli[1], Rahil Mazloumi[2], Farnaz Nafarieh[2], Amir Aghsami[2], Fariborz Jolai[2], [1]FAMU-FSU College of Engineering, Tallahassee, FL, [2]University of Tehran, Tehran, Iran, Islamic Republic of. Contact: sabazari@fsu.edu

The purpose of this study is to compare the efficacy of various machine learning algorithms for survival analysis of Covid-19 based on several blood test characteristics. In particular, Cox Proportional Hazards models with survival response data are compared to Logistic Regression with binary response data for classification and variable selection performance. Further comparisons are made against Random Forest, Support Vector Machine, Decision Tree, Adaptive Boosting and K Nearest Neighbors classification methods for predicting the survival probabilities. Algorithms are trained and tested on a blood sample dataset which consists of blood's clinical indicators and information of 306 infected patients. According to our findings, age is the most critical feature and LD, Leukocytes and CRP are highly correlated

Sunday, 8AM–9:15AM

SA58

M - Marriott 5

Data Quality Assurance for Industrial Internet

General Session

Session Chair

Yingyan Zeng, Blacksburg, VA

Session Chair

Ran Jin, Virginia Tech, Blacksburg, VA

1 Contextual Bandit Guided Data Farming for Deep Neural Networks in Manufacturing Industrial Internet

Yingyan Zeng[1], Parshin Shojaee[1], Syed Hasib Syed-Hasib-Akhter Faruqui[2], Adel Alaeddini[3], Ran Jin[1], [1]Virginia Tech, Blacksburg, VA, [2]Northwestern, Evanston, IL, [3]University of Texas at San Antonio, San Antonio, TX, Contact: adel.alaeddini@utsa.edu

Deep Neural Networks (DNNs) have shown superior performance in supervised learning in Industrial Internet applications. However, the performance of DNNs relies on large and high-quality data sets with appropriate distributions. Inspired by the theory of Design of Experiments, we propose a Contextual Bandit-based Representation Design (CBRD) to generate data suitable for training DNNs. The CBRD combines the offline experimental design criteria as the arms of a contextual bandit model for DNN training in a joint and interactive way for online batch data. A real case study of the Aerosol Jet Printing process is used to demonstrate the merits of the CBRD method.

2 A Task-Driven Privacy-preserving Data-sharing Framework for Industrial Internet

Parshin Shojaee[1], Muntasir Wahed[2], Yingyan Zeng[1], Avi Seth[2], Ran Jin[1], Ismini Lourentzou[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Blacksburg, VA, Contact: ilourentzou@vt.edu

Despite the Industrial Internet promise of training and deployment acceleration, and the potential to optimize decision processes via sharing rich datasets, adoption is impacted by increased information privacy concerns, limiting interoperability. In addition, not all shared data are equally useful or well-suited across all downstream tasks. While prior work has largely explored privacy-preserving mechanisms, it remains non-trivial how to design data selection mechanisms that model the similarity of data owners to better facilitate partnership.
In this work, we propose PriED, a task-driven data-sharing framework that combines privacy-preserving generative models to facilitate proxy-data exchange, and a dynamic data selection strategy trained with reinforcement learning. We demonstrate performance gains on a real semiconductor manufacturing case study.

3 Monitoring Runtime Metrics of Fog Manufacturing via a Qualitative and Quantitative (QQ) Control Chart

Yifu Li[1], Lening Wang[2], Dongyoon Lee[3], Ran Jin[4], [1]University of Oklahoma, Norman, OK, [2]Ford, Detroit, MI, [3]Stony Brook University, Stony Brook, NY, [4]Virginia Tech, Blacksburg, VA

Fog manufacturing combines Fog and Cloud computing in a manufacturing network to provide efficient data analytics and support real-time decision-making. Detecting anomalies, including imbalanced computational workloads and cyber-attacks, is critical to ensure reliable and responsive computation services. We propose a qualitative and quantitative (QQ) control chart to monitor system anomalies through identifying the changes of monitored runtime metric relationship (quantitative variables) under the presence of dynamic offloading (qualitative variable) using a risk-adjusted monitoring framework. Both the simulation and Fog manufacturing case studies show the advantage of the proposed method compared with the existing literature under the dynamic offloading influence.

4 Ensemble Active Learning by Contextual Bandits for AI Incubation in Manufacturing

Yingyan Zeng[1], Xiaoyu Chen[2], Ran Jin[3], [1]Virginia Tech, Blacksburg, VA, [2]University of Louisville, Louisville, KY, [3]Virginia Tech, Blacksburg, VA, Contact: yingyanzeng@vt.edu

The poor data quality of high-speed, large-volume data collected by Industrial Cyber-physical System (ICPS)s has posed significant challenges to the online updating of artificial intelligence (AI) models. Additionally, it is labor-intensive to annotate all streaming samples. Active learning methods have been proposed to acquire informative samples. However, existing acquisition criteria cannot well balance the trade-off between the exploration and exploitation of the input variable space. We propose an ensemble active learning method by contextual bandits (CBEAL), which incorporates a set of active learning agents designed for exploration or exploitation by a weighted combination and dynamically adjusted the weight based on the usefulness of its decisions. The effectiveness of CBEAL is validated in a numerical simulation study and a manufacturing case study.

Sunday, 8AM–9:15AM

SA59

M - Marriott 6

Active Learning and Sequential Experimental Design for Quality and Reliability Applications

General Session

Session Chair

Ashif Iquebal, 1</sup

1 Multi-block Parameter Calibration in Computer Models

Cheoljoon Jeong[1], Albert Berahas[2], Eunshin Byon[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: ebyon@umich.edu

Parameter calibration aims to estimate unobservable parameters employed in a computer model by utilizing physical process responses and computer model outputs. Existing studies calibrate all parameters simultaneously using an entire dataset. However, in certain applications, some parameters are associated with only a subset of data. This study provides a multi-block calibration approach that considers such heterogeneity. Unlike existing studies that build emulators for the computer model response, we consider multiple loss functions, each for a block of parameters that use the corresponding dataset and estimate the parameters using a nonlinear optimization technique. The superiority of our approach is demonstrated through numerical studies and a building energy simulation case study.

2 Active Learning for Classification with Imperfect Labels

Pouya Ahadi[1], Kamran Paynabar[2], [1]ISyE Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: pouya.ahadi@gatech.edu

In an active learning problem, query samples will be annotated using some oracles. In most cases, these labels include noise due to the noisy oracles. Moreover, uncertain samples are more likely to receive imperfect labels from those labelers. Learning with highly imperfect labeled data points will result in an inaccurate classifier. Some existing approaches use repeated labeling methods that require annotating one sample multiple times. These approaches may label fewer distinct samples due to the limited sampling budget, and thus the classifier might not be well-trained. We propose a novel method for active learning problems to construct a robust classification model. We assign each query sample to a proper labeler to mitigate the effect of label noise on the classifier.

3 Online Exploration-exploitation Trade-off in Active Learning Regression

Upala Junaida Islam, Ashif Iquebal, Arizona State University, Tempe, AZ, Contact: uislam@asu.edu

Active learning reduces the required number of data labeling, the generalization error, and the overall cost of gathering high-fidelity experimental data by actively and intelligently choosing the data to learn from. Active learning in regression problems needs to explore the search space to learn the gist of the overall structure of the underlying function and exploit the regions where the function is unpredictable with limited data. We present an active learning regression approach to learn unknown black-box functions by balancing the exploration-exploitation trade-off online. We propose a Bayesian hierarchical model using Dirichlet Process prior to the trade-off factor in the process. Applied to case studies, it shows faster convergence compared to pure exploration and exploitation strategies.

4 Towards Developing an Autonomous Experimentation Platform (AEP) Through Bayesian Model Averaging (BMA) and Surprise-reacting Experiment Policy

Ahmed Shoyeb Raihan[1], Imtiaz Ahmed[2], [1]West Virginia University, Morgantown, WV, [2]West Virginia University, Morgantown, WV, Contact: ar00065@mix.wvu.edu

AEPs are futuristic manufacturing platforms which can sequentially search the material design space (MDS) and find parameters with targeted properties. Traditional approaches often over-exploits and under-explores the MDS without considering model uncertainty. This work incorporates BMA in the model framework guiding the experiments through surprise-reacting and EI-based strategies. Our approach accounts for model uncertainty identifying the most promising regions in the MDS effectively.

Sunday, 8AM–9:15AM

SA60

M - Marriott 7

Data Analytics in Healthcare Application

General Session

Session Chair

Shujin Jiang, Purdue University, West Lafayette

Session Chair

Jian Liu, University of Arizona, Tucson, AZ

1 Bayesian Spatial Analysis of Socioeconomic Determinants on Covid-19 Mortality: An Application to the State of California

Rasim M. Musal[1], Tahir Ekin[1], Tevfik Aktekin[2], [1]Texas State University, Austin, TX, [2]University of New Hampshire, Durham, NH, Contact: rm84@txstate.edu

This presentation illustrates a spatio-temporal model in the context of biweekly Covid-19 mortality in the state of California. We illustrate multiple models in exploring the factors that affect Covid-19 mortality including vaccination rates, ICU utilization by Covid patients, and various social determinants of health. In particular, we develop exploratory models to assess a static baseline Besag York Mollie model and extend it. In addition to interaction, spatial and interaction effects we incorporate a time series component. This can help healthcare authorities to understand the changes in the disease ecology and assess effect of strategies or explore particular areas of interest that behave better/worse than would be expected under risk neutrality.

2 Improving Health Trajectory Estimation with Generative Iterative Multiple Imputation

Senne Van Steelandt[1], Anahita Khojandi[1], Rama Vasudevan[2], [1]University of Tennessee, Knoxville, TN, [2]Oak Ridge National Laboratory, Oak Ridge, TN

Generative models present a powerful approach to generate realistic health trajectories for individual patients, however, the physiological time-series used to train these models often contain a high degree of sparsity. Various studies on time series prediction have demonstrated that these missingness patterns can be exploited to improve model performance, but these techniques fail when applied in the context of trajectory estimation. We address this issue by developing a novel on-training imputation technique for predicting health trajectories through generative models. Using a synthetic and a real-world clinical dataset (MIMIC-III), we show that we achieves state-of-the-art performance in generating realistic health trajectories, and we provide further insights on our technique's performance under varying missingness patterns and degrees of sparsity.

3 Predicting Case-mix Resident Census in Nursing Homes: A Multivariate Count Time Series Forecasting Method

Shujin Jiang[1], Mingyang Li[2], Yuehwern Yih[1], Nan Kong[1], [1]Purdue University, West Lafayette, IN, [2]University of South Florida, Tampa, FL, Contact: jiang557@purdue.edu

We study the problem of forecasting nursing home (NH) resident census from various resident acuity groups. The census data are nonstationary, count time series data with potential correlation in groups. We compare prediction results of autoregression models, vector autoregression models, univariate dynamical generalized linear models, and multivariate dynamical count mixture models using a back-testing method. We conduct case studies based on five years' Minimum Data Set (MDS) data from Indiana NHs. We provide computational insights into nonstationary resident census forecasting and justify the superiority of the proposed multivariate dynamical count time series models.

Sunday, 8AM–9:15AM

SA61

M - Marriott 8

Evolution of Electricity Market Design

General Session

Session Chair

Evangelia Spyrou, National Renewable Energy Laboratory, Golden, CO

Session Chair

James Hyungkwan Kim, [1</sup]

1 Improving Congestion Management in Integrated Balancing Markets

Marie Girod[1,2], Efthymios Karangelos[3], Yannick Perez[1], [1]Laboratoire de Génie Industriel, CentraleSupélec, Université Paris Saclay, Paris, France; [2]RTE, Paris, France; [3]University of Liege, Liege, Belgium. Contact: marie.girod@rte-france.com

European markets integration is currently undergoing a major new stage with the creation of common markets of manually activated balancing reserve. In the design of these balancing markets, the method for computing cross-border capacity has several limitations. We provide an improved capacity management process using a flow-based methodology and a network representation forecast one hour before real-time. We develop a model that simulates a manual balancing process and evaluates its impact on network congestion. Using this model, we estimate the impact of the current and the proposed cross-border capacity computations on both market welfare and network congestion.

2 A New Risk Assessment and Management Paradigm in Electricity Markets

Panagiotis Andrianesis[1], Dimitris Bertsimas[2], Michael C. Caramanis[1], William W. Hogan[3], [1]Boston University, Boston, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Harvard University, Belmont, MA, Contact: panosa@bu.edu

We present early results of an ARPA-E funded project under the PERFORM - Performance-based Energy Resource Feedback, Optimization, and Risk Management - program, which develops innovative management systems that represent the relative delivery risk of each asset, like wind farms, and balance the collective risk of all assets across the grid. We propose a New Risk Assessment and Management Paradigm designed to overhaul Electricity Markets by efficiently addressing uncertainty in the forthcoming massive renewable generation and electrification of fossil fuel reliant energy uses. We present methodologies constituting a risk-driven paradigm to achieve higher adoption of stochastic resources and a more efficient and reliable system operation, and we provide proof of concept on the Southwest Power Pool territory.

3 Hybrid Plant Design in Highly Congested Regions: Implications for Market Design and Transmission Development

James Hyungkwan Kim, Dev Millstein, Julie Mulvaney-Kemp, Ryan Wiser, Lawrence Berkeley National Laboratory, Berkeley, CA, Contact: hyungkwankim@lbl.gov

Transmission congestion can reduce the value of output from hybrid (renewable+storage) plants. These value penalties now occur in some portion of every Independent System Operator (ISO) regions. Partly in response to these congestion penalties and the overall hybrid value decline occurring in higher penetration ISOs, there is interest in both developments of hybrid plant design and the development of new transmission infrastructure. We found differences between the identified optimal configurations in the congested regions and supporting market design to enhance the value of the hybrid plants. Also, we recognized the impact of transmission expansion on the optimal hybrid configuration in the congested region where estimating future electricity costs will depend on the mix and configuration of hybrid plants and the transmission development level.

Sunday, 8AM–9:15AM

SA62

M - Marriott 9

Policy-enabling Models in the Power Sector

General Session

Session Chair

Afzal Siddiqui, Stockholm University, Stockholm, Sweden.

1 Assessing the Potential of Demand Response as a Source of Flexibility in Low-carbon Power Systems: Insights from the French Case

Julien Ancel[1], Olivier Massol[2], [1]Climate Economics Chair, Paris, France; [2]IFP School & City, University of London, Rueil-Malmaison, France.

Long disregarded in power systems, demand side participation is now expected to provide the flexibility required to operate RES-dominated power systems. In light of this, a crucial question remains unanswered: what is the exact potential of Demand Response (DR)? To investigate it, we develop an analogy between load-shedding and load-shifting technologies and hydropower units and use it to examine the optimal operation of a low carbon power system. The resulting multi-stage stochastic linear programming problem is solved using the Stochastic Dual Dynamic Programming (SDDP) technique. As an application, we consider the French case and examine the role of DR on the current system as well as on alternative future configurations. Our findings show that DR susbtantially reduces the cost of a power system provide new insights regarding the economics of these technologies.

2 Basis-oriented Time Series Aggregation

Sonja Wogrin, David Cardona-Vasquez, Udo Bachhiesl, Graz University of Technology, Graz, Austria.

Due to the increasing share of variable renewable energy sources in power systems, models for policy guidance have become more computationally demanding, even making some intractable for realistic systems; thus, arises the need for techniques that improve computational efficiency. One such technique is temporal aggregation via clustering and representative periods; in general, however, the underlying optimization model is completely ignored in the temporal aggregation process, often leading to aggregations that might have good clustering performance, which does not necessarily translate into good optimization results. We analyze how information about the mathematical basis of the optimization model can be used to improve the temporal aggregation when used for aggregated optimization models and present preliminary results of a case study.

3 When a Power Purchase Agreement Reduces Social Welfare

Joseph Edward Duggan[1], Ramteen Sioshansi[2], [1]University of Dayton, Grove City, OH, [2]The Ohio State University, Columbus, OH, Contact: sioshansi.1@osu.edu

We investigate the incentive, market-behavior, and welfare effects of a proposed profit guarantee and associated power purchase agreement (PPA), which was introduced to ensure that generating firms remain viable through periods of higher-than-normal costs. We develop and analyze a stylized Nash-Cournot model of a wholesale electricity market to examine the incentive effects of the proposed PPA. We find that the proposed PPA has incentive impacts that are contrary to its stated aim. The PPA incentivizes uneconomic firms to remain in the market when otherwise they would exit and incentivizes the shutdown of otherwise economically viable firms to restrict output, increasing prices. The theoretical results of the Nash-Cournot analysis are illustrated with a numerical case study, which shows the deleterious consumer and social-welfare effects of this incentive scheme.

4 Bitcoin or No Bitcoin?

Yihsu Chen[1], Andrew L. Liu[2], [1]University of California, Santa Cruz, Santa Cruz, CA, [2]Purdue University, Lafayette, IN, Contact: yihsuchen@ucsc.edu

In response to the crackdown by government elsewhere, energy-intensive bitcoin rigs have searched for other energy sources to support their operations. There is a growing interest in some regional electricity markets in the US to host them. However, concerns about their impact on the market emerge as they are, in fact, a prosumer that can either sell power to or purchase power from the grid. We study their impacts on the wholesale market using a two-stage stochastic programming approach formulated as a complementarity problem. We show that their presence can effectively induce additional capacity if they act as a consumer in favorable conditions.

Sunday, 8AM–9:15AM

SA63

M - Marriott 10

EV Fleet Optimization and Grid Ineractions

General Session

Session Chair

Nawaf Nazir, 1</sup

Session Chair

Chase Dowling, 1</sup

1 An Energy Management System for EV Fleets

Tami Monge, Jamie Hussman, Robert Spragg, NextEra Mobility, San Francisco, CA, Contact: tamara.monge@nexteraenergy.com

Individual electric vehicles have much lower energy costs per mile than their internal combustion counterparts (in most fueling contexts), but fleets of EVs are subject to peak demand effects that can send energy costs soaring. NextEra Mobility has developed an Energy Management System (EMS) that curtails those effects, preserving EVs' cost advantage. The EMS ingests vehicle routes, charger dwell periods, utility tariffs, weather forecasts, and on-site energy resources and passes them to a model predictive controller, which optimizes the charging schedules to minimize the total cost of the electricity used by the fleet. We have developed the EMS by simulating a diverse set of real-world scenarios in preparation for production operation later this year. In this talk we will discuss our approach to solving the optimization problem and findings from the simulations.

2 Algorithms for Electric Vehicle Valuation in Grid Services

Joshua Jaworski[1], Ningkun Zheng[2], Bolun Xu[2], [1]Columbia University, New York, NY, [2]Columbia University, New York, NY, Contact: jjj2146@columbia.edu

Electric vehicles can adjust their charging schedule in response to time-of-use tariffs or spot electricity market prices to reduce the charging cost and aid power grid operation. This talk introduces a computation-efficient algorithm for optimizing electric vehicle charging schedules to provide grid services. The algorithm is based on dynamic programming and uses an analytical approach to update the value function. The proposed approach is convenient and computationally efficient to incorporate price uncertainties and nonlinear battery models such as state-of-charge dependent power ratings and efficiencies, and the calculated value functions provide a base for EV fleet aggregation.

3 Centering Equity in The Design of EV Charging Infrastructure

Hafiz Anwar Ullah Khan[1], Yury Dvorkin[1], Burcin Unel[2], [1]New York University, Brooklyn, NY, [2]New York University, NYC, NY, Contact: hak369@nyu.edu

Access to and affordability of electric vehicle charging infrastructure (EVCI) are the two prominent barriers for EV adoption. In this talk, we identify such socio-demographic features that correlate with the current distribution of EV charging stations in New York City, demonstrating a heavy skew against low-income, Black-identifying, and disinvested neighborhoods. We use this data-driven analysis to design equitable charging tariffs for public EVCI. The designed framework incorporates economic welfare, social costs of environmental and public health impacts, and demographic characteristics. The results demonstrate that charging tariffs can be efficient and promote distributional equity, underscoring the need for policy frameworks that incorporate equity and justice in the rollout of EVCI.

4 Unlocking the Value of Electric Vehicle Fleets as Grid Assets

Eilyan Bitar[1], Feras Al Taha[1], Tyrone Vincent[2], [1]Cornell University, Ithaca, NY, [2]Colorado School of Mines, Golden, CO, Contact: eyb5@cornell.edu

To transform electric vehicles (EVs) into dispatchable resources that provide energy/ancillary services to the grid, it is essential to quantify their capacity to supply energy and defer charging based on their heterogeneous charging requirements. While the aggregate charging flexibility of an EV fleet can be expressed as a Minkowski sum of convex polytopes, it is generally intractable to compute exactly. We propose novel methods to compute accurate inner and outer approximations of the aggregate flexibility set by solving modestly-sized linear programs. We illustrate our methods using real-world EV fleet data.

Sunday, 8AM–9:15AM

SA64

M - Indiana A

Auctions and Market Design Flash Talks

Flash Session

Session Chair

Cagil Kocyigit, University of Luxembourg, Luxembourg, Luxembourg.

Session Chair

Robert Day, University of Connecticut, Storrs, CT

1 Flash Paper

Robert Day, University of Connecticut, Storrs, CT

2 Innovations in Auction Design

Benjamin Lubin, Boston University, Boston, MA

We will preview the content of the session, which will include 4 excellent papers on mechanism design in an auction context. A particular emphasis in this year's session will be on advances in bidder preference elicitation and bidder feedback.

3 Flash Paper

Sven Seuken, University of Zurich, Zuerich, Switzerland.

4 Flash Paper

Yunus C. Aybas, Stanford University, Stanford, CA, Contact: aybas@stanford.edu

We will preview the content of the session, which will include 4 excellent papers on Information Design.

5 Robust Mechanism Design

Cagil Kocyigit, University of Luxembourg, Luxembourg, Luxembourg.

This talk focuses on the use of techniques from robust optimization to investigate how the decisions of a mechanism designer are affected by distributional ambiguity.

6 Supporting Democratic Innovation: Fairness, Representativeness, and Transparency for Citizens' Assemblies

Paul Gölz, Carnegie Mellon University, Pittsburgh, PA, Contact: pgoelz@cs.cmu.edu

Globally, there has been a recent surge in *citizens' assemblies*, which are a form of civic participation in which a panel of randomly selected constituents contributes to questions of policy. Since panels should be demographically representative, and since they should be randomly selected, the selection process poses challenges of fairness, efficiency, predictability, and transparency. I will describe multiple pieces of work in which we support nonprofit organizations in hosting citizens' assemblies.

7 Obviously Strategyproof Single-Minded Combinatorial Auctions

Carmine Ventre, King's College London, London, United Kingdom.

We consider the setting of combinatorial auctions when the agents are single-minded and have no contingent reasoning skills. We are interested in mechanisms that provide the right incentives to these imperfectly rational agents, and therefore focus our attention to obviously strategyproof (OSP) mechanisms. These mechanisms require that at each point during the execution where an agent is queried to communicate information, it should be "obvious" for the agent what strategy to adopt in order to maximise her utility. In this paper we study the potential of OSP mechanisms with respect to the approximability of the optimal social welfare.

8 Flash Paper: Serverless Computing

Ian Kash, 1</sup

In serverless computing, customers provide code to run and conditions which trigger the invocation of the code. They pay only for the time the code is running with the cloud provider managing resources. I'll discuss ongoing work on pricing caching policies in this context.

9 Uniformly Bounded Regret in Dynamic Fair Allocation

Santiago Balseiro[1], Shangzhou Xia[2], [1]Columbia University, Armonk, NY, [2]Columbia University, New York, NY, Contact: sx2182@columbia.edu

We study a dynamic allocation problem in which sequentially arriving resources need to be allocated to fixed agents with additive utilities. Most works on dynamic resource allocation aim to maximize the utilitarian welfare of the agents, which may result in unfair concentration of resources at select agents while leaving others' demand under-fulfilled. We consider the egalitarian welfare objective instead, which aims at balancing the efficiency and fairness of the allocation. We propose a new policy consisting of infrequently re-solving the fluid problem, which attains uniformly bounded regret against the hindsight optimum.

Sunday, 8AM–9:15AM

SA65

M - Indiana B
Sustainability in Agriculture
General Session

Session Chair
Erkut Sonmez, University of Nebraska Lincoln, Lincoln, NE

1 **Dynamic Irrigation Management Under Temporal and Spatial Variability**
Erkut Sonmez[1], Baris Ata[2], Derek Heeren[1], [1]University of Nebraska Lincoln, Lincoln, NE, [2]University of Chicago, Chicago, IL
Recent studies report that agricultural productivity must improve significantly in the near future to meet the increase in demand due to rapid growth of the world population. One way to improve agricultural productivity is to increase irrigation. However, fresh water scarcity, increasing production costs, and the climate change necessitate sustainable and efficient methods for irrigation. This paper studies dynamic irrigation management under uncertainty taking into account temporal variability and spatial soil heterogeneity of the field. Our results reveal that proposed (s, S)-type irrigation policies can improve farmers' expected net benefit and water savings significantly over the commonly used irrigation policies in practice

2 **Feeding the Hungry in the Midst of a Pandemic: How to Build Resilience in Food Bank Operations**
Luv Sharma, Yingru Han, Olga Perdikaki, Pelin Pekgun, University of South Carolina, Columbia, SC, Contact: luv.sharma@moore.sc.edu
In this study, we investigate the role of a critical operational factor in influencing the *ramp-up in distributional capacity* for food banks in the face of emergencies like the Covid-19 pandemic and help build resiliency in operations.

3 **Optimization of Crop Insurance Policy Selection and Fertilizer Management with Water Quality Impacts**
Gorkem Emirhuseyinoglu, Sarah M. Ryan, Iowa State University, Ames, IA, Contact: gorkem@iastate.edu
Weather conditions and market prices are the major uncertainties affecting farm revenue. Farmers apply N to the soil to compensate for its nutrient deficiencies and increase the yield output. However, N leaching through subsurface flow threatens water quality. In the US, federal crop insurance and income support policies defined in the Farm Bill are the primary ongoing financial tools mitigating farmers' financial risk. In addition to providing financial security for farmers, these programs also affect fertilizer management decisions and have unintended consequences for water quality. We build a stochastic program, including CVaR as a risk measure, to find optimal crop insurance choices and N application rates under a range of risk preferences. The results inform the design of support policies and insurance products to improve economic and environmental outcomes.

Sunday, 8AM–9:15AM

SA66

M - Indiana C
Evaluating Technology and Resource Tradeoffs in Energy System Planning
General Session

Session Chair
Neha Patankar, North Carolina State University, West Windsor, NJ

1 **Multiagent Optimization for Coordinated Transmission-distribution System**
Saumya Sakitha Sashrika Ariyarathne[1], Harsha Gangammanavar[2], Jianhui Wang[3], [1]Southern Methodist University, Dallas, TX, [2]Southern Methodist University, Dallas, TX, [3]Southern Methodist University, Dallas, TX, Contact: sariyarathne@smu.edu
In this talk, we present a multiagent optimization model and solution method for coordinating market transactions between the centralized transmission system (TS) and multiple distribution systems (DS). We consider DS operations including generation using distributed energy resources such as rooftop solar and convex relaxations of power flows. Our model concurrently optimizes these operations at individual DS while keeping their competitive

advantages over the other systems. The optimization model at individual also captures the environmental impact of DS operations. The exchange of electricity between the TS and a DS is governed by a linear inverse demand function. We will present the results from computational experiments with our multiagent optimization model.

2 Incorporating Energy Equity and Environmental Justice into Wind Power Siting

Jeffrey A. Bennett[1], Jonathan D. Ogland-Hand[1], Erin Middleton[1], Jessi Eidbo[1], Matthew Prorok[2], Brian Ross[2], Sean Yaw[3], Richard S. Middleton[1], [1]Carbon Solutions LLC, Bloomington, IN, [2]Great Plains Institute, Minneapolis, MN, [3]Montana State University, Bozeman, MT, Contact: jeffrey.bennett@carbonsolutionsllc.com

Although wind is now the least expensive form of new energy generation, its continued deployment faces siting barriers. In this talk, we introduce a tool, *SimWIND^{PRO}*, that supports wind farm siting while concurrently optimizing wind resource potential, transmission costs, and energy equity and environmental justice. We then present a case study in the context of Midcontinent Independent System Operator's (MISO) western region that includes some of the best wind resources in the United States. Our results show that transmission routing is significantly increased when considering energy equity considerations such as traditional fossil fuel communities and environmental impacts such as The Nature Conservancy's Site Renewables Right.

3 A Data-driven Approach to Identify Household Demand Flexibility to Supply a New Power Market Risk Product

Yijiao Wang[1], Li He[2], Mengmeng Cai[2], Shawn Li[3], Elina Spyrou[2], Benjamin Field Hobbs[1], [1]Johns Hopkins University, Baltimore, MD, [2]National Renewable Energy Laboratory, Golden, CO, [3]Johns Hopkins University, Baltimore, MD, Contact: ywang303@jhu.edu

At least two critical gaps prevent the efficient management of delivery risk in electricity markets. First, flexibility of distributed energy resources (DERs) is underutilized. Second, system flexibility is mostly used for reliability purposes and not for economic hedging of delivery risk. In an ongoing project, we propose a new power market risk product. The novel product allows uncertain resources to hedge reliability risks (production imbalances) by procuring system-wide flexibility including flexibility by residential sector load management. Texas household-level smart thermostat data is being studied to identify potential residential load shifting opportunities.

4 Land Tradeoffs in the American West Under Uncertain Future Scenarios

Neha Patankar, Princeton University, Princeton, NJ

In the electricity sector, system stakeholders have multiple priorities that are often ignored by existing power system capacity expansion models (CEMs). Non-modeled priorities, such as the ecological impacts or regional equity of a given transition plan, have significant impacts on the pace and scale of the switch to zero-carbon electricity. These priorities lead to parametric and structural uncertainty in the CEMs. Our analysis employs a model of the Western Interconnection to explore electricity generation pathways for achieving 100% carbon-free electricity supply for the American West by 2045. We show that the Modeling to Generate Alternative (MGA) methodology performs better under parametric uncertainties while MGA's ability to address structural uncertainty depends highly on the type of non-modeled priority.

Sunday, 8AM–9:15AM

SA67

M - Indiana D

Data Driven Decisions: New Paradigms

General Session

Session Chair

Omar Mouchtaki, Columbia University, New York, NY

Session Chair

Omar Besbes, Columbia University, New York, NY

1 Contextual Search in the Presence of Adversarial Corruptions

Akshay Krishnamurthy[1], Thodoris Lykouris[2], Chara Podimata[3], Robert Schapire[1], [1]Microsoft Research, New York, NY, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Harvard University, Allston, MA

We study contextual search which captures settings such as feature-based dynamic pricing. Standard formulations of this problem assume that agents act based on a homogeneous response model. In practice, some responses may be adversarially corrupted. Existing algorithms heavily depend on the assumed response model being accurate for all agents and have poor performance in the presence of even a few such arbitrary misspecifications. We initiate the study of contextual search when some of the agents can behave in ways inconsistent with the underlying response model. In particular, we provide algorithms that attain near-optimal regret in the absence of adversarial corruptions and their performance degrades gracefully with the number of such agents, providing the first results for contextual search in any adversarial noise model.

2 Near-Optimal Decision-Aware Reinforcement Learning

Hamsa Sridhar Bastani[1], Osbert Bastani[2], Tsai-Hsuan Chung[1], Vahid Rostami[3], [1]Wharton School, Philadelphia, PA, [2]University of Pennsylvania, Philadelphia, PA, [3]Macro-Eyes, Seattle, WA, Contact: hamsab@wharton.upenn.edu

We propose decision-aware reinforcement learning via a novel Taylor expansion of the optimal decision loss to provably align the objective of our prediction models with the objective of the downstream sequential optimization problem. Importantly, our approach only requires a simple re- weighting of the training data, allowing it to easily be incorporated into complex modern data science pipelines, yet producing sizeable efficiency gains. We apply our framework to optimize the distribution of essential medicines and vaccines in collaboration with policymakers in Sierra Leone; highly uncertain demand and limited budgets currently result in excessive unmet demand. Out-of-sample results demonstrate that our end-to-end approach can significantly reduce unmet demand across 1200+ health facilities throughout Sierra Leone.

3 Nonstationary Bandit Learning via Predictive Sampling

Yueyang Liu[1], Benjamin Van Roy[1], Kuang Xu[2], [1]Stanford University, Stanford, CA, [2]Stanford Graduate School of Business, Stanford, CA, Contact: yueyl@stanford.edu

Although Thompson sampling is widely used in stationary environments, it does not effectively account for nonstationarities. To address this limitation, we propose predictive sampling, a policy that balances between exploration and exploitation in nonstationary bandit environments. It is equivalent to Thompson sampling when specialized to stationary environments, but much more effective across nonstationary environments because it deprioritizes investment in acquiring information that will quickly lose relevance. To offer insight in the efficacy of predictive sampling, we establish a regret bound. This bound highlights dependence on the rate at which new information arrives to alter the environment. In addition, we conduct experiments on bandit environments with varying information arrival rates and observe that predictive sampling outperforms Thompson sampling.

4 Beyond i.i.d.: Data-driven Decisions in a Heterogeneous Environment

Omar Besbes[1], Will Ma[2], Omar Mouchtaki[1], [1]Columbia University, New York, NY, [2]Columbia University, Cambridge, MA, Contact: om2316@gsb.columbia.edu

The assumption that samples are identically and independently distributed (i.i.d.) is classical and central in the data-driven algorithms literature. This assumption can be questioned in many applications as the collected data is rarely associated with identical distributions. We first propose a general framework for offline data-driven decision-making in a heterogeneous environment in which the stream of historical samples is generated by distributions which lie in a heterogeneity ball and centered around an unknown distribution. We develop asymptotic performances of data-driven policies when the number of samples goes to infinity and the heterogeneity radius goes to 0. We show that for different problems and heterogeneity balls, different performances may arise and we derive new connections with distributionally robust optimization.

Sunday, 8AM–9:15AM

SA68

M - Indiana E

Platforms, Data, and Algorithms

General Session

Session Chair

Ali Makhdoumi, Duke University, Durham, NC

Session Chair

Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA

1 Equity in Resident Crowdsourcing: Measuring Under-reporting Without Ground Truth Data

Zhi Liu[1], Nikhil Garg[2], [1]Cornell University, Ithaca, NY, [2]Cornell Tech, New York, NY, Contact: zl724@cornell.edu

Modern city governance relies heavily on crowdsourcing to identify problems in real-time. A major concern in these systems is that residents do not report problems at the same rates. However, measuring such under-reporting is a difficult task, as distinguishing between low reporting rates and low ground-truth incident rates is challenging. We develop a method to identify heterogeneous reporting rates, without using external ground truth data. Our insight is that rates on *duplicate* reports about the same incident can be leveraged, to turn the question into a standard Poisson rate estimation task. We apply our method to over 100,000 resident reports made to the NYC Department of Parks and Recreation, finding that there are substantial spatial and socio-economic disparities in reporting rates, even after controlling for incident characteristics.

2 Approximate Submodularity in Network Design Problems

Levi DeValve[1], Sasa Pekec[2], Yehua Wei[2], [1]University of Chicago, Chicago, IL, [2]Duke University, Durham, NC

We study network design problems, with a focus on flexibility design (i.e., allocating subsets of limited resources to multiple demand classes) as a motivating case. Using a primal-dual approach, we establish that the flexibility design problem possesses a novel structural property. The property, which we call cover modularity, can be interpreted as an approximate form of submodularity, in the sense that local changes in the objective function can be used to bound global changes. We use this structure to analyze a class of greedy heuristics and establish the first constant factor approximation guarantee for solving the general flexibility design problem. We further demonstrate existence of a cover modular structure in a general class of linear programming formulations, indicating applicability of our approach to a wide range of network design problems.

3 Optimal Auction Design with Deferred Inspection

Ali Makhdoumi, Duke University, Durham, NC

In auctioning digital goods, the platforms have the ability to monitor the payoff of bidders and adjust their payments accordingly. In this talk, we model the design of such auctions and use tools from convex analysis and calculus of variation to find the optimal mechanism. We then explain how the analysis can be applied to other auction design settings where ``local incentive compatibility'' does not imply ``global incentive compatibility''.

4 Promotion Display when Customers Search: A Structural Estimation of Click-then-purchase Behavior in Online Retail

Yi Chen[1], Jing Dong[2], Fanyin Zheng[2], [1]HKUST, Hong Kong, Hong Kong; [2]Columbia University, New York, NY

Promotions are among the most important operational levers for retail platforms to attract customers and improve revenue. For most platforms, since customers first click on a product before making the purchase decision, the platform can choose to display the promotion before or after the click. In this work, we study the impact of promotion display for online retail platforms when customers search. Utilizing a large-scale dataset which contains detailed customer click and purchase information, we estimate a search and purchase model. The estimated model allows us to evaluate different promotion display schemes, propose an easy-to-implement heuristic policy for promotion display, and demonstrate through counterfactual analysis that our heuristic policy can substantially improve the revenue for some product categories.

Sunday, 8AM–9:15AM

SA69

M - Indiana F

Information Design in Operations

General Session

Session Chair

Ozan Candogan, University of Chicago, Chicago, IL

Session Chair

Yiding Feng, 1</sup

Session Chair

Yiding Feng, Microsoft Research, Cambridge, MA

1 Learning to Persuade on the Fly: Robustness Against Ignorance

You Zu[1,2], Krishnamurthy Iyer[3,2], Haifeng Xu[4,5], [1]University of Minnesota, Minneapolis, MN, [2]UNIVERSITY OF MINNESOTA, Minneapolis, MN, [3]University of Minnesota, Saint Paul, MN, [4]University of Virginia, Charlottesville, VA, [5]University of Virginia, Charlottesville, VA, Contact: zu000002@umn.edu

We consider a repeated persuasion setting where a sender seeks to persuade a stream of myopic receivers to choose the sender's preferred actions by selectively sharing information about a state drawn i.i.d. from an unknown distribution. We study the sender's problem of making persuasive recommendations to achieve low regret against the benchmark where the state distribution is commonly known. We propose a signaling algorithm that is persuasive (whp) across all rounds and achieves $\Omega(\sqrt{T\log T})$ regret, where T is the horizon length. The core philosophy behind the design of our algorithm is to leverage robustness against the ignorance of the state distribution. We prove that no algorithm can achieve regret better than $\Omega(\sqrt{T})$ even if the persuasiveness requirements were significantly relaxed.

2 Costly Signaling with Heterogeneous Outside Options

Itai Ashlagi[1], Faidra Monachou[2], Afshin Nikzad[3], [1]Stanford University, Stanford, CA, [2]Harvard University, Cambridge,

MA, [3]University of Southern California, Palo Alto, CA, Contact: monachou@stanford.edu

We study optimal mechanism design in a continuum model of continuous agent types and discrete object qualities, where a planner maximizes social welfare. Each agent has a type (representing her willingness to pay for quality) and a heterogeneous outside option (independently drawn from her type). Our first result considers publicly observed outside options. We show that the optimal incentive-compatible, individually rational mechanism determines a participation threshold for each outside option; an agent with type below that threshold is assigned to her outside option, while an agent with type above that threshold is offered either a single common object quality or a lottery of consecutive common object qualities, possibly pooled with her outside option. Our second result shows that the same mechanism is also optimal in a setting with downward-private outside options.

3 Optimal Test Design with Limited Commitment

Yingkai Li[1], Boli Xu[2], [1]Yale University, New Haven, CT, [2]Northwestern University, Evanston, IL

We study a model where a worker sequentially interacts with multiple employers. The worker's type is unknown to both the worker and the employers, and the employers can schedule tests for privately learning the worker's type. Upon receiving the signals, the employers can decide whether to give an offer and the worker decides whether to accept. Crucially, although the signals are private information for each employer, all other employers can infer the worker's type through the publicly observed actions. We show that in equilibrium, an employer may strategically reject overqualified workers, or lower the hiring standard to make an offer to unqualified workers, so as to lower the worker's belief about his continuation value upon rejecting the offer. We apply this framework to analyze various aspects of labor markets such as the welfare impact of the privacy on job search history.

4 Online Bayesian Recommendation with No Regret

Yiding Feng[1], Wei Tang[2], Haifeng Xu[3], [1]Microsoft Research, Cambridge, MA, [2]Washington University in St. Louis, St.Louis, MO, [3]University of Virginia, Charlottesville, VA, Contact: w.tang@wustl.edu

We introduce and study the online Bayesian recommendation problem for a platform, who can observe a utility-relevant state of a product, repeatedly interacting with a population of myopic users through an online recommendation mechanism. For each user with her own private preference and belief, the platform commits to a recommendation strategy to utilize his information advantage on the product state to persuade the self-interested user to follow the recommendation. Using the Stackelberg regret as the regret notion, our first result is an online policy that achieves O(loglog T) regret, where T is the number of rounds. This regret on its dependency on T is tight. Finally, by formulating the platform's problem as optimizing a linear program with membership oracle access, we present our second online policy that achieves regret O(poly(m log T)) where m is the number of states.

Sunday, 8AM–9:15AM

SA70

M - Indiana G
Topics in Theory of Neural Networks
General Session

Session Chair
Boris Hanin, 1</sup

1 Deep Learning Theory at Limits

Cengiz Pehlevan, Harvard SEAS

A strategy for gaining insight into the complexity of deep learning is to study non-trivial yet tractable limits. I will describe our work on three such limits with a focus on results on representation learning and inductive biases.

2 Overparameterization Improves Robustness to Covariate Shift in High Dimensions

Ben Adlam, Google Brain, Cambridge, MA

A significant obstacle in the development of robust machine learning models is *covariate shift*. Despite its prevalence, a theoretical understanding has remained lacking. We examine the exact high-dimensional asymptotics of random feature regression under covariate shift and present a precise characterization of the limiting test error. Our results motivate a natural partial order over covariate shifts that provides a sufficient condition for determining when the shift will harm (or even help) test performance. We find that overparameterized models exhibit enhanced robustness to covariate shift, providing one of the first theoretical explanations. Additionally, our analysis reveals an exact linear relationship between the in-distribution and out-of-distribution generalization performance, offering an explanation for this surprising recent observation.

3 Learning Sparse Functions with Neural Networks

Theodor Misiakiewicz, Stanford

We consider the problem of learning sparse functions (a function that depends on a latent low-dimensional subspace) with two-layer neural networks (NN). This setting is of interest since neural networks routinely tackle high-dimensional datasets and it is still poorly understood when and how SGD-trained NNs can adapt to latent low-dimensional structure without suffering from the curse of dimensionality.
We consider training a 2-layer NN with online SGD in the mean-field scaling. We show that the SGD trajectory can be well approximated for constant time by a dimension independent dynamics, which we call DF-PDE. In particular, if the DF-PDE converges in constant time to zero test error, so does online SGD. We apply this characterization to sparse functions on the hypercube and show that a hierarchical property —the merged-staircase property— is necessary and nearly sufficient for learning in this regime.

4 Transition to Linearity of General Neural Networks with Directed Acyclic Graph Architecture

Libin Zhu, UCSD

We show that feedforward neural networks corresponding to arbitrary directed acyclic graphs undergo transition to linearity as their "width" approaches infinity. The width of these general networks is characterized by the minimum in-degree of their neurons, except for the input and first layers. Our results identify the mathematical structure underlying transition to linearity and generalize a number of recent works aimed at characterizing transition to linearity or constancy of the Neural Tangent Kernel for standard architectures.

Sunday, 8AM–9:15AM

SA71

M - Arizona
Data-driven Decision Making
General Session

Session Chair

Rui Gao, University of Texas at Austin, Austin, TX

Session Chair

Luhao Zhang, The University of Texas at Austin, Austin, TX

1 Pigeonhole Design: Balancing Sequential Experiments from an Online Matching Perspective

Jinglong Zhao[1], Zijie Zhou[2], [1]Boston University, Boston, MA, [2]Massachusetts Institute of Technology, Cambridge, MA

We study an online experimental design problem, the "Online Blocking Problem." In this problem, experimental units with heterogeneous covariate information arrive sequentially and must be immediately assigned into either the control or the treatment group, with an objective of minimizing the total discrepancy, which is defined as the minimum weight perfect matching between the two groups. To solve this problem, we propose an experimental design method, the "Pigeonhole Design." The pigeonhole design first partitions the covariate space into smaller spaces, which we refer to as pigeonholes, and then, when the experimental units arrive at each pigeonhole, balances the number of control and treatment units for each pigeonhole. We show effectiveness of the pigeonhole design by comparing against the match-pair design and the completely randomized design.

2 Active Learning in the Predict-then-optimize Framework

Paul Grigas, UC Berkeley, Berkeley, CA, Contact: pgrigas@berkeley.edu

We develop the first active learning methods in the predict-then-optimize framework. Our active learning methods are the first to be directly informed by the decision error induced by the predicted parameters, which is referred to as the Smart Predict-then-Optimize (SPO) loss, or a tractable surrogate thereof. In particular, we develop two practical active learning algorithms — a margin-based algorithm and an importance weighting algorithm — with theoretical (e.g., generalization) guarantees. Furthermore, we prove bounds on the label complexity, the number of samples whose labels are acquired, and show that these bounds can be better than the naive supervised learning approach that labels all samples under a natural and previously studied low-noise condition. We also demonstrate numerical evidence showing the practical value of our proposed algorithms.

3 Distributionally Robust End-to-end Learning with Side Information

Luhao Zhang[1], Jincheng Yang[2], [1]The University of Texas at Austin, Austin, TX, [2]The University of Chicago, Chicago, IL

We consider data-driven decision-making under uncertainty with side information, in which exogenous covariates data are available to reveal partial information about random problem parameters and thus facilitate better decisions. The decision maker's goal is to find an optimal end-to-end policy that directly outputs a decision for any new context. We propose a distributionally robust formulation based on the causal transport distance, which preserves the conditional information structure of random problem parameters given the value of covariates. We derive a dual reformulation and study its regularization effect. We prove that the infinite-dimensional policy optimization admits a finite-dimensional convex programming equivalent reformulation. This result renders a new class of optimal policy for adjustable robust optimization.

4 **Robust Two-stage Optimization with Covariate Data**

Bart Paul Gerard Van Parys, MIT Sloan School of Management, Cambridge, MA

We consider a generalization of two-stage decision problems in which the second-stage decision may be a function of a predictive signal but can not adapt fully to the realized uncertainty. We will show how such problems can be learned from sample data by considering a family of noise regularized sample average formulations. Furthermore, our regularized data-driven formulations admit convex distributionally robust counterparts which enjoy desirable out-of-sample performance guarantees. Finally, we show that all derived data-driven formulations can be solved efficiently using canonical stochastic gradient algorithms.

Sunday, 8AM–9:15AM

SA72

M - California

Misinformation and Platform Design

General Session

Session Chair

Z. Jessie Liu, Johns Hopkins

1 **Prevalence and Propagation of Fake News**

Banafsheh Behzad[1], Susan E. Martonosi[2], [1]California State University, Long Beach, Long Beach, CA, [2]Harvey Mudd College, Claremont, CA, Contact: banafsheh.behzad@csulb.edu

In recent years, scholars have raised concerns on the effects that unreliable news, or "fake news," has on our political sphere, and our democracy as a whole. For example, the propagation of fake news on social media is widely believed to have influenced the outcome of national elections, including the 2016 U.S. Presidential Election, and the 2020 COVID-19 pandemic. What drives the propagation of fake news on an individual and the network levels, and which interventions could effectively reduce the propagation rate? Our model disentangles bias from truthfulness of an article and examines the relationship between these two parameters and a reader's own beliefs.

2 **People are More Likely to Believe and Share Fake News on Smartphones (vs. PCs)**

Z. Jessie Liu[1], Minzhe Xu[2], Yang Yang[3], [1]Johns Hopkins University, Baltimore, MD, [2]Iowa State University, Ames, IA, [3]University of Florida, Gainesville, FL, Contact: jzliu@jhu.edu

Are smartphone users, compared with PC (desktop or laptop) users, more or less likely to believe and share fake (but not true) news, and why? This project explored this question by analyzing a dataset that includes 97,765 Twitter replies to 5,802 source tweets. Our data analysis showed a significant and positive smartphone effect on one's receptivity to misinformation. We further tested possible mechanisms in two lab experiments, which revealed that this device effect is driven by smartphone users' lack of deliberation, but *not* due to the difference in screen size or individual traits (such as age or education) associated with using smartphones vs. PCs. Instead, we showed that the lack of deliberation is a result of environmental distractions brought about by the portability of smartphones.

3 **Debunking Misinformation in Advertising**

Jessica Fong, University of Michigan, MI

We study the efficacy of debunking messages in reducing the impact of misinformation on purchase behavior, and whether such messages correct consumers' misinformed beliefs - an ideal outcome from a policy-maker's perspective - or merely reinforce correct beliefs, as predicted by biased Bayesian updating. We implement a conjoint experiment that measures willingness-to-pay under exposure to real-world misinformation and debunking messages. Focusing on three product categories where misinformation is prevalent, we find that debunking can repair the decrease in willingness-to-pay caused by misinformation by correcting misinformed beliefs. We discuss incentives for firms to debunk or introduce products that conform to misinformation.

4 **Fake Sales and Ranking Algorithms in Online Retail Marketplace with Sponsored Advertising**

Fei Long[1], Yunchuan Liu[2], [1]The University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]University of Illinois, Champaign, IL, Contact: Fei_Long@kenan-flagler.unc.edu

We study the optimal algorithm decisions of a platform on ranking products sold by sellers--who may use fake sales to boost the rankings of their products--and the impact on consumers and sellers. We design a model of an online retail marketplace with competing sellers. The platform decides whether to tolerate fake sales and whether to rank its organic results based on sellers' qualities or popularities. The sellers decide whether to buy fake sales and how much to bid for sponsored advertising on the platform. We show a platform may strategically tolerate or even encourage popularity-boosting fake sales by a seller when the seller's quality level is extreme relative to competitors. Furthermore, fake sales may benefit consumers by increasing price competition and may also benefit competing sellers by reducing the high-quality seller's dominance.

Sunday, 8AM–9:15AM

SA73

M - Colorado

Sustainable Collaborative Service Systems

General Session

Session Chair

Sina Shokoohyar, Stillman School of Business - Seton Hall University, South Orange, NJ

Session Chair

Vahid Ghomi, Penn State Mont Alto, Highspire, PA

1 Improving Supply Chain Resilience Through Investment in Flexibility and Innovation

Vahid Ghomi[1], Vahid Nooraei[2], Sina Shokoohyar[3], Mansoor Shekarian[4], Mahour Parast[4], Farnaz Ghazi Nezami[5], [1]Penn State Mont Alto, Waynesboro, PA, [2]North Carolina Agriculture and Technical State University, Waynesboro, PA, [3]Stillman School of Business, Seton Hall University, South Orange, NJ, [4]North Carolina A&T State University, Greensboro, NC, [5]Kettering University, Flint, MI

We examine how organizations improve resilience and their response to SC disruptions through investment in flexibility and innovation. There are several approaches and conceptualizations of flexibility and innovation in the literature. Nevertheless, how flexibility and innovation can enhance an organizational response to disruptions has not received much attention. We extend the research in SC resilience by investigating the relationships between flexibility, innovation, and resilience under disruption risk. The findings show that innovation and flexibility have a positive impact on resilience. By developing a novel multi-objective mixed-integer linear programming, the findings reveal that disruption risks affect resilience and firms' ROI, so investing in improvements in flexibility and innovation decreases the impact of disruptions.

2 A Systematic Quantitative Review of Sustainable Transportation Case Studies

Sina Shokoohyar[1], Amirsalar Jafari Gorizi[2], Vahid Ghomi[3], Weimin Liang[4], Hak J. Kim[5], [1]Stillman School of Business, Seton Hall University, South Orange, NJ, [2]American University, Washington, D.C., DC, [3]Penn State Mont Alto, Highspire, PA, [4]Saint Joseph's University - Erivan K. Haub School of BusinessSaint Joseph's University - Erivan K. Haub School of Business, Philadelphia, PA, [5]Hofstra University, Hempstead, NY, Contact: aj2917a@student.american.edu

Following the COVID-19 epidemic and a slew of new climate change supply chain disruptions, a holistic approach to sustainable transportation is required. This study looked at 358 case studies and divided them into twenty categories based on the mode of transportation and eleven categories based on the authors' principal concerns. Keyword analysis and topic modeling revealed three distinct tendencies in the cohort. The findings were divided into four categories: in-vehicle improvements, built-environment elements, human factors, and planning and regulations, with a corroborating look at the benefits of the United States' infrastructure bill.

3 Shared Mobility in Post-COVID Era: New Challenges and Opportunities

Sajjad Shokouhyar[1], Sina Shokoohyar[2], Anae Sobhani[3], Amirsalar Jafari Gorizi[4], [1]Shahid Beheshti University, Tehran, Iran, Islamic Republic of; [2]Seton Hall University, South Orange, NJ, [3]University of Hartford, West Hartford, CT, [4]American University, Washington, DC

4 Economic and Environmental Evaluation for Production System Design in Controlled Environment Agriculture

Guiping Hu, Saiara Samira Sajid, Iowa State University, Ames, IA

The world population is anticipated to reach 9.7 billion by 2050 and to meet the growing food demand, controlled environment agriculture has evolved as a paradigm shift in agriculture. Significant advancement has been made in the design and production of controlled environment agriculture in the past few decades. It should be noted that currently opportunities and obstacles co-exist with the design and management of vertical farming. Some key benefits of vertical farming are improved crop yields, protection from extreme weather conditions, water savings, and efficient use of lands. On the contrary, high labor and fixed cost, immature technology, and high energy consumption are among the challenges yet to be addressed. Thorough evaluation of the economic and environmental performance of the production system is of paramount importance. Analyses are designed such as carbon footprint, energy consumption, net present cost (NPC) with the Levelized cost of energy (LCOE), and analysis of demand-supply to guide the evaluation and decision making in system design for the controlled environment agriculture.

5 Consumer Preference Towards the Green Services in the Electronics Industry: A Social Media Approach

Sanaz Ghorbanloo[1], Sajjad Shokouhyar[1], Sina Shokoohyar[2], [1]Shahid Beheshti University, Tehran, Iran, Islamic Republic of; [2]Seton Hall University, South Orange, NJ, Contact: sina.shokoohyar@shu.edu

Green services, also known as environmentally friendly services, have become a key driver for many consumers in the electronics industry. In recent years, consumers have often considered the company's environmental footprint before purchasing products and services. Hence, this study looks at the consumer sentiment around sustainability in the environment and how that impacts consumers' preference toward sustainable services. The research method of this paper follows a quantitative and qualitative content analysis using sentiment analysis techniques that provided a lexicon-based approach based on Twitter data. The study data showed that "raw materials", "energy consumption", "waste management", "eco-packaging", "use of recycled plastic", "manage greenhouse gases", and "carbon emission" is the most significant priority of consumers.

Sunday, 8AM–9:15AM

SA74

M - Florida

Digital Finance and Technology

General Session

Session Chair

Agostino Capponi, Columbia University, New York, NY

1 Speedex: A Scalable, Parallelizable, and Economically Efficient Distributed Exchange

Geoffrey Ramseyer, Stanford University, Stanford, CA, Contact: geoff.ramseyer@cs.stanford.edu

SPEEDEX is adecentralized exchange (DEX) that lets participants securely trade assetswithout giving any party undue control. SPEEDEX offers several advantages overprior DEXes. It achieves high throughput—over 200,000 transactions per secondon 48-core servers, even with tens of millions of open offers. SPEEDEX runsentirely within a Layer-1 blockchain. It eliminates internal arbitrageopportunities and eliminates some common types of front-running attacks. Itskey design insight is its use of an Arrow-Debreu exchange market structure thatfixes the valuation of assets in a given block of transactions. This designfurthermore makes trade operations commutative and hence efficientlyparallelizable. SPEEDEX is scheduled for deployment in one of the largest Layer-1 blockchains.

2 The Evolution of Blockchain: From Public to Private Mempool

RUIZHE JIA[1], Agostino Capponi[1], Ye Wang[2], [1]Columbia University, New York, NY, [2]ETH Zurich, Zurich, Switzerland. Contact: RJ2536@COLUMBIA.EDU

We study the economic incentives behind the adoption of private pools. Validators may choose to not monitor private pools to preserve rents extracted from arbitrageurs, hence creating execution risk for users. Private pools neither eliminate frontrunning risk nor reduce transaction fees. The welfare of validators increases, but the welfare of arbitrageurs goes down. A private pool leads to higher aggregate welfare compared to a public pool only blockchain. Empirically, we find that Flashbots private pools increase arbitrageurs' cost-to-revenue ratio by a third.

3 Proof-of-Work Cryptocurrencies: Does Mining Technology Undermine Decentralization?

Sveinn Olafsson, Stevens Institute of Technology, Hoboken, NJ

Does the proof-of-work protocol serve its intended purpose of supporting decentralized cryptocurrency mining? To address this question, we develop a game-theoretical model where miners first invest in hardware to improve the efficiency of their operations, and then compete for mining rewards in a rent-seeking game. We argue that because of hardware constraints faced by miners, centralization in mining is lower than indicated by both public discourse and recent academic work, and that centralization is countercyclical with respect to mining reward. Furthermore, our results highlight that advancements in hardware efficiency do not necessarily lead to larger miners increasing their advantage, but may rather allow smaller miners to expand and new miners to enter. We show that our model predictions are consistent with a detailed empirical analysis of the Bitcoin network.

4 Differential Liquidity Provision in Uniswap V3 and Implications for Contract Design

Francisco Marmolejo Cossío, Harvard University, Cambridge, MA, Contact: fjmarmol@seas.harvard.edu

Decentralized exchanges (DEXs) facilitate trading assets on-chain without the need of a trusted third party. Amongst these, constant function market maker DEXs such as Uniswap handle the most volume of trades between ERC-20 tokens. In Uniswap v3, liquidity providers (LPs) are given the option to differentially allocate liquidity to be used for trades that occur within specific price intervals. We formalize the profit and loss that LPs can earn in simplified trade dynamics and are able to compute optimal liquidity allocations for liquidity providers who hold fixed price trajectory beliefs. We use this tool to shed light on the design question regarding how v3 contracts should partition price space for permissible liquidity allocations. Our results suggest that a richer space of potential partitions can simultaneously benefit both LPs and traders.

Sunday, 8AM–9:15AM

SA75

M - Illinois

Decarbonization in the Water Sector

General Session

Session Chair

Christian Hernandez-Negron, 1</sup

Session Chair

Erin Baker, 1</sup

1 Assessment of the Impact of Farm-scale Renewables on the Carbon Footprint of Center-pivot Irrigation

Nyarko Nanaadom, Western New England University, mmm, AZ

Small Town and Rural (STAR) communities in the United States depend heavily on center-pivot irrigation, which is supplied primarily by grid-connected or diesel-powered pumps. The purpose of this research is to understand how farm-scale renewables can reduce the carbon footprint of center-pivot irrigation. The Global Change Analysis model (GCAM) is used to model the outcome of how much greenhouse gas emissions could be saved if center-pivot irrigation were powered with farm-scale renewables, including green ammonia technologies.

2 Decarbonizing the Water Sector - What Can We Learn from the Energy Sector?

Aaron J. Simon[1], Seth Snyder[2], [1]Carbon Direct, New York, NY, [2]Northwestern University, Chicago, IL

Decarbonizing water and wastewater treatment is an enormous challenge, and also an engineering opportunity. The water sector will benefit from decarbonization of the energy sector because water treatment requires energy and because the water sector can learn from the energy sector's experience. In this talk, we explore the nexus between water and energy, the coupled challenges of decarbonizing both, the differences in scale between water, energy and carbon flows, and case studies from the energy sector. We place decarbonization strategies into a consistent framework that spans sectors.

3 Optimal Management of Food, Energy and Water System in the Presence of Uncertainties

Tianye Wang, George Washington University, Washington, DC, Contact: twang87@email.gwu.edu

This research examines the impact of uncertainties in water supply and the demand for electricity on the nexus of food, energy and water systems (FEWS). Specifically, we develop a suite of optimization models that consider the FEWS as a spatially distributed multi-agent system (MAS) of cities, hydropower plants, irrigation areas, and the policymaker. The uncertainties are addressed using scenarios in a two-stage stochastic process. The methodology is applied to a stylized representation of the Columbia River Basin (CRB) to test its effectiveness particularly in the prescription of the optimal agent responses in the system and to inform policymaking.

Sunday, 8AM–9:15AM

SA76

M - Michigan

George B. Dantzig Dissertation Prize

Award Session

Session Chair

Azarakhsh Malekian, University of Toronto, Toronto, ON, Canada.

Session Chair

Daniela Saban, Stanford University, Aachen

Faster Algorithms for Steiner Tree and Related Problems: From Theory to Practice

Daniel Rehfeldt, Technische Universität Berlin, Berlin,

Germany.
The Steiner tree problem in graphs (SPG) is a classic NP-hard problem. This thesis advances the state of the art in solving SPG and well-known relatives, often found in real-world applications. Based on new theoretical results (e.g., polyhedral descriptions and complexity), the thesis introduces an exact solver for SPG and 14 related problems. The solver is on each of the 15 problem classes significantly faster than previous solvers. The solver is available with source code for academic use (https://scipjack.zib.de/) and is used in industry, for example for the planning of fiber-optic networks.

Causal Inference for Social and Engineering Systems

Anish Agarwal, Massachusetts Institute of Technology, Newton, MA
What will happen to Y if we do A? A variety of meaningful questions can be formulated this way: What if a patient is given a new therapy? What if data center operator introduces a new congestion control protocol? We explore answering such counterfactual questions using observational data and/or very limited experimental data. Two key challenges are: (i) counterfactual prediction in the presence of latent confounders; (ii) estimation with modern datasets which are high-dimensional, noisy, and sparse. The main framework we introduce is connecting causal inference with tensor completion with missing not at random data. The efficacy of our framework is shown on high-impact real-world applications.

Data-Driven Operations in Changing Environments

Ruihao Zhu, Massachusetts Institute of Technology, Cambridge, MA
Recent advances in data science technologies have enabled big-data analytics for operations management problems. Currently, most existing works in this field critically assume the operational environments remain unchanged throughout. However, real-world operational environments are often time-varying and dynamically evolving. In this thesis, we study three different scenarios of operations management in changing environments.

Learning and Earning Under Noise and Uncertainty

Su Jia, CMU, Pittsburgh, PA
Sequential decision-making under uncertainty is central to a range of operations and marketing problems. In the face of an unknown environment, the decision-maker needs to strike a balance between learning the known environment (“learning”) and selecting nearly optimal decisions (“earning”). The trade-off between learning and optimization can be modelled as the Multi-Armed Bandits (MAB) problem, which has attracted significant attention from a range of communities in recent years, including machine learning, operations research and marketing. While most of the fundamental problems in this area have been theoretically well-understood, these algorithms have been rarely deployed in practice. In contrast, while marketing research on sequential decision-making has been focused on the practical side, their results are usually empirical and lacking of rigorous analysis. This thesis serves as a preliminary step towards filling this gap. We will consider practical sequential decision-making problems arising from some of the most fundamental marketing areas including survey design, pricing and content recommendation, and provide theoretical insights via provable performance guarantees

Sunday, 8AM–9:15AM

SA77

M - Texas

Managing Innovation, Collaboration, and User Behavior: Insights from Behavioral Operations

General Session

Session Chair

Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL

1 How Mobile App Updates Affect User Engagement: Empirical Evidence from Mobile App Releases

Alejandro Hernandez De la Lanza, Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL, Contact: alejandro.lanza@kellogg.northwestern.edu
We investigate how to schedule app updates to enhance user engagement, the key driver of app success.

2 Collaboration in Sequential Projects

Ruth Beer[1], Anyan Qi[2], Ignacio Rios[2], [1]Baruch College, CUNY, New York, NY, [2]The University of Texas at Dallas, Richardson, TX, Contact: ruth.beer@baruch.cuny.edu
We explore the decisions of two workers choosing between exerting effort towards a collaborative joint project where their respective tasks need to be completed sequentially, or an outside option. The optimal policy prescribes that when the incentive to finish early is high enough, both workers forgo the outside option and finish the project as early

as possible. On the other hand, a behavioral experiment shows that completing the project takes 60% longer than prescribed by the optimal policy. We analyze the behavioral drivers of this result, and we propose mechanisms to "nudge" workers' behavior.

3 Computer Vision to Measure Product Design Visual Similarity

Egbert Amoncio[1], Tian Chan[2], Cornelia Storz[3], [1]Goethe University Frankfurt, Frankfurt, Germany; [2]Emory University's Goizueta Business School, Atlanta, GA, [3]Goethe University Frankfurt, Frankfurt, Germany. Contact: amoncio.egbert@its.uni-frankfurt.de

Computer vision (CV) enables computers to "see" and "understand" images. We propose that the Structural Similarity Index Measure (SSIM) can be used to quantify the visual similarity across product designs. To test this idea, we first apply SSIM to measure the visual similarity of pairs of designs over a corpus of 400,000 U.S. design patent images granted from 1976 to 2020. We then validate the measure with a validation survey involving 382 online observers. Finally, using the validated similarity measure, we show new and rigorous evidence that aesthetic knowledge spillovers are geographically localized. We discuss how the ability to leverage CV to measure similarity over images opens new avenues of research, and we provide open access to the code and data.

4 The Impact of AI Monitoring on Service Consumption: A Theoretical and Empirical Analysis

Zhaohui (Zoey) Jiang[1], Yao Cui[2], [1]Tepper School of Business, Carnegie Mellon University, Pittsburgh, PA, [2]Cornell University, Ithaca, NY, Contact: zhaohuij@andrew.cmu.edu

With recent technological advancement, many companies introduce AI as a part of their service, e.g., using AI devices to guide consumer behaviors. In this paper, we study the impact of such AI monitoring on consumer service usage. We develop a game-theoretic model featuring the heterogeneous impact of AI monitoring on consumers with different skill levels. We partner with an international car sharing company and design a randomized field experiment to empirically test hypotheses generated from the model. We show theoretically and verify empirically that consumers with either low or high skill levels (as opposed to a medium skill level) benefit more from AI monitoring. We further leverage these findings to provide policy recommendations to companies that are introducing such AI monitoring devices.

5 The Distributional Impact of Fatigue on Performance

Hessam Bavafa[1], Jonas Oddur Jonasson[2], [1]Wisconsin School of Business, Madison, WI, [2]MIT Sloan School of Management, Somerville, MA

Little is known about how people-centric factors affect the shape of service time distributions, despite distributional statistics (variance or quantiles) being key drivers of system performance in many service industries. We investigate, empirically, the impact of within-shift worker fatigue on the average, variance, and quantiles of service times. We find that the average service time increases by 5% throughout the course of an average shift. Furthermore, the workers become less consistent with fatigue; service time variance increases by 39% during a normal shift. In addition to an upward shift in mean service times, both the upper and lower tails of the distribution have more weight for fatigued workers.

Sunday, 8AM–9:15AM

SA78

M - Utah

The Offline Socio-economic Impacts of Online Interventions

General Session

Session Chair

Yash Babar, University of Wisconsin-Madison, Madison, WI

1 The Impact of E-scooters on Retail Visits: Empirical Analysis Using Graph Neural Networks

Ruichun Liu, Unnati Narang, UIUC, Champaign, IL, Contact: narang.unnati@gmail.com

Shared micromobility services have expanded rapidly in recent years. Within micromobility, electric scooters (e-scooters) account for 63% of the trips. However, not much is known about the effects of e-scooters. This research examines the effects of e-scooters on visits to retailers. The results from a difference-in-differences analysis show that e-scooters significantly increase visits to restaurants. We also find a stronger effect for previously less visited restaurants and non-chain restaurants, suggesting that e-scooters facilitate the discovery of less known restaurants by consumers. To analyze the mechanisms, we use spectral convolutional graph neural networks. E-scooter trips to restaurants are shorter and slower than other trips (e.g., grocery), suggesting that use of e-scooters for leisure and restaurant discovery could explain our results.

2 The Impact of Early Digital Movie Releases on Box Office Revenue: Evidence from the Korean Market

Yangfan Liang[1], Gordon Burtch[2], Daegon Cho[3], Michael D. Smith[4], [1]Pittsburgh, PA, [2]Boston University, Boston, MA, [3]KAIST, Seoul, Korea, Republic of; [4]Carnegie Mellon University, Pittsburgh, PA

Most movies in the United States are first released exclusively via theaters for 2-3 months. These lengthy theatrical exclusivity windows have come under pressure with the rise of digital distribution channels, sparking debate between movie studios and theater owners about the possible impact of shortened exclusivity windows on box-office revenue and overall movie profitability. Our work informs this debate by examining early home digital release that have taken place in the South Korean movie market. By utilizing a triple differences design, we observe a statistically and economically insignificant decline in theatrical revenue from early home release, equivalent to a ~0.8% drop in the first eight weeks' theatrical revenue. We also estimate that early home release increases the marginal profit to studios over the first eight weeks of movie release by ~12%.

3 Entry of Online Grocery Delivery Services in the U.S. and Widening of the Nutritional Inequalities

Hyeonsik Shin, Taha Havakhor, Min-Seok Pang, Temple University, Philadelphia, PA, Contact: hshin@temple.edu

This paper examines the effect of third-party online grocery delivery services (OGDS) on the obesity rate. By exploiting the nationwide quasi-experimental setting of Instacart's staggered entries at the US county-level in 2004-2017, we find that the entry of Instacart lowers the obesity rate by 0.64 percentage points and, however, that this impact becomes greater for the high-income counties. Further analyses show that the Instacart entry leads to large grocery stores more concentrated in few zip-codes, widening nutritional inequality gaps between the wealthy and the poor. This study contributes to the information systems (IS) literature by providing robust empirical evidence that points to the role of digital platforms in exacerbating societal inequalities. Policy implications such as lowering barriers to use of OGDS for the low-income population are discussed.

4 E-Access versus Physical Access: An Analysis of the Rural Health Care Program

Eric Xu, University of Minnesota, Minneapolis, MN

While our current conception of telemedicine has existed for half a century, beginning with the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC), only recent telecommunication advancements have increased the pace of adoption amongst patients and practitioners. Therefore, we examine the impact of telemedicine adoption on primary care use, specifically examining the conditions by which telehealth consultations become a substitute for in-person care or a compliment to in-person care. Using a unique dataset of insurance claims for primary care visits, we examine in-person, asynchronous, and synchronous primary care visits.

Sunday, 8AM–9:15AM

SA79

JWM - Room 201

The Frontier of Collaborative Design

General Session

Session Chair

Alison Olechowski, University of Toronto, Toronto, ON, Canada.

1 Model-robust Experimentation Strategy for Estimation of Expensive Black-box Functions with Mixed Quantitative and Qualitative Factors

Gautham Sunder[1], Christopher Nachtsheim[2], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, Contact: sunde153@umn.edu

Design of experiments is an indispensable tool during product development for characterizing the relationship between product features and key product quality metrics and for identifying the optimal product configuration. The model-robust experimentation strategy proposed in this study was inspired by our collaboration with a large medical device manufacturer on hyperparameter tuning of deep neural networks while developing an automated quality inspection system. The proposed adaptive experimentation strategy is a hybrid between Response Surface Optimization (RSO) and Bayesian Optimization (BO) methods. Our simulation study illustrates that the proposed experimentation strategy is more efficient than BO methods for estimating a locally second-order black-box function and has comparable performance to BO methods when the black-box function is nonlinear.

2 Analysis of Communication Patterns in Engineering Product Design Via Enterprise Social Networks

Alison Olechowski, University of Toronto, Toronto, ON, Canada.

Enterprise social network messaging sites are becoming increasingly popular for team communication in engineering and product design. These digital communication platforms capture detailed messages between members of the design team and are an appealing data set for researchers who seek to better understand communication in design. This exploratory study investigates whether we can use enterprise social network messages to model communication patterns throughout the product design process. We apply a variety of Natural Language Processing techniques to a data set comprising of 250,000 messages sent by 32 teams enrolled in a 3-month intensive product design course. Our study delivers implications for engineering idea convergence and divergence, effective team communication, and development of shared understanding.

3 Data-driven design: Managing Beyond the Hype

Julie Johnson, University of Waterloo, Waterdown, ON, Canada.

Recent literature on data-driven design describes how big data and machine learning algorithms are dramatically changing design as well as the organizations in which design is practiced. Despite this promise, there is still much that we don't know about how new data-driven design processes are evolved and adopted by design teams and organizations. The goal of this research is to discover how design management should adapt to this paradigm shift. We provide a survey of research to date, identify its limitations, and identify opportunities for future investigation.

4 Technology Affordances and Collaborative, Cloud-based Cad

Tucker Marion[1], Alison Olechowski[2], Satish Nambisan[3], [1]Northeastern University, Boston, MA, [2]University of Toronto, Toronto, ON, Canada; [3]Case Western Reserve University, leveland, OH, Contact: t.marion@neu.edu

Modern CAD platforms enable synchronicity, where actions move at the same rate, and exactly together. For those studies evaluating specific CAD tools, little research has focused on synchronicity, collaboration and cloud characteristics. Recent research has begun to use a technology affordance lens to examine innovation and knowledge creation in large-scale collaboration networks. Technology affordances are relational and denote action possibilities offered by a set of technology features to meet the goals of an individual, group or organization. The aim of our research is to develop a conceptual framework for mid-level affordances of cloud-based CAD that links specific engineering challenges within knowledge-based theory on collaborative networks.

Sunday, 8AM–9:15AM

SA80

JWM - Room 202

Human, Machines, and Algorithms Session 1

General Session

Session Chair

Yicheng Song, University of Minnesota, Minneapolis, MN

1 Frequency-biased Diffusion: Disproportionate Reception of Rare Categories of Events in Social Networks

Alice Jayoung Jang, Virginia Tech, Blacksburg, VA, Contact: ajjang@vt.edu

The quality of information that diffuses in social networks is a current concern. While the previous research has focused on the lack of accuracy of information in social networks, we focus on another dimension of quality, namely, representativeness of overall mix of information that diffuses in social networks. We conducted randomized online laboratory experiments of information diffusion with multi-step social networks. We find that the further someone is down a diffusion chain, the more the mix of information that they receive is biased toward rarer categories of events. We name the disproportionate exposure to rarer categories of events "frequency-biased diffusion". We also show that this systematic bias risks de-emphasizing the importance of empirically common categories of events and over-emphasizing the importance of empirically rare categories of events.

2 Emojis Predict Dropouts of Remote Workers: An Empirical Study of Emoji Usage on Github

Xuan Lu[1], Wei Ai[2], Zhenpeng Chen[3], Yanbin Cao[3], Qiaozhu Mei[1], [1]University of Michigan, Ann Arbor, MI, [2]University of Maryland, Ann Arbor, MI, [3]Peking University, Beijing, China. Contact: luxuan@umich.edu

Emotions at work have long been identified as critical signals of work motivations, status, and attitudes, and as predictors of various work-related outcomes. When more and more employees work remotely, these emotional signals of workers become harder to observe through daily, face-to-face communications. The use of online platforms to communicate and collaborate at work provides an alternative channel to monitor the emotions of workers. This paper studies how emojis, as non-verbal cues in online communications, can be used for such purposes and how the emotional signals in emoji usage can be used to predict future behavior of workers.

3 A Concept-based Hierarchical Method for Cross-document Modeling and Predictions

Yu Qin, Paul J. Hu, Olivia R. L. Sheng, University of Utah, Salt Lake City, UT, Contact: yu.qin@eccles.utah.edu

The rapidly proliferated information technology has fueled the creation of voluminous and often fragmented information that is essential to various business purposes. Although abundant, such information is difficult to use and interpret, due to several limitations of existing analytics methods. Toward that end, cross-document modeling is crucial. It leverages natural language processing to extract essential information and identify nonobvious relationships from textual documents. In this study, we propose a two-stage concept-based hierarchical deep learning method to extract and model important concept information from relevant but fragmented source documents, which enables downstream predictive analytics for business applications. We use a financial scenario to illustrate the value and use of our method, in comparison with several benchmark methods.

4 Understanding Instructor Performance in Digital Education with a Hierarchical Bert Model

Wen Wang, Carnegie Mellon University, Fornebu

With the development of technology, online education has been growing rapidly over the past decade. Despite its economic and societal importance, there is little empirical research that assists in understanding instructor performance in digital education. In our paper, we conduct a systematic study to evaluate instructors' online teaching style and their instructional materials using a unique dataset that consists of 1,085 online courses collected from Coursera. Our results show that instructors' verbal cues and their course structure design are both significantly associated with instructors' performance evaluation. We then propose a hierarchical BERT model to predict instructors' performance in digital education. Our proposed model captures the hierarchical structure within each course as well as the deep semantic features extracted from the course content.

Sunday, 8AM–9:15AM

SA81

JWM - Room 203

Supply Chain Optimization at Amazon

General Session

Session Chair

Chun Ye, Amazon.com

1 A Practical Approach to Model the Impact of Origin and Destination Flows Variability in a Logistics Network

Julie Poullet[1], Jochen Koenemann[2], Cristiana L. Lara[1], [1]Amazon, Seattle, WA, [2]University of Waterloo, Waterloo, ON, Canada. Contact: jpoullet@amazon.com

Supply chain networks of e-commerce retailers are subject to high variability. This variability is both inherent to their business, such as demand volume driven by customers, and a result of actual operations, such as fulfillment decisions driven by capacity awareness and inventory availability. Such variability negatively impacts costs, as most resources are scheduled weeks in advance. Specifically, it creates large linehaul cost headwinds for the middle mile network: variability in lane volume leads to expensive last-minute truck adhocs and cancellations. We develop a practical approach to incorporate Amazon fulfillment variability to strategical planning decisions. We propose a methodology to study how such variability impacts different network designs and derive insights for designing more resilient networks with respect to operational variability.

2 Tenet Based Network Design

Yuan Li[1], Xiaoyan Si[1], Shahbaaz Mubeen[1], Yijiang Li[2], [1]Amazon, Seattle, WA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: yyuanli@amazon.com

Amazon's growing outbound networks came with exponentially increasing complexities and challenges for both operations and plannings. To continue offering superior customer experience at the best speed, selections, and prices, we need to break the complexity spirals. To do so we investigate several network connection tenets that impose more structures to the network. We illustrate trade-offs considered in practice, evaluated through optimizations/simulations.

3 A Base Cost Distribution Model to Control Towards Source to Sink Target Flow Ratios

Qi Chen, Amazon, Bellevue, WA

We present a probabilistic model for controlling aggregate target flow ratios from a set of sources to a set of sinks, through the application of offset costs to influence a higher-granularity discrete decision oracle operating on individual flow packets. We evaluate model performance against varying levels of orthogonality in net background control influences to the decision oracle. We also describe a coupled lower level corrector to close the control gap.

4 **Dimension Reduction and Inference in Strategic Planning Through ML**
Zhikun Gao[1], Chun Ye[2], [1]Amazon, Seattle, WA, [2]Amazon.com, Seattle, WA
In planning a delivery network, finer network design assumptions would lead to better accuracy of cost and utilization metrics estimation. However, at early stage, the granularity of assumption is coarse. Thus, it requires us to estimate the key business metrics (e.g. cost and speed) of a network only from its high-level design assumptions. We propose a ML model to identify impactful drivers to key business metrics and use them to construct a consolidated network, which abstracts away lower-level details. This method reduces the complexity of planning a network, meanwhile estimates the key metrics at a suitable degree of accuracy. As a result, the key metrics can be evaluated directly from early planning stage to provide directional guidance for detailed builds plan.

Sunday, 8AM–9:15AM

SA82

JWM - Room 204
Life as a PhD Student
Panel Session

Session Chair
Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY

1 **Moderator**
Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY
Deciding to start a Ph.D. is not an easy task. Yet, many of us decide to trust our abilities and knowledge to take that step and enroll in the program of interest. While everyone's path is unique, for the most part, life as a Ph.D. student is challenging and requires hard work, sacrifice, and perseverance. It makes one wonder why to pursue this path? How to overcome the challenges faced during these years? Is it worth the sacrifice? This panel is intended to cover all these questions about life as a Ph.D. student, hearing opinions from current and former Ph.D. students.

2 **Panelist**
Milan Preet Kaur, Rensselaer Polytechnic Institute, Troy, NY

3 **Panelist**
John Ayaburi, Colorado School of Mines, Golden, CO

4 **Panelist**
Aaron Swift, Colorado School of Mines, Golden, CO

5 **Panelist**
Lan Peng, University at Buffalo-SUNY, Buffalo, NY

Sunday, 8AM–9:15AM

SA83

JWM - Room 205
Planning for Sustainable Energy
Contributed Session

Session Chair
An Pham, University of Michigan/Center for Sustainable Systems, Ann Arbor, MI

1 **Designing Sustainability Transitions Towards a Net-zero Emissions and Circular Future**
Vyom Thakker, Bhavik R. Bakshi, The Ohio State University, Columbus, OH, Contact: thakker.8@osu.edu
Industry and governments are pledging to achieve sustainability and circularity targets to mitigate climate change by as early as 2030. However, recent reports suggest that most of these institutions are unable to make solid action plans for achieving these targets. This is partly due to the oversight of potential innovations, emerging technologies and policy interventions. The objective of this work is to perform planning optimization to obtain eco-innovation roadmaps to meet sustainability targets, while minimizing investment costs and carbon budget utilization. The constraints account for long term planning, evolution of eco-innovation readiness of adoption, and changing background emissions over the time horizon. The framework generates a 'gantt chart' to describe an optimal investment strategy, for innovations in the plastic packaging industry.

2 **Achieving Power Sector Carbon Neutrality in a Low-cost Renewable Era**
Gang He, Stony Brook University, Stony Brook, NY

Clean power transition is at the center to achieve mid-century carbon neutrality goals. The cost of solar and wind has plummeted in the past decade, and solar and wind electricity has been achieving grid parity. Low-cost renewables offer new perspectives for energy system decarbonization that was less visioned before. In this talk, Dr. He will discuss the pathways of clean power transition and their system impacts using high-resolution models, to reflect the need for integrating variable renewable energy and phasing out coal to achieve carbon neutrality in the power sector at a low-cost renewables era.

3 The Value of Advanced Planning for a Negative Emissions Power System

An Pham[1], Michael Craig[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: anph@umich.edu

Few studies examine the impact of planning for negative emission systems (NES) to achieve aggressive mitigation pathways under different timelines. We fill this critical gap by quantifying power system consequences of planning for NES at two different points along decarbonization pathways - beginning in 2020 and in 2050. We use an optimization-based capacity expansion model applied to the Eastern Interconnection (EI) and Electric Reliability Council of Texas (ERCOT). We show that planning for NES in 2020 lowers annual cost by $14 billion or 2% ($2 billion or 2%) in EI (ERCOT) compared to planning for NES in 2050. The value of planning for NES early increases when technological constraints are more stringent. Our results suggest planning for NES in 2020 compared to 2050 yields little cost saving, indicating that utilities should continue planning for net-zero systems by 2050.

Sunday, 8AM–9:15AM

SA84

JWM - Room 206

Simulation Optimization and Output Analysis

General Session

Session Chair

David J. Eckman, Texas A&M University, College Station, TX

1 On Constructing Confidence Sets for Multi-objective Stochastic Optimization

Susan R. Hunter[1], Raghu Pasupathy[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN

We consider the context of multi-objective stochastic optimization; that is, multi-objective optimization when the objective functions can only be observed with stochastic error in presence of a dataset of size n. We seek frequentist, asymptotically valid in n, (1-alpha) confidence sets on the efficient set (in the decision space) and the Pareto set (in the objective space). Toward this end, we discuss the construction of an appropriate Central Limit Theorem (CLT) in infinite dimensions, as well as its translation into a finite-dimensional object that can be computed.

2 Finding a Portfolio of Best Systems for Subjective Constraints

Yuwei Zhou[1], Sigrun Andradottir[2], Seong-Hee Kim[2], [1]University of Chicago, Chicago, IL, [2]ISyE Georgia Tech, Atlanta, GA, Contact: Yuwei.Zhou@chicagobooth.edu

We consider the problem of finding a portfolio of systems with the best primary performance measure among finitely many simulated systems as stochastic constraints on secondary performance measures are relaxed. By finding the best systems under a variety of constraint thresholds, the decision maker can identify a robust solution with respect to the constraints or consider the trade-off between the primary performance measure and the level of feasibility of the secondary performance measures. Given that there is no change in the underlying simulated systems, we propose an indifference-zone procedure that recycles simulation observations. We prove that the proposed procedure identifies the portfolio of the best systems with at least a pre-specified probability and show that it saves observations compared with repeatedly applying existing procedures.

3 Simulation Optimization with Censored Streaming Data

Roberto Szechtman, Naval Postgraduate School, Monterey, CA

We consider online optimization of physical systems with censored information. As realizations of the system materialize, the information gathered to-date is used to optimize the system's execution. The information available is incomplete in two ways: (i) the system's parameters are initially unknown, but can be estimated from physical realizations; and (ii), the system's inputs may be censored. We motivate this framework with a variety of examples, and establish convergence results for policies that take advantage of uncensored estimators.

4 Confidence Bands for Shape-Constrained Performance Measures of Simulation Models

David J. Eckman[1], Matthew Plumlee[2], Barry L. Nelson[2], [1]Texas A&M University, College Station, TX, [2]Northwestern

University, Evanston, IL, Contact: eckman@tamu.edu

Many grey-box simulation models give rise to performance measures possessing known functional properties, such as monotonicity, Lipschitz continuity, or convexity. We introduce a framework that accommodates and exploits such forms of functional information to infer the performances of unsimulated solutions. In particular, we use mathematical programming to construct upper and lower bounds on the unknown performance measure. Asymptotically, these lower and upper bounds achieve a desired level of confidence uniformly over the solution space and are consistent pointwise. These ideas are illustrated in a series of examples and compared to existing approaches.

Sunday, 8AM–9:15AM

SA85

JWM - Room 207

Teaching/DEIC/MIF: Inclusive Pedagogy Experiences in Teaching OR/MS courses

General Session

Session Chair

Ruben Proano, 1</sup

1 Integrating Social Justice into Engineering Classes

Destenie S. Nock, Carnegie Mellon University, Pittsburgh, PA

Multiple studies call for engineering education to integrate the social aspect of engineering into classroom instruction. Yet, there is uncertainty regarding whether integrating these social topics into engineering curriculum will support or detract from learning of technical concepts. We evaluate how reframing technical assessments to include social justice concepts impacts student learning, and investigate how well students can integrate social justice into engineering decision making. We use a within subject design in which students were exposed to both conditions (questions with and without social justice context) we evaluate how social justice framing impacts overall student learning of technical topics. The majority of students showed an increase in critical thinking skills related to evaluating the social justice implications of technical decisions.

2 Inclusion and Equity in an Online Management Science Course

Kenneth E. Murphy, University of California Irvine, Irvine, CA, Contact: murphyke@uci.edu

DEI initiatives in academic institutions seek to expand opportunity, raise awareness, and enhance skills to meet the challenges of an increasingly diverse world. How do the concepts of equity and inclusion apply in the instruction of math modeling courses? This presentation provides working definitions for these constructs in the context of OR/MS course delivery. We present student perceptions of course inclusivity and equity based on data gathered in a medium-sized online management science course. We then consider the relationship between these metrics and engagement and outcome variables with the goal of informing on tangible actions for instruction and course administration.

3 A Scaffolding Module for Teaching Undergraduate Data Analytics Inclusive of Limited Prior Backgrounds in Programming and Analytics

Mihir Mehta, Pennsylvania State University, State College, PA

Undergraduate students with a little background in programming and data analytics often face challenges in learning problem-solving skills. To help all students become better problem-solvers, we developed a scaffolded assignment that leverages publicly available data sets. In this presentation, we describe our scaffolding module implementation. We designed active incremental learning exercises to assist with project completion. We highlighted similarities between different types of datasets. We helped students to develop essential analytics skills useful for areas such as manufacturing, retail, and finance, through this engaging and positive learning-based implementation.

4 Promoting Inclusion Through Effective Groupwork

Susan E. Martonosi, Harvey Mudd College, Claremont, CA

Active learning techniques have been shown to improve learning for all students, and particularly for students from underrepresented groups. In this talk, I will focus on active learning groupwork that I use in my undergraduate classes. I will discuss three important principles that guide my use of groupwork to promote inclusion: 1) Everybody should have a role; 2) The task should be properly scaffolded. 3) A collaboration mindset should be cultivated. These principles will be illustrated through successful (and less-than-successful) classroom examples.

Sunday, 8AM–9:15AM

SA86

JWM - Room 208

AAS Best Student Presentation Competition 3/3

Award Session

Session Chair

Keji Wei, Sabre, Grapevine, TX

1 Resilient Airline Scheduling to Minimize Delay Risks

Deniz Simsek, Northwestern University, Evanston, IL

Airlines tend to design their flights schedules with the primary concern of the minimization of operational costs. However, the recently emerging idea of resilient scheduling defined as staying operational in case of unexpected disruptions and adaptability should be of great importance for airlines as well due to the high opportunity costs caused by the flight cancellations and passenger inconvenience caused by delays in the schedule. In this study, we integrate resilient airline schedule design, aircraft routing and fleet assignment problems with uncertain non-cruise times and controllable cruise times. We follow a data-driven method to estimate flight delay probabilities to calculate the airport congestion coefficients required for the probability distributions of non-cruise time random variables. We formulate the problem as a bi-criteria nonlinear mixed integer mathematical model with chance constraints. The nonlinearity caused by the fuel consumption and CO_2 emission function associated with the controllable cruise times in our first objective is handled by second order conic inequalities. We minimize the total absolute deviation of the aircraft path variability's from the average in our second objective to generate balanced schedules in terms of resilience. We compare the recovery performances of our proposed schedules to the minimum cost schedules by a scenario-based posterior analysis.

3 A Cloud-based Low Altitude Surveillance System for Advanced Air Mobility Operations: Cost-benefit Analysis for The State of Ohio

Esrat Farhana Dulia, Kent State University, Kent, OH

Advanced Air Mobility (AAM) will enable emerging aircraft to operate efficiently in lower altitude airspace in the near future. To detect and track AAM traffic, a Low Altitude Surveillance Information Clearinghouse (LASIC) can serve a vital role as a cloud-based data collection, monitoring, and distribution center, where AAM operators handling different AAM use cases — passenger and cargo transportation, medical delivery etc. — will subscribe to receive relevant AAM traffic data to plan their operations. In this work, we present a framework for the LASIC of Ohio and perform a cost-benefit analysis. The insights gained justify investment in this infrastructure, showing that LASIC will generate revenues from subscriptions for investors and benefit AAM operators and policymakers.

4 Iterative Exact and Heuristic Algorithms for Airline Timetable Development

Ritesh Ojha, Georgia Institute of Technology, Atlanta, GA

Airline companies operate flights in markets (defined as origin-destination pairs) to satisfy customer demand as much as possible with available resources (i.e aircrafts). Designing a flight timetable for even one major airline is an enormous undertaking. In this research, we formulate the airline timetable development problem over a time-expanded network. Key decisions in the model are represented by flight-arc variables, which determine the fleet type and departure time of an aircraft. Overall, these departures must meet given demand for every market, and must satisfy airport operating hours, minimum inter-departure times, and overnight aircraft parking constraints. We develop a multi-phase integer-programming based solution approach that works with relatively smaller integer programs in every phase to yield high quality feasible solutions (flight timetables) for practically-sized instances. Preliminary results are illustrated using data available from the Bureau of Transportation Statistics.

Multimodal Strategies for Mitigating Congestion from Urban Parcel Delivery Integrating Drones, Non-motorized Vehicles and Trucks

Ang Li[1], Mark M. Hansen[2], Bo Zou[3], [1]University of California-Berkeley, Emeryville, CA, [2]University of California-Berkeley, Berkeley, CA, [3]University of Illinois, Chicago, IL

The explosive growth in e-commerce, the increasing urgency of de-carbonization, the rapid advances in UAV technology, and the continuous disruptive development of the gig economy create needs and opportunities for dramatic improvements in urban package delivery. To mitigate the congestion impact from truck and van traffic, as well as reduce costs and travel times, last-mile delivery should in many cases be shifted toward non-motorized modes and UAV. In this research, we propose a suite of multimodal, congestion-sensitive strategies for urban delivery, by integrating traditional motorized vehicles, non-motorized modes, and UAV. We first conceptualize and optimize the integrated delivery strategy combining different types of vehicles, then incorporate congestion effects into the integrated delivery strategy.

Sunday, 8AM–9:15AM

SA87

JWM - Room 209
Management of Electronic Waste
Contributed Session

Session Chair
Gazi Duman, University of New Haven, West Haven, CT

1 On Robust Optimization, Blackouts and The Law

Dirk Lauinger[1], François Vuille[2], Daniel Kuhn[3], [1]EPFL, Lausanne, Switzerland; [2]Etat de Vaud, Lausanne, Switzerland; [3]Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, Switzerland. Contact: dirk.lauinger@epfl.ch

Vehicle-to-grid is the idea of meeting the growing demand of electricity storage, e.g., for frequency regulation with batteries of parked electric vehicles. Frequency regulation providers promise to charge or discharge their batteries whenever the grid frequency deviates from its nominal value. They must honor their promises for all frequency deviation trajectories that satisfy certain properties prescribed by EU law. We encode the law in a robust optimization model and find that the penalties for non-compliance with market rules are currently too low. This suggests that "crime pays".

2 Planning a Circular Economy System for Electric Vehicles Using Network Simulation

Sidi Deng[1], Yuehwern Yih[1], John W. Sutherland[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN, Contact: deng100@purdue.edu

This study develops a stochastic activity network to simulate a circular economy system for rebuilding/renewing used electric vehicles and extracting maximum value from end-of-life components and materials. The designed process chain coordinates and synergizes concomitant procedures such as disassembly, processing, and reassembly. The network framework integrates a process planning model and a cost-benefit model to consider both system productivity and its pricing strategy. The results provide evidence for the technical viability of the proposed system design from an operational viewpoint and suggest its promising economic potential in industrial practice.

3 Battery Energy Storage Systems: When Does Heterogeneity Work?

Joonho Bae, Roman Kapuscinski, John M. Silberholz, University of Michigan Ross School of Business, Ann Arbor, MI, Contact: baejh@umich.edu

With the rapid development of technology and the increased availability of batteries (e.g., retired batteries from electric vehicles), battery operators often have the option of investing in heterogeneous systems that can be built from battery modules with different types, ages, and capacity ratings. What complicates this decision is the fact that the projected benefits from a heterogeneous battery portfolio fluctuate considerably due to many factors such as battery degradation. We consider contingency applications (e.g., backup battery power system) where the battery operator commits to provide energy in an emergency under the presence of uncertainty. This paper uses analytical modeling to systemically characterize the benefits of heterogeneity in battery systems and establish general lessons.

4 Electronic Waste Prediction for Circular Economy: A Novel Grey Forecasting Model

Gazi M. Duman[1], Elif Kongar[2], Surendra Gupta[3], [1]University of New Haven, West Haven, CT, [2]Fairfield University, Fairfield, CT, [3]Northeastern University, Boston, MA, Contact: gduman@newhaven.edu

Electronic waste is today one of the fastest growing municipal solid waste streams in the US. Accurate e-waste predictions that municipalities can utilize to build appropriate reverse logistics infrastructures play an important role in waste collection, recycling and disposal operations. The literature offers a wide range of approaches that investigate e-waste estimation. Among these, Grey Modeling has drawn attention due to its ability to provide meaningful results with even small-sized data. The proposed non-linear grey Bernoulli model with convolution integral improved by Particle Swarm Optimization demonstrates superior accuracy over alternative models. Furthermore, Fractional Order Accumulation method is applied to increase the precision of the forecast. A case study utilizing Washington State e-waste data is provided for comparative analysis.

Sunday, 9:35AM–10:45AM

SP

CC - Sagamore 5
Plenary: Cynthia Rudin
Plenary Session

Welcome

Brad Weaber[1], Radhika Kulkarni[2], Elena Gerstmann[3], [1]INFORMS Annual Meeting Host, Brad Weaber Consulting Group, LLC, Washington, DC, [2]INFORMS President, SAS Institute Inc. (retired), Durham, NC, [3]INFORMS Executive

Director, Catonsville, MD

Opening Remarks

Sheldon H. Jacobson, General Chair, University of Illinois, Urbana, IL

1 Do Simpler Machine Learning Models Exist and How Can We Find Them?

Cynthia Rudin, Duke University, Durham, NC

While the trend in machine learning has tended towards building more complicated (black box) models, such models are not as useful for high stakes decisions - black box models have led to mistakes in bail and parole decisions in criminal justice, flawed models in healthcare, and inexplicable loan decisions in finance. Simpler, interpretable models would be better. Thus, we consider questions that diametrically oppose the trend in the field: for which types of datasets would we expect to get simpler models at the same level of accuracy as black box models? If such simpler-yet-accurate models exist, how can we use optimization to find these simpler models? In this talk, I present an easy calculation to check for the possibility of a simpler (yet accurate) model before computing one. This calculation indicates that simpler-but-accurate models do exist in practice more often than you might think. Also, some types of these simple models are (surprisingly) small enough that they can be memorized or printed on an index card.

Sunday, 11AM–12:15 PM

SB01

CC - Room 101

Heavy-tailedness, Dependence and Robustness in Econometrics, Economics and Finance

General Session

Session Chair

Rustam Ibragimov, Imperial College Business School, London, United Kingdom.

1 The Bias of the Gini Coefficient

Victor de la Pena, Department of Statistics, Columbia University, Fairfield, CT

In this talk, I will present a formula for the exact biasof the sample Gini coefficient.

2 A Machine Learning Attack on Illegal Trading

Artem Prokhorov, University of Sydney Business School, Woodcroft, Australia.

We design an adaptive framework for the detection of illegal trading behavior. Its keycomponent is an extension of a pattern recognition tool, originating from the field of signalprocessing and adapted to modern electronic systems of securities trading. The new methodcombines the flexibility of dynamic time warping with contemporary approaches from extremevalue theory to explore large-scale transaction data and accurately identify illegal trading patterns.Importantly, our method does not need access to any confirmed illegal transactions fortraining. We use a high-frequency order book dataset provided by an international investment firm to show that the method achieves remarkable improvements over alternative approaches inthe identification of suspected illegal insider trading cases.

3 Change Point Detection in Time Series Using Mixed Integer Programming

Alexander Semenov, University of Florida and St. Petersburg State University, Shalimar, FL

We use recent advances in mixed integer optimization (MIO) methods to develop a framework for identification and estimation of structural breaks in time series. The framework requires a transformation of the the classical structural break detection problem into an Mixed Integer Quadratic Programming problem. MIO is capable of finding provably optimal solutions to this problem using a well-known optimization solver. The framework allows to determine the unknown number of structural breaks. In addition to that, we demonstrate how to accommodate a specific required number of structural breaks, or a minimal required number of breaks. We demonstrate the effectiveness of our approach through extensive numerical experiments on synthetic and real-world data.

4 Intergenerational Transmission of Tail Inequality in Incomes

Joseph Gatus[1], Rustam Ibragimov[2], Paul Kattuman[3], [1]Goldman Sachs, London, United Kingdom; [2]Imperial College Business School, London, United Kingdom; [3]University of Cambridge, Cambridge, United Kingdom. Contact: pak13@cam.ac.uk

It is known that over the last many decades income inequality has increased substantially. It is also known that much of the increase has been in the upper tail of the income distribution. It would be useful to know to what extent the increase in upper tail income inequality is inter generationally transmitted. The tail index of the income distribution is a summary measure of inequality among top incomes. We examine the direction and extent to which the intergenerational mobility estimated for the United Kingdom using the British Household panel survey accounts for the changes the tail index of the income distribution of the parent's generation to the tail index of the income distribution of the child's generation. We elucidate the methodological contribution and discuss findings and implications for the evolution of upper tail income inequality.

5 New approaches to Robust on Market (Non-) Efficiency, Volatility Clustering and Nonlinear Dependence

Rustam Ibragimov, Imperial College Business School, London, United Kingdom.

Many financial and economic variables, including financial returns, exhibit nonlinear dependence, heterogeneity and heavy-tailedness. These properties may make problematic the analysis of (non-)efficiency and volatility clustering in economic and financial markets using traditional approaches that appeal to asymptotic normality of sample autocorrelation functions of returns and their squares. This paper presents new approaches to deal with the above problems. We provide the results that motivate the use of measures of market (non-)efficiency and volatility clustering based on (small) powers of absolute returns and their signed versions. We further provide new approaches to robust inference on the measures in the case of general time series, including GARCH-type processes. The approaches are based on robust t-statistics tests and new results on their applicability are presented. In the approaches, parameter estimates (e.g., estimates of measures of nonlinear dependence) are computed for groups of data, and the inference is based on t-statistics in the resulting group estimates. This results in valid robust inference under heterogeneity and dependence assumptions satisfied in real-world financial markets. Numerical results and empirical applications confirm the advantages and wide applicability of the proposed approaches.

Sunday, 11AM–12:15 PM

SB02

CC - Room 102

Accounting Information and Data Analytics

General Session

Session Chair

Arion Cheong, California State University at Fullerton, Irvine, CA

1 Strategic Competitive Positioning: An Unsupervised Structural Hole-based Firm-specific Measure

Myunghwan Lee, Gene Moo Lee, Hasan Cavusoglu, Marc David L. Seidel, University of British Columbia, Vancouver, BC, Canada. Contact: myunghwan.lee@sauder.ubc.ca

Our research proposes structural hole-based strategic competitive positioning (SCP) measures to capture a firm's competitive and strategic positioning. Drawing on the network theory and structural holes concept, we operationalize SCP measures using a machine learning approach called doc2vec, creating a similarity matrix of all existing U.S. publicly traded firms. This enables us to construct firm-level measures of strategic competitive positioning. To show the effectiveness of the proposed measures, we provide illustrative examples and conduct a case study on the imprinting effect of IPOs on short- and long-term firm performance. This paper makes a significant methodological contribution to the information systems and strategic management literature by proposing a network theory-based approach to measure firm-level competition and strategic positioning.

2 Impact of Viewers Targeting on Viral Marketing in Social Network Service

Youhyun Lee, University of Florida, Gainesville, FL, Contact: youhyun.lee@ufl.edu

The research investigate the answer of following question. Can targeting viewers contribute to spread a branded post in Social network service more broadly? Targeting viewers means a marketing campaign considers followers' interests when it decides to pay for an influencer to seed a branded post.

3 Cookie Intermediates: Does Competition Leads to More Privacy? Evidence from the Dark Web

Arion Cheong[1], D. Daniel Sokol[1], Tawei Wang[2], [1]California State University at Fullerton, Irvine, CA, [2]DePaul University, Chicago, IL

In this study, we focus on firms voluntarily share their customer information with third parties and the corresponding consequences. Specifically, we collect first-party cookies of U.S. firms that are identified as a digital online platform and examine how they share customer information through these first-party cookies. Based on this sample, we then analyze how the market structure of an industry sector affects the level of personal information leakage on the darkweb. The results show that firms in less concentrated markets share more customer information with third-party entities and experience more customer privacy information leakage than the firms in more highly concentrated markets. Further, we demonstrate that the data sharing activities with data brokers with more highly concentrated market share result in less customer personal information leakage. Our result suggests that the market structure and the level of competition are two factors that should be considered for policy decision-making. regarding privacy policy.

Sunday, 11AM–12:15 PM

SB03

CC - Room 103

Machine Learning in Finance

General Session

Session Chair

Xin He, City University in Hong Kong, Hong Kong, China.

1 Data Driven Wealth Management

Sikun Xu[1], Ali Hirsa[2], Miao Wang[2], Federico Klinkert[3], [1]Washington University in St. Louis, St. Louis, MO, [2]Columbia University in the City of New York, New York, NY, [3]ASK2.AI, New York, NY, Contact: sikun@wustl.edu

In this research we established a data driven system for wealth management. The wealth management system consists of four major modules: security selection, asset allocation, portfolio optimization and risk management. It utilizes a large variety of data including fund performance, alternative data, macroeconomic indicators, etc., to assist dynamic and robust portfolio decisions. We designed a dynamic, explainable and automated pipeline of machine learning and deep learning models to process the large amount of hetero-structured data. We tested our system in the U.S. mutual fund market and in comparison to traditional wealth management methodologies, we are able to achieve superior performance.

2 Portfolio Choice for Online Loans and Implications for Platforms

Zonghao Yang[1], Moris Simon Strub[2], Ram Gopal[3], Xiao Qiao[1], [1]City University of Hong Kong, Hong Kong, China; [2]Southern University of Science and Technology, Shenzhen, China; [3]University of Warwick, Coventry, United Kingdom. Contact: zonghao.y@my.cityu.edu.hk

Using over one million LendingClub loans, we investigate the suitability of online loans as an investment. We introduce generalized portfolio policies, where we propose a nonlinear portfolio policy based on a shallow neural network. The nonlinear loan portfolio outperforms the naïve equal-weight portfolio and earns competitive rates of return to that of the S&P 500 while showing limited comovement. Our results indicate that online loans are an attractive novel asset class for investors. Platforms may consider embedding a dual-layer portfolio framework in a robo-advising system, which would expand the access of sophisticated loan portfolios to a broad set of investors.

3 The Factor Model Failure Puzzle

Carter Davis[1], Brian Boyer[2], Fahiz Baba-Yara[1], [1]Kelley School of Business, Indiana University, Bloomington, IN, [2]BYU Marriott School of Business, Provo, UT, Contact: ckd1@iu.edu

Despite the weak theoretical assumptions needed to guarantee the existence of a factor model that prices the cross-section of stock returns we show in a meta-analysis of fifteen state-of-the-art models that none of these models can price the mean-variance efficient portfolio of the other fourteen. No one model effectively describes the cross-section of US equities. Our results highlight the need to benchmark new factor models against each other, rather than traditional test assets. When markets are incomplete, an infinite number of stochastic discount factors price assets, but empirically, we have yet to find just one. We refer to this as the*factor model failure puzzle*. We present a theoretical model with many weak anomaly trading signals and show that slight methodological deviations lead to different factor models that all fail as observed empirically.

4 Attention Based Dynamic Graph Neural Network for Asset Pricing

Ajim Uddin, Xinyuan Tao, Dantong Yu, New Jersey Institute of Technology, Newark, NJ, Contact: au76@njit.edu

Networks among firms (sectors) play an essential role in asset valuation. These networks are dynamic and continuously evolve in response to market micro and macro changes. This paper develops an end-to-end graph neural network model to capture the implication of dynamic network structure in asset pricing. First, we apply the graph attention mechanism to learn dynamic network structures of the equity market over time and then use a recurrent convolutional neural network to diffuse and propagate firms' fundamental information into the learned networks. The superiority of our model is demonstrated in both return prediction and portfolio Sharpe ratio. The dynamic network learned from our model represents general market conditions over time and explains the equity network systemic risk previously identified in the literature.

Sunday, 11AM–12:15 PM

SB04

CC - Room 104
Intelligent Decision Making Technique and Application in Transportation
General Session

Session Chair
Ruilin Ouyang, Northeastern University, MATTAPAN, MA

1 **Column Generation Based Load Builder Engine for Walmart's First-mile Transportation Network**
Kunlei Lian[1], Ming Ni[1], Liqing Zhang[2], Mingang Fu[3], Ti Zhang[4], Yu Zheng[1], [1]Walmart, Bentonville, AR, [2]Walmart, Humble, TX, [3]Walmart, Palo Alto, CA, [4]Walmart, Sunnyvale, CA, Contact: ming.ni@walmart.com
Tens of thousands of shipments need to be moved from geographically dispersed suppliers to distribution centers daily on Walmart's first-mile transportation network. Efficiently consolidating shipments into bigger loads allows Walmart to earn preferred rates, reduce operational costs and improve overall supply chain efficiency. We present an in-house developed optimization engine that employs column generation (CG) to create promising candidate loads and identify the optimal loads. Upon transforming the problem into the CG framework, the main problem identifies shipment dual values, which are then utilized by various tailored heuristic/metaheuristic algorithms to solve the pricing problem efficiently.

2 **Powering Walmart's Spark Driver Assignment: Driver Matching 2.0, a Scalable Service Design with Machine Learning and Optimization**
Xi Chen, Walmart, Sunnyvale, CA
Spark delivery service is Walmart's last mile delivery solution. This paper presents a novel system design that provides efficient and customized offer assignment to Spark drivers with the help of machine learning (ML) and optimization, and with a robust system design that can scale to serve all Spark-enabled markets. The optimization engine forms the backbone of the system that searches for the global optimal driver assignments, while multiple ML services are incorporated into the system to model driver preference and driver real time activity. A distributed high-performance system is designed to provide reliability, scalability and maintainability to our driver assignment system. After launching the system on large scale, an encouraging improvement in multiple performance metrics have been observed, with few to none engineering concerns.

3 **Optimizing Outbound Multi-stop Routing Plan for Walmart Grocery Network**
Xiaojie Wang, Tiantian Nie, Fereydoun Adbesh, Ti Zhang, Walmart, Sunnyvale, CA
Creating routing plans that satisfy both safety and operational requirements moving pallets from distribution centers (DCs) to stores is essential and challenging when considering commodities that vary from dry to perishable and scale of the problem. To address the routing and load planning automatically, optimally and simultaneously, a set of algorithms were developed and deployed in a hosting application - Load Planner (LP). This talk focuses on demonstrating the related techniques considering stores' time window, department of transportation (DOT) rules, and feasible load design requirements, etc. Our LP algorithm obtains routing solutions that show a 3.7% reduction in miles and a 3.7% reduction in the number of routes compared to the original solver system with 4 DCs and one month of data.

Sunday, 11AM–12:15 PM

SB06

CC - Room 106
Cyber Security and Special Topics
General Session

Session Chair
Anh Ta, University of Nebraska Omaha

1 **Improving Cyber Resilience of Critical Assets Network**
Kam-Fung Cheung, Barney Tan, The University of New South Wales, Sydney, Australia. Contact: kf.cheung@unsw.edu.au
The COVID-19 pandemic accelerates the digitisation of businesses, while its associated cyber threats affect various industries such as logistics and retail. The unavailable critical assets due to successful cyberattacks undermine an organisation's profit, thus there is an urgency in enhancing cyber resilience of the critical assets network, i.e., the backbone network, in the organisation. This paper proposes a novel model based on eigenvector centrality to identify (hidden) critical assets in an organisation and improve their resilience by adding redundant links among them. With the case study of a retail company, managerial

insights on enhancing cyber resilience in the critical assets network such as designing backup strategies and managing shadow IT systems.

2 Provider-firm Cybersecurity Investment Spillover: Implications for the Supply Chain

Hooman Hidaji, University of Calgary, Calgary, AB, Canada. Contact: hooman.hidaji@haskayne.ucalgary.ca

As cybersecurity threats become more prevalent and IT supply chains more intertwined, providers and firms need to invest in cybersecurity to secure their supply chains. A critical managerial problem is the level and interaction of the cybersecurity investments by the providers and firms. While some provider investments substitute potential firm investment, others are complementary to the firm investment. We use a general-form model to study this problem. We find that provider investment incentivizes firm investment only if the provider investment has a positive spillover on firm investment, and that downstream competition negatively impacts this effect. Interestingly, in the case of substitutable (complementary) provider-firm investment spillover, increased provider investment benefits firm profit only if downstream externality is positive (negative).

3 Critical Infrastructure Risk Assessment at Scale

Jason Reinhardt[1], Derek Koolman[2], Jeffrey Munns[3], Lauren Wind[3], Merideth Secor[2], [1]Sandia National Laboratories, Livermore, CA, [2]Cybersecurity and Infrastructure Security Agency, Arlington, VA, [3]SPA, Alexandria, VA, Contact: jason.reinhardt@associates.cisa.dhs.gov

The Cybersecurity and Infrastructure Security Agency (CISA) has the mission to lead the National effort to understand, manage, and reduce risk to our cyber and physical infrastructure. CISA has developed a representation of critical infrastructure (CI) as a functional graph of interconnected nodes based on the National Critical Functions (NCFs) to enable risk analysis at the national scale. A Risk Architecture (RA) is being created that uses the NCF dependency structure in a risk analytic framework. The RA employs a matrix formalism approach for risk analysis of disparate and interconnected CI at scale. This talk will introduce the NCF structure and the RA, describe the matrix formalization used, and discuss examples.

4 Effect of Executive Qualification on Information Security Risk

Hau Tran[1], Linh Le[2], Anh Ta[3], [1]University of North Texas, Denton, TX, [2]Penn State Behrend, Erie, PA, [3]University of Nebraska Omaha

This study empirically investigates whether the presence of a Chief Information Officer (CIO) on the board of directors reduces firms' information security risks, measured by the incidence of cyberattacks. In addition, the study shows that the qualification of CIOs also plays a role in managing information security incidents. The findings extend the literature about the role of the top management team in mitigating information security risks.

Sunday, 11AM–12:15 PM

SB07

CC - Room 107

Big Data Applications in Global Operations and Management

General Session

Session Chair

Xiaojin Liu, Virginia Commonwealth University, Richmond, VA

Session Chair

Pankaj Kumar, Virginia Tech

1 Know Your Users Before You Spend: A Data-driven Optimization Approach to Enhance User Engagement Using Visual Analytics

Mayukh Majumdar[1], Subodha Kumar[2], Chelliah Sriskandarajah[3], [1]University of San Diego, San Diego, CA, [2]Fox School of Business, Temple University, Philadelphia, PA, [3]Texas A&M University, College Station, TX

Social media platforms have become an increasingly popular channel for firms to advertise their products via social media posts. How to effectively develop posts with compelling features and understand what users prefer to engage thus become important tasks. Even though post development using social media analytics by utilizing budget efficiently is essential for firms, it has not been examined rigorously in the literature. To bridge this important gap, we propose a novel optimization framework for analyzing and publishing social media posts across multiple platforms for a planning horizon under a firm's limited budget. Our framework and the findings have important implications for firms aiming to improve their social media presence.

2 Correlation-Enhanced Deep Learning and Its Applications in Operations Management

Hu Yang[1], Kedong Chen[2], [1]Central University of Finance and Economics, Beijing, China; [2]Old Dominion University,

Norfolk, VA, Contact: kchen@odu.edu
Deep learning is gaining popularity in operations management (OM) research. However, traditional deep learning (DL) methods such as long short-term memory (LSTM) and Gated Recurrent Unit (GRU) cannot well handle spatially correlated data in prediction. Interrelationships between regions constitute an important feature in real-world OM data and problems. To improve prediction accuracy, we take spatial correlation into consideration and propose correlation-enhanced deep learning as an extension to traditional DL models. We apply the proposed method to practically critical OM problems and illustrate its applications. We demonstrate a superior prediction performance after using correlation-enhanced deep learning.

3 Data Science-driven Monitoring of Slug-flow Process in Crystallization Synthesizing

Yanjun Qian, Virginia Commonwealth University, Richmond, VA

In continuous chemical manufacturing, the slug-flow process plays an important role in crystallization synthesizing and provides better process control and reproducibility. However, it is challenging to maintain the uniformity of the crystal size when scaling-up slugs. Thanks to the advances in in-line imaging technologies, we can apply state-of-the-art data science methods to improve flow control for better crystallization quality. We first adopt image processing and deep learning to detect all the slugs along with the crystals inside them. Then, their sizes and shapes are analyzed by statistical methods to model the slug flow behaviors. With the in-line monitoring and modeling, the proposed work will lead to a controller to scale up slug-flow without sacrificing slug and crystal size uniformity.

4 How Do Online Signals of Social Identity Affect Businesses in the Restaurant Industry?

Ali Adeli[1], Yash Babar[2], Gordon Burtch[3], [1]The University of Memphis, Memphis, TN, [2]University of Wisconsin-Madison, Madison, WI, [3]Boston University, Boston, MA, Contact: amadeli@memphis.edu

Flags, posters, photos, stickers, and other pieces of shop décor can all signal the social identity of shopkeepers. Past research has shown that these sorts of offline identity cues can have large consequences on consumer behavior. Recently, digitization has led most brick-and-mortar establishments to present an online business profile. Whereas social identity may be inferred as a byproduct of casual inspection in the offline space, with online presentations, businesses gain greater control over what, when, and how they signal social identity information. Both Google and Yelp have introduced identity signaling features into their platforms, enabling establishments to post explicit indicators of owner race, gender, and minority allyship. In this work, we ask whether, when, and how these identity-signaling features impact Restaurants and other eating places.

Sunday, 11AM–12:15 PM

SB08

CC - Room 108
Big Data and Machine Learning
Contributed Session

Session Chair
Md Asif Bin Syed, West Virginia University, Morgantown, WV

1 Learning from Imbalanced Data with Triplet Adversarial Samples

Jaesub Yun[1], Jong-Seok Lee[2], [1]Sungkyunkwan University, SUWON-SI, Korea, Republic of; [2]Sungkyunkwan University, Suwon, Korea, Republic of. Contact: yunjaesub@gmail.com

Class imbalance is one of the most challenging problems in the field of machine learning. To address this issue, we present a novel synthetic sample generation method that incorporates both the triplet loss and the adversarial attack scheme. The former is intended to create a synthetic sample that is similar to original minority class samples, whilst the latter is to place the synthetic sample close to its decision boundary. Both aim to increase classification performance by strengthening minority class generalization. The proposed method outperformed the state-of-the-art algorithms on artificial and real-world datasets, demonstrating better classification performance.

2 Out-of-distribution Detection Using Angular Margin Loss and Regularization Between Output and Penultimate Layers of Neural Networks

TaeWook Kim[1], Jong-Seok Lee[2], [1]Sungkyunkwan University, Suwon, Korea, Republic of; [2]Sungkyunkwan University, Suwon, Korea, Republic of. Contact: redxtar@skku.edu

Discriminating out-of-distribution (OOD) samples from in-distribution ones is important in terms of the safe use of machine learning models. This research proposes a novel training scheme for neural networks to detect OOD. The proposed method employs the angular margin loss as a learning objective and regularization between output and penultimate layers of a neural network. The former is to create discriminative embedding features and the latter is to make gentle prediction surfaces near decision boundaries in the created embedding space. Both intend to eventually prevent overconfident predictions. Numerical experiments showed that our method improved the OOD detection of a classifier while preserving its classification performance.

3 A Convolutional-LSTM Architecture Inspired Track Association Algorithm for Marine Vessels

Md Asif Bin Syed[1], Imtiaz Ahmed[2], [1]West Virginia University, Morgantown, WV, [2]West Virginia University, Morgantown, WV, Contact: ms00110@mix.wvu.edu

Tracking multiple moving objects in real-time in a dynamic threat environment is important in national security and surveillance. In this work, we have implemented the Conv-LSTM for the association of the Marine vessels using the time series features collected by an Automatic Identification system.In order to implement the Deep learning Algorithm, the data must first be preprocessed for missing values before being fed into the Conv-LSTM architecture. Then the Conv-LSTM architecture has been used for the Classification of the input data. For the benchmarking, We have compared our algorithm with other time series classification algorithms. Given the imbalanced characteristics of AIS data, the F1 score is used to evaluate the performance of the Conv-LSTM. The result demonstrates that the Conv-LSTM outperforms in the classification of AIS datasets.

Sunday, 11AM–12:15 PM

SB09

CC - Room 109

Data Mining Flash Session II

Flash Session

Session Chair

Ziwei Su, Northwestern University, Evanston, IL

1 OR in Practice: Opportunities, Challenges, and Best Practices

Filippo Focacci, Decision Brain, Paris, France.

We bring together a group of OR enthusiasts from business owners, to practitioners to academic researchers to share their perspectives on adoption of OR in today's challenging economic environment. In this flash paper we will dig into global disruptions and how OR-based methods and systems can and are being used to support organizations in maneuvering through uncertainty.

2 A Deep RL Framework for Reach-avoid Zero-sum Games and Its Application to Viability Kernel and Backward Reachable Set

Jingqi Li[1], Donggun Lee[2], Somayeh Sojoudi[3], Claire Tomlin[1], [1]University of California, Berkeley, Berkeley, CA, [2]University of California, Berkeley, Berkeley, CA, [3]University of California, Berkeley, El Cerrito, CA, Contact: jingqili@berkeley.edu

We consider the reach-avoid zero-sum game problem, where the goal is to find a set in the state space such that the system starting at a state therein could be controlled to reach a given target set without violating constraints under the worst-case disturbance. We solve the problem by designing a new value function with a contracting Bellman backup, where the super-zero level set recovers the reach-avoid set. We prove that the proposed method can be adapted to compute the viability kernel and the backward reachable set. Finally, we adopt the Conservative Q-Learning to alleviate the curse of dimensionality issue such that a conservative approximation to the reach-avoid set can be learned.

3 Extending and Improving Iterative Kernel-based Regressions Using Tensor Processing and Local Models

Ben Hen[1], Ángela Fernández[2], Neta Rabin[1], [1]Tel-Aviv University, Tel-Aviv, Israel; [2]Universidad Autónoma de Madrid, Madrid, Spain. Contact: netara@tauex.tau.ac.il

Iterative kernel-based regression constructs a multi-scale representation of the train data, where the modes are the average residuals. We describe several extensions of this model. For dealing with data that has non-uniform noise, we compute a point-dependent stopping criterion. Localization in the frequency is achieved by combining the iterative regression with Emperical Mode Decomposition (EMD). Processing of tabular datasets is done by operating on the row and column spaces of the data. Experimental prediction and forecasting results are demonstrated on real world dataset.

4 Analyzing Self-presentation Text on Linkedin: Who is Noble, Who is Humble?

Vivian Simon[1], Neta Rabin[1], Hila Chalutz Ben-Gal[2], [1]Tel Aviv University, Tel Aviv, Israel; [2]Tel Aviv Afeka Academic College of Engineering, Tel Aviv, Israel. Contact: hilab@afeka.ac.il

The growing practice of AI enabled recruitment systems via social networks has become a major component of talent recruitment tools. Data overflow of personal information may result in conscious or unconscious bias. Efforts have been made to eliminate such bias but further investigation is needed. We analyze candidates' textual self-presentation utilizing ML methods on a training dataset of 14K LinkedIn profiles. Our results indicate that some features have significant influence on gender gaps of textual self-presentation. Our research methods may be adopted by AI-enabled recruitment tools to improve the diversity of candidates and reduce bias.

5 Nonparametric Empirical Bayes Prediction in Mixed Models

Trambak Banerjee, University of Kansas, Lawrence, KS

We develop a novel framework, EBPred, for empirical Bayes prediction in mixed models. The predictions from EBPred rely on the Best Predictor of the random effects, which are constructed without any parametric assumption on the distribution of the random effects and offer a natural extension to the BLUP when the true random effect distribution is not Normal. We develop theory to show that the corresponding predictions from EBPred are asymptotically optimal in terms of mean squared error for prediction. Extensive simulation studies demonstrate that EBPred outperforms existing predictive rules in mixed models and the efficiency gain is substantial in many settings.

6 Data-Driven Robust Optimization with Conformal Prediction

Chancellor Johnstone[1], Eugene Ndiaye[2], Bruce Cox[3], [1]Air Force Institute of Technology, Dayton, OH, [2]Georgia Institute of Technology, Atlanta, GA, [3]Air Force Institute of Technology, Dayton, OH

One method of incorporating uncertainty into making optimal decisions is through robust optimization (RO), which minimizes the worst-case scenario over uncertainty sets. Conformal prediction is a method for uncertainty quantification that works with any prediction methodology and provides information on the uncertainty around some data point of interest, under fewer assumptions that traditional uncertainty sets. We discuss previous work to connect robust optimization and conformal prediction, practical issues, current work to solve these issues and potential methodological applications. This topic is a work in progress.

7 Knowledge Graphs and Covid-19: Challenges, Opportunities and Successes

Mayank Kejriwal, University of Southern California, Marina del Rey, CA

The impacts of the COVID-19 pandemic have had not just health, but also socio-political and economic ramifications. Improvements in Artificial Intelligence (AI), cheap computation, and availability of open datasets present both an opportunity and novel challenges in applying AI to complex real-world problems, such as COVID-19. In this flash talk, I will briefly review an innovative applied AI technology called a knowledge graph (KG) that can robustly facilitate a wide range of information and analytical needs. As evidenced by creative implementations in industry and academia, KGs have already played an important role in the fight against COVID-19, but face many challenges (and opportunities).

8 Rate-Optimal Contextual Online Matching Bandit

Yuantong Li[1], Chi-Hua Wang[2], Guang Cheng[3], Will Wei Sun[2], [1]University of California, Los Angeles, Los Angeles, CA, [2]Purdue University, West Lafayette, IN, [3]University of California, Los Angeles, Los Angeles, CA, Contact: yuantongli@ucla.edu

Two-sided online matching platforms have been employed in various markets. However, agents' preferences in present market are usually unknown and must be learned from data. With the growing availability of side information involved in the decision process, modern online matching methodology demands the capability to track preference dynamics for agents based on their contextual information. This motivates us to consider a novel Contextual Online Matching Bandit prOblem (COMBO), which allows dynamic preferences in matching decisions. In this paper, we propose a Centralized Contextual - Explore Then Commit (CC-ETC) algorithm to adapt to the COMBO.

9 Soft-Cascading Assortment Bandits

Hyun-jun Choi, Min-hwan Oh, Seoul National University, Seoul, Korea, Republic of. Contact: nschj1@snu.ac.kr

We propose a new sequential assortment selection problem, soft-cascading assortment bandits. The decision-making agent offers a user a cascade of slates where each slate is a set of items. A distinct feature is allowing the user to leave the system completely when there are no attractive items, which is prohibited in the existing cascade bandit models. The feedback of user choice is given by a multinomial logit choice model. We propose a UCB algorithm for this problem with provable guarantees. The empirical experiments support the theoretical claims.

10 Stochastic Simulation Calibration of Inexact Computer Models

Ziwei Su[1], Matthew Plumlee[2], [1]Northwestern University,

Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: ziwei.su@northwestern.edu
Stochastic simulation models generate random samples designed to emulate a system or process. To help align the simulation model with the target process, data is used to calibrate the model. Calibration is especially difficult when the model is inexact, meaning that there is always a difference between the model and the target process (model discrepancy). Much of the existing literature on calibration under model discrepancy focus on deterministic models. Calibration for stochastic models is harder as the discrepancy is now a difference between distributions. In this talk, I will discuss recent developments in stochastic simulation calibration of inexact computer models that address the challenges of simultaneous parameter and discrepancy estimation.

Sunday, 11AM–12:15 PM

SB10

CC - Room 110
Intelligent Systems Design and Social Issues
General Session

Session Chair

Chenglong Zhang, Chinese University of Hong Kong, Shenzhen, Shenzhen, China.

1 The Effect of Emoji on Intervention for Misinformation

Seonjun Kang[1], Yeongin Kim[2], Victoria Yoon[1], [1]Virginia Commonwealth University, Richmond, VA, [2]Virginia Commonwealth University, Glen Allen, VA, Contact: kangs10@vcu.edu
With the development of social media, we can quickly obtain information from a variety of sources. However, as social media also promotes the spread of misinformation, the damage caused by distorted facts is also increasing rapidly. Therefore, social media platforms have been intervening to prevent the spread of misinformation. For example, Facebook shows a label on top of a photo or video of a misinformation article and displays a link to a fact-checker's assessment. However, emojis accompanying online articles that capture other users' emotional reactions to the article undermine the label's effectiveness. Drawing on cognitive dissonance theory, emotions as social information theory, and social influence theory, we study the effect of emojis on the trust in the intervention and the online article believability.

2 Contagion of Investor Sentiment in Online Investment Communities: Evidence from Dynamic Visuals on Stocktwits

Ming Gu, University of California, Irvine, Irvine, CA
We study the associations of GIFs with user-declared stock sentiment, trading behavior, and future stock returns at the firm-day level. On firm-days with GIF postings, we find higher net bullish sentiment, higher retail order imbalance, and short sale volume; and initial positive abnormal returns followed by a longer-term reversal. The GIF associations with sentiment, return overreaction, and short sale volume are stronger on firm-days with popular GIFs, with GIFs with declared sentiment, with GIFs from influencers, and in firms with higher retail ownership. Retail buys and retail sells separately, and not order imbalance, are stronger in firms with higher retail ownership. Our findings suggest that dynamic visuals in social media postings are associated with greater investor attention and higher bullish sentiment, resulting in net buying and overpricing.

3 Is that Decision Fair? A Formal Model to Assess an Individual's Belief on the Fairness of a Decision

Chenglong Zhang[1], Young U. Ryu[2], Varghese S. Jacob[2], [1]Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [2]University of Texas-Dallas, Richardson, TX, Contact: chenglong.zhang@utdallas.edu
The concept of fairness has been addressed by many disciplines. However, prior studies have not formally represent individuals' view of a fair decision mathematically nor determined how to represent the degree to which a decision is viewed as fair by individuals. Based on the concept that "fairness is in the eye of the beholder," we provide a framework to formally represent individuals' view of the fairness of a decision using the scheme in Dempster and Schafer's theory of evidence. This allows us to capture the strength of the individual's fairness belief and represent the person's indifference to the outcome of the decision. We further illustrate how a decision-maker can use the knowledge of the fairness beliefs of a group of individuals to make an optimal decision on the fairness criteria. We also used data from Tweeter and Youtube to validate and operationalize our model.

Sunday, 11AM–12:15 PM

SB11

CC - Room 111

AI-driven Business Analytics: New Advances and Applications

General Session

Session Chair

Denghui Zhang, 1</sup

Session Chair

Zixuan Yuan, 1</sup

1 Using Artificial Intelligence to Mitigate Human Errors in Nuclear Power Plants: A Case in Operation and Maintenance

Bhavya Reddy Kolta[1], Ezgi Gursel[2], Anahita Khojandi[2], Mahboubeh Madadi[3], Jamie Coble[2], Vivek Agarwal[4], Vaibhav Yadav[4], Ronald Laurids Boring[4], [1]San Jose State University, San Jose, CA, [2]University of Tennessee, Knoxville, TN, [3]San Jose State University, San Jose, CA, [4]Idaho National Laboratory, Idaho Falls, ID, Contact: bhavyareddy.kotla@sjsu.edu

Human errors(HEs) are an important concern in safety-critical systems such as nuclear power plants(NPPs). HEs attributed to many deadly accidents and outage incidents. Despite increased automation in NPPs, HE remain unavoidable. Hence, HE detection is as important as prevention. In this study, we develop an unsupervised anomaly detection technique based on generative adversarial networks(GANs). GAN trained to detect mismatches between continuously-recorded sensor and manually-collected surveillance data; tested on both real-world and external dataset obtained from testbed. Results benchmarked against unsupervised anomaly detection algorithms, like one-class support vector machine and isolation forest. Results indicate improved anomaly detection performance by proposed GAN, showing promise for future development of AI-based HE detection systems.

2 Hierarchical Knowledge Transfer Networks for Traffic Accident Forecasting on Heterogeneous Spatio-temporal

Bang An[1], Amin Vahedian Khezerlou[2], Xun Zhou[3], Nick Street[3], Li Yanhua[4], [1]Iowa University, Iowa City, IA, [2]Northern Illinois University,, DeKalb, IL, [3]University of Iowa, Iowa City, IA, [4]Worcester Polytechnic Institute, Worcester, MA, Contact: bang-an@uiowa.edu

Traffic accident forecasting is a significant problem for transportation management and public safety. However, this problem is challenging due to the spatial heterogeneity of the environment and complex factors resulting in accidents. Recent traffic accident prediction methods have attempted to use deep learning models to improve accuracy. However, most of these methods focus on small-scale and homogeneous areas and fail to handle heterogeneity in large regions. To address these limitations, this paper proposes a novel Hierarchical Knowledge Transfer Network model to capture irregular heterogeneity patterns better. Extensive experiments on a real-world accident dataset from the state of Iowa demonstrate that the proposed model can accurately capture underlying heterogeneous patterns and greatly improve prediction performances

3 A Discrete Search Game with Multiple Hidden Objects

Thuy Bui, Thomas Lidbetter, Rutgers Business School, Newark, NJ, Contact: tb680@business.rutgers.edu

Consider a zero-sum game between a Hider and a Searcher. The Hider places m objects in m of n boxes ($n>m$). The Searcher picks an infinite sequence corresponding to the order in which the boxes are searched. Every time the Searcher looks in box i, if the target is there, he finds it independently with overlook probability p_i and pays a cost of c_i. The game concludes when k $(1 \le k \le m)$ objects are found. The payoff of the game is the expected cost paid until the Searcher finds k objects. We consider the case where the parameters p_i are all equal and the parameters c_i are all equal 1. We give a full solution to this game for any arbitrary number of boxes n and number of objects m, k. We also prove the existence of a pure optimal strategy and construct the pure optimal strategy for some cases.

4 Acqui-hiring or Acqui-quitting: Post-M&A Turnover Prediction via a Dual-fit Model

Denghui Zhang[1], Howard Zhong[2], Jingyuan Yang[3], [1]Rutgers Business School, Newark, NJ, [2]ESCP Business School, Paris, France; [3]George Mason University, Fairfax, VA, Contact: dhzhangai@gmail.com

Gaining highly skilled human capital is one of the primary reasons for corporate mergers and acquisitions (M&A), especially for knowledge intensive industry. However, the inevitable tensions brought by the divergent cultures and organizational misalignment during M&A process result in high talent turnover rate and ultimately integration failure. Hence, it is imperative to understand and prepare for potential effects of M&A on employee turnover. To this end, we propose a novel dual-fit heterogeneous Graph Neural Network model to predict talent turnover trend by taking into account complex relationship among the acquirer firm, acquiree firm, and the acquired employees. Specifically, we design a dual-fit model comprised of both the firm-level and employee-firm fit. Extensive evaluations on large-scale real-world data demonstrate the effectiveness of our approach.

Sunday, 11AM–12:15 PM

SB12

CC - Room 113

Physician-in-the-loop AI

General Session

Session Chair

Michael Lash, University of Kansas, Lawrence, KS

Session Chair

Tinglong Dai, Johns Hopkins University, Baltimore, MD

1 Operationalizing Physician-in-the-Loop Treatment Recommendations

Michael Lash[1], Tinglong Dai[2], [1]University of Kansas, Lawrence, KS, [2]Johns Hopkins University, Baltimore, MD, Contact: michael.lash@ku.edu

Artificial intelligence has become increasingly prevalent in shaping healthcare decisions. However, because healthcare providers (esp., physicians) are ultimately responsible for these decisions, human involvement in the decision-making process is required. In this paper, we model and analyze a physician-in-the-loop AI treatment recommendation system. We characterize the conditions under which physicians might choose to use or not use AI systems. We also consider trust, the patient's perceived benefit, and the trade-offs between the two.

3 Human and AI Collaboration - Incorporating Artificial Intelligence as an Enablement into Adverse Event Identification for Pharmacovigilance

PROMIT ROY[1], Yufei Huang[2], [1]Trinity College Dublin, Dublin, Ireland; [2]Trinity Business School, Trinity College Dublin, Dublin, Ireland. Contact: royp@tcd.ie

Traditionally, Adverse Event (AE) detection and monitoring for Drug Safety in Pharmacovigilance involve many manual processes. Trained experts have to go over a huge amount of text-based information collected from patients, healthcare professionals and the engaged public. The process is time- and cost-intensive with low speed and varied accuracy. Recently, Artificial Intelligence (AI) and Machine Learning (ML), have been adopted into the process to collaborate with human experts to extract potential AEs via natural language processing and text mining. In this study, we use a large data set from an international pharmaceutical company to identify the viability of using an AI and ML in real-time AE detection and evaluate its impact on effectiveness and efficiency. We observe a significant improvement in both speed and accuracy in AE detection and monitoring.

2 Jumpstarting Online Interactions to Promote Smoking Cessation- Analyzing the Role of Seed Users in an Online Health Community

Xiangyu Wang, University of New South Wales (UNSW), Sydney, Australia.

When starting a new online community, a useful practice is to recruit "seed users" to create content and encourage participation from community members. However, in the context of online health communities (OHCs), where users with similar health concerns interact, the impact of interacting with seed users on members' health outcomes remains unknown. Using data from an OHC for smoking cessation, we found that support from seed users predicts member abstinence. In addition, seed users who were former smokers were more effective in supporting others to quit. The analysis of posting behaviors also revealed differences between the support provided by seed users who were former smokers vs. current smokers. Outcomes of this study can aid the design of a supportive OHC and the promotion of smoking cessation.

Sunday, 11AM–12:15 PM

SB13

CC - Room 114

Applied OR in Risk and Readiness Analysis

General Session

Session Chair

Shaun Doheney, Amazon Web Services (AWS), Stafford, VA

1 Optimally Assigning Army Recruiters

Timothy Lambert[1], Lihui Bai[2], [1]United States Army and the University of Louisville, Louisville, KY, [2]University of Louisville, Louisville, KY

In 2021, the United States Army Recruiting Command (USAREC) had approximately 9000 recruiters actively seeking to bring young men and women into the United States Army. The requirement was to contract a combined 93520 future soldiers into both the Regular Army and Army Reserve. However, USAREC fell over 20000 contracts short of that requirement. Although this presentation will not explore environmental factors that may have resulted in some of the shortfall, it will show that realigning recruiters can provide opportunities to increase contracts. This presentation presents an integer linear program, Optimally Assigning

Army Recruiters, using recruiting station locations and production rates to provide an optimal assignment of Army recruiters that maximizes market potential.

2 **Educational Wargaming for Operational Energy**

Nicholas Ulmer, United States Navy, Pacific Grove, CA

Naval Postgraduate School developed and played an educational DND-style game with an ultimate goal of providing an enriching experience of how operational energy is a critical component of military force development. The purpose of the game was explained to players as a visceral sense of winning or losing based on the operational energy decisions made in two phases of gameplay. They achieve this through connecting procurement and technology investment decisions to operational consequences. The focus has been on education and provocation vice analysis. However, comments from students afterwards provide evidence of lasting impression, understanding, and appreciation for the complexity of operational energy in warfare

Sunday, 11AM–12:15 PM

SB14

CC - Room 115

Challenges and Innovative Solutions for Urban Logistics

Joint Session

Session Chair

Zhengtian Xu, George Washington University, DC

Session Chair

Qi Luo, Clemson University, Clemson, SC

1 **Optimal On-demand Order Assignment Through Dynamic Surge Pricing in Online Meal-delivery Markets via Deep Reinforcement Learning**

Azadeh Gharibreza Yazdi[1], Vadim Sokolov[2], Elise Miller-Hooks[1], [1]George Mason University, Fairfax, VA, [2]George Mason University, Fairfax, VA, Contact: agharibr@gmu.edu

Meal delivery companies connect customers to restaurants by assigning orders to crowd-sourced drivers. During peak demand periods, there may be insufficient at-will drivers available. The meal delivery company may wish to provide incentives through surge prices to encourage drivers to take new jobs. In this presentation, we propose a deep reinforcement learning method to derive optimal surge pricing policies during demand surges in this dynamic, stochastic multi-agent setting.

2 **Dynamic Routing of Drones for Last-Mile Delivery with Demand Uncertainty**

Linxuan Shi[1], Zhengtian Xu[2], Miguel Lejeune[3], [1]The George Washington University, Washington, DC, [2]The George Washington University, Washington, [3]George Washington University, Arlington, VA, Contact: shilx@gwmail.gwu.edu

Drones, given their advantage in avoiding ground obstacles and congestion, are projected as a promising means of transportation for the shipping and delivery market. This study aims at conceptualizing and modeling the use of drone fleets for urban logistics, including parcels, meals, groceries, among others. We focus on the dynamic deployment problem of a drone fleet for last-mile delivery by considering stochastic demand arrivals with heterogeneity and uncertainty in the delivery items' weights, pickup/drop-off locations, and delivery windows. A two-stage stochastic programming model is formulated and solved through an ad-hoc solution algorithm. The first stage accounts for the system-level considerations regarding fleet deployment, followed by the second stage delineating the interactions between the stochastic demand and dispatching decisions of drones.

3 **Strategies for Assigning Delivery Jobs with Uncertain Ready Times to At-will Couriers**

Weiwen Zhou[1], Elise Miller-Hooks[1], Sagar Sahasrabudhe[2], [1]George Mason University, Fairfax, VA, [2]Grubhub, Chicago, IL, Contact: wzhou5@gmu.edu

This presentation proposes a dynamic order assignment and courier routing problem that arises in a stochastic, dynamic meal delivery environment with uncertainty in upcoming orders, handling times and availability of couriers who sign in and out from the delivery platform at will. A stochastic, discrete event simulator is developed to replicate real meal delivery operations and an ejection chain neighborhood-embedded tabu search heuristic is proposed for its solution.

Sunday, 11AM–12:15 PM

SB15

CC - Room 120

Decision-making, Utilization, and Outcomes in Emergency Departments

General Session

Session Chair
Gabriel Zayas-Caban, University of Wisconsin Madison, Madison, WI

Session Chair
Valerie Odeh-Couvertier, University of Wisconsin, WI

1 Average Response Curves for Treatment Time in the Emergency Department

Sebastian Alejandro Alvarez Avendano, University of Wisconsin, Madison, WI, Contact: alvarezavend@wisc.edu

We estimate average responses curves for treatment time in the Emergency Department. Extending treatment time is a promising solution for improving admission decisions. Providing support for this solution, however, is difficult because this intervention (treatment) is a continuous time-to-event; is strongly influenced by unmeasured patient health needs; and may be only modifiable up to a shift in the realized time. We show that average responses curves for treatment time cannot be identified nonparametrically due to unmeasured confounding from patient health needs. We thus use a parametric model that includes a latent variable for health needs and a threshold regression model for the admission process.

2 Temporal Analysis of Frequent Emergency Department Visits: A Machine Learning Approach

Lloyd Fernandes[1], Hyojung Kang[1], Seokgi Lee[2], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]Youngstown State University, Youngstown, OH, Contact: lloydf2@illinois.edu

Frequent emergency department (ED) users account for only 4.5 - 8% of all ED patients but 21 - 28 % of all ED visits. Identifying patients who use the ED often can help hospitals identify and address such patients through a more streamlined care management system and reduce the burden on EDs. The objective of this study is to build a prediction model that can identify ED frequent users based on their past electronic health records. We implement various machine learning techniques to make effective use of the temporal nature of the electronic health record and use natural language processing based embedding techniques to encode high dimensional diagnosis codes.

3 Association Between Advanced Image Ordered in The Emergency Department and Subsequent Imaging for Abdominal Pain Patients

Valerie Odeh-Couvertier, University of Wisconsin, WI

Abdominal pain is associated with high rates of emergency department (ED) imaging utilization and revisits. A better understanding is needed on when the decision to image is justified. We evaluated associations between ED imaging on subsequent outpatient imaging and revisits among abdominal pain patients discharged from the ED. Imaging in the ED was associated with lower imaging utilization and revisit to an ED after discharge, suggesting that ED imaging may replace downstream imaging.

4 Impact of Ridesharing Entry on Hospitals' Emergency Department (ED) Admissions

Saeed Piri, University of Oregon, Eugene, OR

In this paper, we examine the impact of information technology (IT)-enabled ridesharing platforms on healthcare demands, specifically at hospitals' emergency departments (EDs). We consider the rollout of ridesharing platforms over time in distinct locations and analyze changes in Emergency Department (ED) hospital admissions. Employing a difference-in-differences design, we analyze HCUP (Healthcare Cost and Utilization Project) data from the state of Florida, that has patient-level arrival and treatment data for 42 million emergency department patient encounters. We find that the availability of ridesharing services has a positive and significant effect on ED arrivals, indicating enhanced accessibility. To identify the heterogeneous impact of ridesharing, we repeated our analysis in different patient sub-populations. Our results indicate the most significant effect applies to young, middle-aged, low-income, and non-critical patients. Additionally, in a post-hoc analysis, we find a significant increase in ED service time for patients with less critical conditions and no change in length of visit for critical patients. The rise in ED demand due to ridesharing entry can have two distinct implications for emergency departments. On the one hand, ridesharing entry addresses the access barrier when the patient's condition is non-critical, but ED usage is necessary. This is a positive impact of ridesharing services availability, especially since it helps low-income communities the most. Therefore, hospitals and ridesharing companies can collaborate to address the challenge of healthcare access. On the other hand, ridesharing entry may exacerbate already overcrowded EDs by facilitating non-critical and unnecessary ED usage, which can be an adverse effect. In this case, effective patient triage to identify those with urgent needs may become even more essential after ridesharing entry.

Sunday, 11AM–12:15 PM

SB16

CC - Room 121
Healthcare OM under a Pandemic
General Session

Session Chair
Vedat Verter, Michigan State University, East Lansing, MI

1 Managing Hospital Resources Amid a Pandemicfor Improving Regional Health Outcomes

Vedat Verter[1], Beste Kucukyazici[1], Angelos Georghiou[2], Bahman Naderi[3], Anand Nair[4], [1]Michigan State University, East Lansing, MI, [2]University of Cyprus, Nicosia, Cyprus; [3]Amazon Web Cervices, Marina del rey, CA, [4]Michigan State University, East Lansing, MI, Contact: verter@msu.edu

During the early week of the COVID-19 pandemic, surge capacity was managed by transferring patients among different hospitals within the same health network, repurposing ORs as ICU beds and cancelling elective surgeries. Using publicly available data from Michigan, we develop an analytical framework to study how these policies can be implemented individually, or in combination, in order to optimize the pandemic response in a region, while delivering care to uninfected patients.

2 Managing Medical Equipment Capacity with Early Spread of Infection in a Region

Apurva Jain, Swapnil Rayal, University of Washington, Seattle, WA, Contact: apurva@uw.edu

We develop a model for a regional decision-maker to analyze the requirement of medical equipment capacity in the early stages of a spread of infections. We use a stochastic differential equation to capture the growth of infections in a community spread and shutdown model. We develop results to determine shutdown time, to show how to compensate for limited medical equipment capacity, and to show how capacity-sharing across regions can deliver a peak-timing benefit beyond traditional risk pooling.

3 Countermeasures Against Challenges of Vaccine Production Capacity Building

Fuminori Toyasaki[1], Hongmei Sun[2], [1]York University, Toronto, ON, Canada; [2]York University, Kanata, ON, Canada. Contact: toyasaki@yorku.ca

Vaccines have helped defeat several pandemics and epidemics in human history. In the recent COVID-19, vaccines have been developed at unprecedented speed, enabling effective vaccines to help defeat the pandemic. Despite the significant contribution of vaccination to global health, the low vaccine coverage rate has usually been a severe concern internationally. This study sheds light on vaccine capacity management by answering the following research questions:
1. What types of government procurement contracts can align the interests of the government and the vaccine manufacturer to coordinate the vaccine supply chain and improve the supply of vaccines?
2. Can a high-competent vaccine developer always send an outsourced vaccine manufacturer a credible signal for its true competence when information asymmetry exists between the two parties?

Sunday, 11AM–12:15 PM

SB17

CC - Room 122
Operations Research with Impactful Applications in Healthcare
General Session

Session Chair
Lauren Lindley Czerniak, 1</sup

1 Uncertainty in Patient Condition and Treatment Pathways in a Tiered Ambulance Allocation Model

Eric G. Stratman[1], Laura Albert[2], Justin J. Boutilier[3], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Middleton, WI, [3]University of Wisconsin-Madison, Fitchburg, WI, Contact: egstratman@wisc.edu

Changes in federal regulation allow eligible emergency medical patients to be treated at the scene of an incident or an alternative destination other than an emergency department. These new treatment pathways can reduce emergency medical service (EMS) expenditure and enhance the quality of care; however, the pathways available to a patient are uncertain until EMS personnel arrive at the scene of the incident and assess the patient. We develop a tiered EMS resource allocation model for a system with uncertainty in patient condition. The model optimally allocates resources considering the information known following the phone triage and the recourse actions that may be taken once the patient's true condition and treatment pathways are known. We demonstrate the value of these new treatment pathways and flexible EMS fleet strategies.

2 Optimal Prioritization and Discharge Policies for Medicaid Waiver Services

Yuqing Chen[1], Qiushi Chen[1], Can Zhang[2], [1]Pennsylvania State University, University Park, PA, [2]Duke University, Durham, NC, Contact: ykc5346@psu.edu

Medicaid waiver programs provide critical services for patients with developmental disabilities to support the care in home and community-based settings. Due to both a rapid increase in demand and limited resources for such services, the current waiting time is extensive and detrimental to the patients. Prior studies have focused on identifying either optimal prioritization or discharge policies in managing the waitlist, whereas joint decisions of both have not been extensively studied. We propose a Markov Decision Process (MDP) modeling framework for examining jointly optimal prioritization and discharge decisions and studying how the option of early discharge can lead to different structures of prioritization decisions.

3 Identifying Individuals at Risk of Vision Threatening Diabetic Retinopathy

Erik Rosenstrom, Julie Simmons Ivy, Maria Mayorga, North Carolina State University, Raleigh, NC, Contact: erosens@ncsu.edu

Diabetic retinopathy (DR) is a complication from diabetes which can become vision threatening (VTDR) and cause blindness. In the US, an estimated 899,000 diabetic adults have VTDR despite it being preventable with timely treatment. VTDR is difficult to catch due to the slow progression and dependence on patients' care seeking behavior. Here we address these challenges by leveraging 20+ years of electronic health records to construct and extend ensemble classifiers to (i) identify patients that will develop VTDR within the next year and (ii) to identify those that will develop DR in the next year. We can achieve high recall (>80%) for both classification tasks. In practice this classifier can personalize care coordination to improve utilization and timing without any additional patient actions.

4 Closed-form (R,S) Inventory Policies for Hospital Pharmacies Experiencing Supply Chain Disruptions

Lauren L. Czerniak, Mark S. Daskin, Mariel S. Lavieri, Burgunda V. Sweet, Jenn Leja, Matthew A. Tupps, Karl Renius, University of Michigan, Ann Arbor, MI, Contact: czernl@umich.edu

Hospital pharmacy managers make decisions for thousands of different perishable drugs that experience supply chain disruptions. This makes (a) quick to solve and (b) easy to implement inventory policies of utmost importance in this application area. We derive closed-form solutions for a perishable lost-sales (R,S) periodic review inventory system with supply chain disruptions. We perform a numerical analysis to (i) illustrate the impact of ignoring perishability and supply chain disruptions, (ii) show the importance of accounting for the length and time between supply chain disruptions, (iii) demonstrate the consequences of selecting simplicity over model accuracy, and (iv) study the influence of stochastic demand.

Sunday, 11AM–12:15 PM

SB18

CC - Room 123
Post-COVID, What's Next?
Panel Session

Session Chair
Gian-Gabriel P. Garcia, Georgia Institute of Technology, Atlanta, GA

Session Chair
Mariel Sofia Lavieri, University of Michigan, Ann Arbor, MI

1 Moderator

Mariel Sofia Lavieri, University of Michigan, Ann Arbor, MI

2 Panelist

Ozlem Ergun, Northeastern University, Boston, MA

3 Panelist

Margaret L. Brandeau, Stanford University, Stanford, CA

4 Panelist

Amy Cohn, University of Michigan

5 Panelist

Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA

6 Panelist

Sanjay Mehrotra, Northwestern University, Evanston, IL

Sunday, 11AM–12:15 PM

SB19

CC - Room 124
Discharges and Readmissions
Contributed Session

Session Chair
Fatma Pakdil, Eastern Connecticut State University, Willimantic, CT

1 Joint Admission and Discharge Control with Readmissions

Zhiyuan Lou[1], Jingui Xie[2], Taozeng Zhu[3], [1]Technical University of Munich, Heilbronn, Germany; [2]Technical University of Munich, Heilbronn, Germany; [3]Dongbei University of Finance and Economics, Dalian, China. Contact: zhiyuan.lou@tum.de

Admission and discharge decisions play essential roles in hospital intensive care unit (ICU) bed capacity management. In this model, we formulate the readmission of patients as an endogenous process that relies on previous discharge decisions. We develop a model to consider early discharge decisions and admission control jointly, including emergency diversion and elective scheduling. By applying the riskiness index, we can reformulate the problem as a sequence of convex mixed-integer problems and solve it efficiently. We use the MIMIC-III data to validate our model. The numerical study shows that the capacity overload risk is under control by applying our model. We also compare the effects of different admission and discharge policies.

2 How a Dedicated Post-discharge Unit Can Reduce Hospital Congestion and Costs

Maryam Khatami[1], Jon M. Stauffer[2], Mark Alan Lawley[2], [1]Indiana University, Bloomington, IN, [2]Texas A&M University, College Station, TX, Contact: mkhatami@iu.edu

Depending on the patient's condition, up to 60% of inpatients are transferred to post-acute care facilities. They may experience several days of non-medical inpatient stay until the hospital finds a facility that fits their needs, contributing to overcrowding in upstream units. We study the feasibility of creating a "post-discharge-unit" (PDU) for ready-for-discharge patients experiencing transfer delays. We use a multistage stochastic program to address the PDU capacity planning issue. Our results, using data from a large hospital, show that a PDU can reduce costs and improve access to inpatient beds. Compared to current practice in our partner hospital, a PDU could increase access to inpatient beds by up to 13% and result in 2-21% cost savings. Also, PDU capacity in hospitals with a larger number of patients waiting for transfer is more sensitive to variation in PDU costs.

3 Using Machine Learning Methods to Develop Risk-adjusted Prediction Models in Healthcare

Sonia Jahangiri, Nasibeh Azadeh-Fard, Rochester Institute of Technology, Rochester, NY, Contact: sj1374@rit.edu

In-hospital mortality, hospital length of stay (LOS), and readmission are the most significant measures for evaluating the performance of the healthcare system. We use the Nationwide Readmission Database (from the Agency for Healthcare Research and Quality) consisting of approximately 35 million patient data, to develop a novel risk-adjusted prediction model that integrates clinical and non-clinical data. The most significant variables were selected using the combination of Boruta and Random Forest techniques. Then, different machine learning methods were used to build a risk-adjusted model to predict the risk of readmission, LOS, and in-hospital mortality.

4 The Length of Stay and Readmissions of Pneumonia Patients: An Analysis Using NRd in HCUP Between 2010 and 2018

Fatma Pakdil[1], Steve Muchiri[1], Nasibeh Azadeh-Fard[2], [1]Eastern Connecticut State University, Willimantic, CT, [2]RIT, Rochester, NY, Contact: pakdilf@easternct.edu

Hospital length of stay (LOS) and readmissions are commonly considered major patient outcomes for measuring quality and cost of healthcare services. This paper examines the relationship between the readmissions and LOS of pneumonia patients using the Nationwide Readmission Database provided by the Healthcare Cost and Utilization Project (HCUP) between 2010 and 2018. This study analyzes the relationship between LOS and 30-day readmissions of pneumonia patients. Obtaining a further understanding of the relationships between LOS and readmission rates of pneumonia patients may provide insightful knowledge for policy and decision-makers.

Sunday, 11AM–12:15 PM

SB20

CC - Room 125

Emerging Topics in Health Decision Analysis

Panel Session

Session Chair

Jun Zhuang, University at Buffalo, Buffalo, NY

Session Chair

Gilberto Montibeller, Loughborough University, Loughborough, United Kingdom.

Session Chair

Elisa Frances Long, UCLA Anderson School of Management, Los Angeles, CA

1 Lessons Learned from Applying Multi-criteria Decision-making Methods to Early-stage Pharmaceutical Development Decisions

Deepak Veeraraghavan, Strategic Decisions Group,

Düsseldorf, Germany. Contact: vdeepak@sdg.com
Multi-criteria decision-making (MCDM) methods have been shown to be well suited to support early-stage pharmaceutical development decisions. In 2019, the authors applied value-based thinking and MCDM methods to prioritize early-stage development assets at Bayer Pharmaceuticals. In this presentation, the authors reflect on the implications of this new approach and present lessons for decision analysts and decision makers in the pharmaceutical industry. They discuss best practices for developing a set of fundamental objectives, operationalizing those objectives, and taking steps to de-bias the organizational decision-making process.

2 **Panelist**
Julie Simmons Ivy, North Carolina State University, Raleigh, NC

3 **Panelist**
Deepak Veeraraghavan, Strategic Decisions Group, Düsseldorf, Germany. Contact: vdeepak@sdg.com

4 **Panelist**
Gilberto Montibeller, Loughborough University, Loughborough, United Kingdom.

5 **Panelist**
Metin Cakanyildirim, The University of Texas at Dallas, Richardson, TX, Contact: metin@utdallas.edu

Sunday, 11AM–12:15 PM

SB21

CC - Room 126

Decision Modelling in Supply Chain Management

General Session

Session Chair
Jonathan W. Welburn, RAND Corporation, Santa Monica, CA

1 **Value of Customer Preference Information in Supply Chain Network Design**
Austin Saragih[1], Milena Janjevic[2], Jarrod D. Goentzel[2], Gilberto Montibeller[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Loughborough University, Loughborough, United Kingdom.
Understanding shifting customer preferences and cost complexities are essential to designing successful supply chains. However, acquiring all customer and operational information is costly during the design phase. This study provides a strategic framework to evaluate the appropriate amount of information needed a priori in supply chain network design. We analyze the value of full information (VOFI) and partial information (VOPI) and their acquisition costs. We identify the optimal strategy for information acquisition over spatial areas against its marginal cost.

2 **Presenter**
Jonathan W. Welburn, RAND Corporation, Santa Monica, CA

3 **Forecasting Demand for Optimal Inventory with Long Lead Times: An Automotive Aftermarket Case Study**
Norman Keith Womer[1], Christopher Anderson[2], [1]University of Missouri-St Louis, Saint Louis, MO, [2]University of Missouri-St Louis, Saint Louis, MO, Contact: womerk@umsl.edu
Accuracy in predicting customer demand is essential for inventory policy under periodic review, long lead-time, and a target fill rate. This study uses stock control metrics to evaluate the forecast by different simple to more complex predictive analytical techniques. We show how traditional forecast error measures are inappropriate for inventory control, despite their frequent use. We do so, by evaluating demand forecast performance looking at holding cost, stock out cost, and customer service levels. We also evaluate an econometric autoregressive model of demand for the parts manufacturer. This study adds to the limited case study research on demand forecasting under long lead times using stock control metrics, dynamic model updating, and the Prais-Winsten method of estimating demand.

Sunday, 11AM–12:15 PM

SB22

CC - Room 127

Behavioral Operations in the Public Sector

General Session

Session Chair
James Fan, Naval Postgraduate School, Seaside, CA

1 **Behavioral Responses to Nonprofit Performance Metrics: Efficiency vs. Impact**

Hasti Rahemi[1], Gloria Urrea[2], Leon Valdes[3], [1]University of Colorado Boulder, Boulder, CO, [2]University of Colorado Boulder, Superior, CO, [3]University of Pittsburgh, Pittsburgh, PA, Contact: hasti.rahemi@colorado.edu

Donors seek to evaluate the performance of nonprofit organizations (NPOs) before making donation decisions. The most commonly studied performance metric is Program Spending Ratio (PSR), which captures an NPO's expenditure on their programs as a fraction of their total expenses. However, PSR might do more harm than good, as it contributes to the NPO's starvation cycle. Therefore, we study whether and how NPOs can use additional metrics to communicate their performance to donors and reduce their reliance on PSR. Specifically, we investigate two performance metrics—impact and cost effectiveness—and how they interact with PSR information. Using a series of experiments, we shed light on whether and how donors' willingness to donate to an NPO is affected by these additional metrics.

2 Association Between Time and Monetary Donation

Chao Wu, Mahyar Eftekhar, Arizona State University, Tempe, AZ, Contact: eftekhar@asu.edu

Charities are cautioned against providing volunteer opportunities to potential donors because volunteers are considered as unreliable source of labor supply, and volunteering is assumed to crowd out monetary donation. In this study, we examine the causal relationship between individuals' volunteering and their subsequent donation decisions through two sets of experiments.

3 New Workers or New Tasks? An Augmented Reality Field Experiment with Public Sector Maintenance Officers

James Fan[1], Jelle de Vries[2], Clay Greunke[3], Perry McDowell[3], [1]Naval Postgraduate School, Seaside, CA, [2]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands; [3]Naval Postgraduate School, Monterey, CA, Contact: james.fan@nps.edu

We investigate the benefits of augmented reality guidance for a sophisticated maintenance procedure in a controlled field experiment at the Center for Naval Aviation Technical Training. Using naval maintenance officers as participants, we explore the interaction between guidance modality, worker experience, and task-switching.

4 Effects of Horizons, Delays and Magnitudes on the Time Preferences of US Agricultural Producers and Land-Grant University Students

Diya Ganguly[1], Paul Feldman[2], Paul Ferraro[3], Kent Messer[4], [1]University of Delaware, DE, [2]Texas A&M University, College Station, TX, [3]Johns Hopkins University, Baltimore, MD, [4]University of Delaware, Newark, DE

Economic experiments often utilize convenience samples that involve student participants. We aim to examine if students serve as good model participants for decision -making by farmers. Using large-sample field experiments with agricultural producers and university students from the same states we compare time and risk preferences across these two samples. To elicit time preference, we use the convex time budget methods to understand decisions in delayed payoffs, at the individual level. We compare differences in magnitude, delay, and horizon effects between student and producer populations. To elicit risk preferences, we use Eckel and Grossman's (2002) risk elicitation method and compare constant relative risk aversion estimates across student and producer populations.

Sunday, 11AM–12:15 PM

SB24

CC - Wabash 1

Nextmv / KNIME

Technology Tutorial

1 A Developer-first Approach to Decision Modeling with the Nextmv CLi and SDK

Ryan O'Neil, Nextmv, Philadelphia, PA, Contact: ryan@nextmv.io

Nextmv is building a decision automation platform, which includes a developer-friendly toolset for building, testing, deploying, and operating optimization models. We will give you an overview of what's possible with the Nextmv CLI and SDK and provide several examples to demonstrate its capabilities - from vehicle routing with a hybrid ALNS - Decision Diagram solver to workforce scheduling with an open source MIP solver.

2 Codeless Data Science with KNIME

Aline Bessa, KNIME, Austin, TX, Contact: aline.bessa@knime.com

In this tutorial, we will introduce KNIME Analytics Platform, an open-source tool for codeless data science. We will show how KNIME can be used to tackle a variety of data science tasks, from data ingestion to interpretation of model results. The tutorial will include a live, practical demonstration of the tool.

Sunday, 11AM–12:15 PM

SB25

CC - Wabash 2
Choosing Opponents in Tournaments
Tutorial Session

Session Chair
Mabel Chou, National University of Singapore, SG, SG, Singapore.

1 **Choosing Opponents in Tournaments**
Nicholas G. Hall[1], Zhixin Liu[2], [1]Ohio State University, Columbus, OH, [2]University of Michigan-Dearborn, Dearborn, MI
We consider the design of tournaments that use a preliminary stage, followed by several rounds of single elimination play. Many sports, including for example most U.S. major sports, use this format. The tournament design problem involves determining the sequence of matchups re-quired to determine a winner. This problem has been extensively studied within the literature of operations research and economics. The conventional design of the single elimination rounds is a "bracket" based on a prior ranking or seeding of the players. However, this design suffers from several deficiencies, insofar as natural expectations about the results of the design are not satis-fied. First, the expectation that higher ranked players having a higher probability of winning is not satisfied. Second, the probability that the top two players meet is not maximized. Third, there is the widely observed issue of tanking or shirking at the preliminary stage, where there are disincentives for a player to win. Fourth, top ranked players randomly incur unfortunate matchups against other players, which introduces an unnecessary element of luck. Finally, the use of a conventional fixed bracket is limiting, in that it fails to allow players to consider infor-mation that develops during the tournament. Our proposed solution involves allowing higher ranked players at the single elimination stage to choose their next opponent at each round. Us-ing data from 1,902 men's professional tennis tournaments during 2001-2016, we demonstrate the reasonableness of the results obtained. We also perform sensitivity analysis for the effect of increasing irregularity in the pairwise win probability matrix on three traditional performance measures. Finally, we consider strategic shirking behavior, and show how our opponent choice design can eliminate or reduce such behavior, including in for some famous examples. In sum-mary, compared with the conventional design, the opponent choice design provides higher probabilities that the best player wins and also that the two best players meet, and reduces shirk-ing by both individual players and groups.

Sunday, 11AM–12:15 PM

SB26

CC - Wabash 3
Location Analysis to Popularize Alternative Fuel Vehicles
Joint Session

Session Chair
Yudai Honma, The University of Tokyo, Meguro-Ku, Japan.

Session Chair
Ibrahim Capar, Bowling Green State University, Bowling Green, OH

1 **Considering Capacity in Designing Electrical Vehicle Chargers Network**
Ibrahim Capar[1], Ozgur M. Araz[2], Ismail Capar[3], [1]Bowling Green State University, Bowling Green, OH, [2]University of Nebraska–Lincoln, Lincoln, NE, [3]Texas A&M University, College Station, TX, Contact: icapar@bgsu.edu
Electrical vehicles (EVs) have a critical role in the future of sustainable transportation systems. In this paper, we present a network design framework to improve the infrastructure for EVs with quality of service constraints taken into considerations. We present a novel charging station location model with capacity allocation. The model maximizes the flow captured and minimizes the average service time for drivers. The model formulation allows assessing capacity and quality of service trade-offs and support service network design decisions. Operational insights are derived and presented for reflecting EV drivers' expectations. We demonstrate an application of the developed solution approach on real road network and evaluate the performance based on both computational efficiency and solution quality.

2 **Exact Solution Algorithms of Continuous P-median and P-center Problems of Manhattan Distance**
Thomas Byrne[1], Atsuo Suzuki[2], Mihiro Sasaki[2], [1]University of Strathclyde, Glasgow, United Kingdom; [2]Nanzan University, Nagoya, Japan. Contact: tom.byrne@strath.ac.uk
We propose algorithms to obtain the exact solutions of continuous p-Median and continuous p-Center problem of Manhattan distance. They are combinatorial problems and as far as we know, no practical algorithm to obtain the exact solution has been proposed. To overcome the difficulty, we propose Big Triangle and Small Triangle (BTST) and

Big Rectangle and Small Rectangle (BRSR) algorithms for both problems and obtain the exact solutions. We obtain a tight lower bound of the objective function in a triangle or rectangle which is essential for the BTST and BRSR algorithms by geometrical consideration. We show the effectiveness of the algorithms using the lower bound by the computational experiments.

3 Location-Routing Problem for Emergency Refueling Station Deployment to Support Alternative Fuel Vehicles Evacuation

Denissa Sari Darmawi Purba[1], Simon Balisi[2], Eleftheria Kontou[3], [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]University of Illinois at Urbana-Champaign, Urbana, Contact: dpurba2@illinois.edu

Alternative fuel vehicles may pose challenges to evacuation planning due to their short driving range and sparse refueling infrastructure on transportation networks. Deployment and strategic siting of emergency refueling stations are needed to support the evacuation of alternative fuel vehicles to reach a shelter. This study proposes a location-routing problem with hop constraints that optimize the placement of emergency refueling stations of each alternative fuel type to support their evacuation routing. We develop a bender-decomposition method with a transformed network to solve the location problem and a matheuristic branch-and-price method to design evacuation routes that minimize travel and refueling time and satisfy the hop constraints of each vehicle type. We perform preliminary numerical experiments on the Sioux Falls network.

4 Locational Analysis of In-motion Wireless Power Transfer System for Long-distance Trips by Electric Vehicles

Yudai Honma, Daisuke Hasegawa, Katsuhiro Hata, Takashi Oguchi, The University of Tokyo, Tokyo, Japan. Contact: yudai@iis.u-tokyo.ac.jp

The popularization of electric vehicles (EVs) is limited by their driving range and long charging times. To address this, in-motion wireless power transfer systems (WPTSs) are currently attracting attention as a new system. In-motion WPTSs have coils embedded under the road to transfer power from the WPTSs to EVs while driving. However, the main drawback of WPTSs is its large investment, especially in supporting the long-distance trips of EVs on expressways. Therefore, this paper proposes a new mixed-integer programming model (MIP) to determine the optimal location of WPTSs for maximized total feasible flow demand. By focusing on long-distance trips on expressways, we proposed the first flow-capturing model for WPTS locations that can solve for the distance of WPTS installed as continuous variables, and solve problems based on real-scale data using a general MIP solver.

Sunday, 11AM–12:15 PM

SB27

CC - Room 138

Community Engagement and Diversity, Equity and Inclusion in OR/analytics

Joint Session

Session Chair

Michael P. Johnson, University of Massachusetts Boston, Boston, MA

1 Vulnerable to Interconnected! Redefining Community Engaged Decision Making for Wicked Problems

Sajani Kandel[1], Namesh Killemsetty[2], [1]University of Massachusetts Boston, Boston, MA, [2]O.P. Jindal School of Government and Public Policy, Sonipat, New Delhi, India.

Value-focused thinking (VFT) is a widely used analytical approach to identify and structure the preferences of multiple stakeholders in a complex decision-making context. With its roots in decision sciences, VFT has been applied to understand decision making in large organizations involving professionals who are experts in the area. We argue that VFT has immense potential outside traditional domain in providing a unique perspective of marginalized communities to create community-valued/ centric decision opportunities. The paper uses two cases of VFT research application,1) housing preferences of slum communities in Odisha, India, and 2) climate change adaptation strategies in predominately black neighborhood in Boston,US, to elaborate the principal characteristics and methodological consdideration of VFT application in a non-traditional context.

2 Agent-based Model of Police Funding Tradeoffs Through the Lens of Legitimacy and Hardship

Jack Mitcham, University of Massachusetts Boston, Boston, MA, Contact: jack.mitcham001@umb.edu

There are mixed results in the literature when examining the impact of police spending and social welfare spending on crime rates. Here, we use an agent-based model to explore the impacts of the tradeoff between police spending and social welfare spending on crime in an attempt to explain

those mixed results and to provide guidance for policymakers who are implementing these funding decisions. We find that by including hardship of the people and their view of police legitimacy, the impact of increasing police spending has diminishing returns on the crime rate and under certain circumstances can lead to an increase in crime.

3 Using Analytics to Create Equity Throughout the Supply Chain

Kendra C. Taylor, KEYFFICIENCIES, Inc., Atlanta, GA, Contact: kendra@keyfficiencies.com

When we consider equity in business, we tend to consider it within a single company or institution. What if we expanded the view to include laborers experiencing harsh treatment and conditions to provide products and services that support the full supply chain. We will explore how companies are expanding Equity while tackling labor trafficking in their supply chain.

4 Bridging the Digital Divide: Role of Digital Platforms and Policy Framework

Roohid Ahmed Syed[1], Shivendu Shivendu[2], [1]University of South Florida, Tampa, FL, [2]University of South Florida, Tampa, FL, Contact: roohidahmed@usf.edu

Digital divide is a global phenomenon that gained much attention during the recent COVID-19 pandemic. Extent theoretical research has studied the impact of market regulation and subsidies to Internet Service Providers on broadband adoption. In this paper, we study two levels of digital divide: access divide and use divide. We model the heterogeneity of consumers along two dimensions: marginal valuation for broadband speed and digital literacy. Using game theoretic approach, we study the conditions for optimality for two types of subsidies: broadband subsidy and digital literacy training subsidy. The subsidies are provided by a social welfare maximizing social planner. We also consider a monopolist platform whose profits depend on the level of use divide and analyze the impact of platform's incentives on social planner's optimal subsidy strategy.

Sunday, 11AM–12:15 PM

SB28

CC - Room 139

Emerging Topics in Behavioral Operations Management

General Session

Session Chair

Swanand Kulkarni, Atlanta, GA

Session Chair

Basak Kalkanci, Georgia Institute of Technology, Atlanta, GA

1 Startup Fundraising and Equity Split: Do the Number of Investors and Contract Form Matter?

Evgeny Kagan[1], Kyle Hyndman[2], Anyan Qi[3], [1]Johns Hopkins Carey Business School, Washington, [2]University of Texas at Dallas, Richardson, TX, [3]The University of Texas at Dallas, Richardson, TX, Contact: axq140430@utdallas.edu

We study equity division between an entrepreneur and one or more potential investors. The investor(s) and the entrepreneur negotiate how much equity (ownership) in the startup the investor(s) should receive in exchange for their investment. The value of that equity is uncertain at the time of the negotiations. We examine how the allocation of startup equity between the entrepreneur and the investors is affected by the following: (1) the number of investors, (2) the outside option of the entrepreneur, and (3) whether investors receive downside protection via ``Preferred Stock'', as is sometimes done in practice.

2 Algorithm Reliance Under Pressure: The Effect of Customer Load on Service Workers

Clare Snyder[1], Stephen Leider[2], Samantha Meyer Keppler[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: claresny@umich.edu

Augmented (human + algorithm) intelligence can increase customer service efficiency and quality, allowing companies to increase service scale�if customer-facing workers use the algorithms. Service operations and algorithm reliance literature present conflicting evidence about how workers will rely on algorithms in the service setting. With a laboratory experiment, we show that workers' algorithm reliance is low, but that it increases with customer load. This effect grows over time as the high customer load creates more opportunities for feedback about the algorithm. With a second study, we show that learning interventions can further encourage algorithm reliance. Our results contribute to theory at the intersection of service operations and algorithm reliance and have practical implications about the algorithm-augmented service model.

3 When Less is More: Operations and Incentives of an On-demand Medical Crowdsourcing Platform

Jingxuan Geng[1], Guangwen (Crystal) Kong[2], Marco Shaojun Qin[1], [1]Temple University, Philadelphia, PA,

[2]Temple University, Wynnewood, PA, Contact: jingxuan.geng@temple.edu

We study how the pricing and non-pricing operational tools can be used to effectively balance supply and demand on a medical crowdsourcing platform. Specifically, we derive theoretical models and find that the pricing alone does not always yield optimal alignment between inquiries and answers. However, a platform can address it by capping the number of opinions in each inquiry (i.e., the control limit). Together with the optimal price, control limit allows the platform to charge higher and avoid doctors' over-participation. It also helps to retain high-quality doctors on the platforms. Interestingly, the platform's profit increases with patients' delay sensitivity (i.e., a patient prefers medical opinions that arrive earlier), and the effect of control limit substitutes the effect of delay sensitivity. We empirically test our predictions and get consistent results.

4 Spatial Information Sharing on On-demand Service Platforms: A Behavioral Examination

Swanand Kulkarni[1], Basak Kalkanci[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: swanandkulkarni@gatech.edu

Through a game-theoretic model and lab experiments, we examine how mechanisms to share demand-supply mismatch information spatially affect a platform's matching efficiency. We compare surge information sharing (where all drivers learn about a surge, common practice today) with full (where drivers learn about the demand conditions in all zones) and local information sharing (where only nearby drivers learn about a surge). Experimentally, with full or local information sharing, the platform achieves comparable matching efficiency to surge despite being dominated in theory and serves more customers than predicted. Thus, sharing demand-supply mismatch either fully or in a personalized manner can alleviate coordination problems on platforms.

Sunday, 11AM–12:15 PM

SB29

CC - Room 140

Pharmaceutical Supply Chain Management: Drug Shortage and Drug Quality

General Session

Session Chair

Parshuram Hotkar, Indian School of Business, Hyderabad, India.

Session Chair

Hanu Tyagi, University of Minnesota, Minneapolis, MN

1 Mitigating the US Drug Shortages: Policy Interventions and Quality Reward

Sergey Naumov, In Joon Noh, Hui Zhao, Smeal College of Business, The Pennsylvania State University, University Park, PA, Contact: huz10@psu.edu

Using a two-stage system dynamics model, we capture essential features of the pharmaceutical market and supply chain related to drug shortages in the US and evaluate a number of existing and ongoing government interventions (such as quality reward) to improve supply chain resilience and mitigate drug shortages.

2 The Impacts of a Non-profit Organization on Drug Shortages

Junghee Lee[1], Hyoduk Shin[2], Daewon Sun[1], Jennifer K. Ryan[3], [1]University of Notre Dame, Notre Dame, IN, [2]UC-San Diego, La Jolla, CA, [3]University of Nebraska–Lincoln, Lincoln, NE, Contact: jlee93@nd.edu

The ongoing drugs shortages critically threaten public health. To mitigate the drug shortages, philanthropies and hospital systems founded a non-profit organization that "better" sources drugs. We investigate how the advent of the non-profit entity reshapes the competition and impacts the performance of each entity in a pharmaceutical drug supply chain.

3 Generic Drugs, Manufacturing Location, and Drug Safety

John V. Gray[1], In Joon Noh[2], George Ball[3], [1]Fisher College of Business, The Ohio State University, Columbus, OH, [2]Smeal College of Business, Penn State University, State College, PA, [3]Operations and Decision Technologies, Kelley School of Business, Indiana University, Bloomington, IN, Contact: gray.402@osu.edu

Generic drugs now represent nearly 90% of drugs dispensed in the United States. Consumers, doctors, and pharmacists generally assume that generics are interchangeable, allowing organizations that buy generic drugs to often focus mostly on the price. Partially because of this pricing pressure, generic drugs are increasingly made in lower-cost locations, such as India. In this study, we examine whether the location of manufacture relates to generic drug safety.

4 Impact of Expedited Approvals on Drug Shortages

Parshuram Hotkar[1], Diwakar Gupta[2], [1]Indian School of Business, Hyderabad, India; [2]University of Texas, Austin, TX, Contact: parshuram_hotkar@isb.edu

Many critical drugs, especially sterile injectable drugs, experience frequent shortages, and these shortages exact significant financial and human toll. In 2016, the US congress passed the Cures Act to expedite the review process and approvals of medical products. Through an empirical study, we investigate the impact of expedited approvals on the competition and drug shortages.

Sunday, 11AM–12:15 PM

SB30

CC - Room 141

Platform and Digital Operations

General Session

Session Chair

Basak Kalkanci, Georgia Institute of Technology, Atlanta, GA

Session Chair

Li Ding, NULL, Atlanta, GA

1 Customers' Multi-homing in Ride-hailing: Evidence from a Structural Model

Sandeep Chitla[1], Maxime Cohen[2], Srikanth Jagabathula[1], Dmitry Mitrofanov[3], [1]NYU Stern School of Business, New York, NY, [2]McGill University, Montreal, QC, Canada; [3]Boston College, Chestnut Hill, MA

Using a large panel dataset with repeated choices of riders for both Uber and Lyft, we estimate a structural "consider-then-choose" model to better understand the trade-offs faced by riders. We find that riders' choices are not fully explained by operational factors such as price and waiting time, indicating that riders view the platforms as differentiated services and not as commodities. We also find that the multi-homing behavior of riders is only observed for a small fraction of the rides.

2 Trips for Tips? The Impact of Tips on Drivers' Relocation Decisions

Li Ding[1], Seyedmorteza Emadi[2], Basak Kalkanci[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of North Carolina-Chapel Hill, Chapel Hill, NC, Contact: lding60@gatech.edu

Using a large-scale and granular taxi trip dataset, we analyze the role of passenger tips in drivers' relocation decision-making process using structure estimation. Inspired by different tip information sharing practices adopted in platform companies (e.g., real-time or delayed information sharing), we conduct counterfactual analysis to examine how tip information sharing policies affect drivers' income and platform efficiency.

3 The Impacts of Algorithmic Work Assignment on Fairness Perceptions and Productivity: Evidence from Field Experiments

Bing Bai[1], Hengchen Dai[2], Dennis Zhang[3], [1]Washington University-St Louis, Saint Louis, MO, [2]UCLA Anderson School of Management, Los Angeles, CA, [3]Washington University in St Louis, ST LOUIS, MO, Contact: hengchen.dai@anderson.ucla.edu

The growing concern that algorithms may reproduce or even magnify the inequality historically exhibited by humans calls for research on how people perceive the fairness of algorithmic decisions (vs. human-based decision-making) and consequently, adjust their work motivation. We study how algorithmic (vs. human-based) task assignment processes change workers' fairness perceptions and productivity. In two field experiments with Alibaba where warehouse picking workers received tasks either from an algorithm or a human, the algorithmic assignment process was perceived as fairer and yielded productivity gains, despite that the two processes used the same underlying rule to allocate tasks. We showed via online experiments that people in the U.S. also viewed algorithmic task assignment as fairer.

4 Analysis of Automated Grocery Stores on Consumption Choices

Zhe Zhang[1], Xiaofeng Liu[2], [1]University of California-San Diego, San Diego, CA, [2]UC San Diego, La Jolla, CA, Contact: z9zhang@ucsd.edu

Unlike traditional physical grocery stores, autonomous stores, such as Amazon Go, don't have cashiers or check-out stations. With the advanced AI technology, consumers can walk in, pick out what they need, and then just walk out to complete a purchase trip in an autonomous store. In this paper, we try to understand the effects of autonomous stores on consumer purchase and traditional stores performance. We analyze the consumer purchase from the perspectives of purchase trips, product categories, and traditional stores. The paper could provide helpful insights for the retailers who would like to adopt autonomous stores or other new technology in the future.

Sunday, 11AM–12:15 PM

SB31

CC - Room 142

Emerging Topics on Service Platform
General Session

Session Chair
Vahideh Manshadi, Yale University, New Haven, CT

Session Chair
Daniela Saban, Stanford University, Aachen

1 **Behavior-aware Queueing: When Strategic Customers Meet Strategic Servers**
Yueyang Zhong[1], Raga Gopalakrishnan[2], Amy R. Ward[1], [1]The University of Chicago Booth School of Business, Chicago, IL, [2]Smith School of Business at Queen's University, Kingston, ON, Canada. Contact: yzhong0@chicagobooth.edu
Service system design is often informed by queueing theory. Traditional queueing theory assumes that servers work at constant speeds. While this is reasonable in computer science and manufacturing contexts, servers in service systems are people, and, in contrast to machines, both systemic and monetary incentives created by design decisions impact their work speeds. We use asymptotic analysis to study how server work speed is affected by managerial decisions concerning (i) how many servers to staff and how much to pay them, and (ii) whether and when to turn away customers, in the context of a finite-buffer many-server queue in which the work speeds emerge as the solution to a noncooperative game. In addition, we characterize the "price of anarchy" by comparing the performance under the equilibrium with that under the optimal solution to the centralized optimization problem.

2 **Matchmaking Strategies for Maximizing Player Engagement in Video Games**
Mingliu Chen, Xiao Lei, Adam Elmachtoub, Columbia University, New York, NY
We propose a general framework to analyze the dynamic matching problem in online video games, aiming to maximize player engagement. Players have different skill levels, which affect the outcomes of matches, and the win-loss record influences their willingness to remain engaged. We fully characterize the optimal matching policy on a stylized model where there are two skill levels, and players churn only when they experience a losing streak. The optimal policy always matches as many low-skilled players who are not at risk of churning to high-skilled players who are one loss away from churning. Compared to the industry status quo that matches players with the same skill level together, we prove the benefit of optimizing the matchmaking system grows linearly with the number of skill levels. Our framework can also handle the addition of AI bots and pay-to-win system.

3 **Platform Fulfillment: Antitrust and Upstream Market Power**
Amandeep Singh[1], Jiding Zhang[2], Senthil Veeraraghavan[3], [1]University of Washington, Seattle, WA, [2]New York University Shanghai, Shanghai, China; [3]University of Pennsylvania, Philadelphia, PA, Contact: amdeep@uw.edu
Fulfillment by Platform (FBP) has been widely adopted by many e-commerce sellers. Despite providing better service to customers, platforms have come under regulatory scrutiny. We demonstrate that the adoption of fulfillment services offered by platforms improves consumer welfare but also affects competition among the sellers in the upstream markets. We use data from a leading online retailing marketplace to estimate the welfare effects of downstream fulfillment on upstream supply echelons. We find that the adoption of fulfillment by platform affects upstream market competition, measured by the Herfindahl-Hirschman Index, which is attributable to the higher cost of service. In particular, smaller merchants, with lower margins, are forced to increase their prices more to remain profitable with FBP, leading to a price disadvantage compared to bigger merchants.

4 **Dynamic Matching with Competition over Resources**
Ali Aouad[1], Alireza Amanihamedani[1], Daniel Freund[2], [1]London Business School, London, United Kingdom; [2]MIT, Cambridge, MA
XXX

Sunday, 11AM–12:15 PM

SB32

CC - Room 143
Artificial Intelligence and Financial Technologies
General Session

Session Chair
Xue Tan, Indiana University, Bloomington, IN

1 **Identifying Linked AI Repositories on Github: A Graph Self Supervised Learning Approach**
Ben Lazarine[1], Sagar Samtani[2], [1]Indiana University, Bloomington, IN, [2]Indiana University, Bloomington, Contact: belazar@iu.edu

Artificial Intelligence (AI) has seen a rapid acceleration in its use and development in recent years for safety-critical systems like production business systems, transportation, and medicine. A critical factor that has enabled this acceleration has been the AI development community's adoption of open-source software (OSS) practices. While OSS platforms, particularly GitHub, have helped accelerate AI development, they also lead to the accelerated spread of security issues. Therefore, this research aims to predict linkages between open-source AI tools on GitHub through a novel self-supervised deep learning-based graph embedding approach to help identify unknown influential vulnerable open-source AI packages for mitigation.

2 Identifying Major Human Behaviors Impacting Depression Using Sensor Signal Data: A Multiview-based Attention Approach

Aijia Yuan, Indiana University, Bloomington, IN, Contact: yuana@iu.edu

Mental health has become a leading cause of disability worldwide, and depression is one of the most common and serious mental illnesses affecting millions of people. In addition, student has been identified as one of the most vulnerable populations to depression. Although many universities provide counseling services to monitor students' mental health status, traditional approaches usually involve interviews and self-reports that require massive human labors and expenses. Therefore, we choose sensor signal data as an alternative to assess students' mental health conditions more objectively, ubiquitously, and cost-effectively. For this study, in addition to depression detection, we aim to identify the human behaviors associated with depression by developing a novel deep learning-based attention mechanism.

3 An Interaction Analysis of Targeting Across Multi-platforms in the Consumer Purchase Funnel

Ran (Alan) Zhang[1], Shivendu Shivendu[2], Daniel Zantedeschi[3], [1]Texas Tech University, Lubbock, TX, [2]University of South Florida, Tampa, FL, [3]University of South Florida, Tampa, TX, Contact: ran.alan.zhang@ttu.edu

We advance an empirical strategy aiming at measuring synergistic effects of online platforms for targeted advertising along the consumer-purchasing funnel. Gauging interaction effects between activities on different platforms is challenging, due to the presence of the "activity biases" where the most active users end up being targeted more frequently. We use a combination of matching strategy for multiple treatments and the control function approach mitigating the potential endogeneity issue. We find that targeting across platforms is positively associated with the ultimate conversion for consumers at the lower funnel, but there is no synergistic effect for the upper funnel consumers. Our finding points to the presence of complementarities between social media and traditional platforms along the purchasing funnel.

4 Price Discrimination in Crowdfunding

Weijia You[1], Xiahua Wei[2], [1]Beijing Forestry University, Iowa City, [2]University of Washington, Bothell, WA

In crowdfunding, fundraisers employ multiple marking strategies to attract backers to raise more funds, among which coupon is becoming popular while the impact is unclear yet. This study aims to fill in the gap. Based on the project-level panel data from a leading crowdfunding platform, we find that coupon positively contributes to the funds raised for the campaigns of most of the campaigns but not those in the categories of donation and publication. Regarding the coupon strategies, for the campaigns in the category of technology and design, there is a U shape relationship between the types of the coupons distributed and funds raised. We also find that coupons with higher minimum requirements, lower discounts, and in the early stage of the campaign can hurt the fundraising. These findings provide managerial implications for the fundraiser and the platform.

Sunday, 11AM–12:15 PM

SB33

CC - Room 144

Sustainability in Agricultural and Food Supply Chains

General Session

Session Chair

Andre Du Pin Calmon, Scheller College of Business, Georgia Institute of Technology, Atlanta, GA

Session Chair

Philippe Blaettchen, Bayes Business School (formerly Cass), City University of London, London, United Kingdom.

1 Optimal Pricing Policies for Precision Agriculture Technologies

Heng Chen[1], Ying Zhang[2], [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Clemson University, Clemson, SC, Contact: heng@unl.edu

Precision agriculture can improve the efficiency of agricultural operations through reduced inputs and improved yields. Agricultural technology providers have used outcome-based pricing to promote the application of precision agriculture. In this paper, we explore the implications of outcome-based pricing on the adoption rate of precision agriculture and the benefits to farmers and technology providers. We build a two-period game model to study a provider's optimal pricing decisions, considering that the provider may learn in the second period through the experience in the first.

2 Traceability Technology Adoption in Supply Chain Networks

Philippe Blaettchen[1], Andre Du Pin Calmon[2], Georgina Hall[3], [1]Bayes Business School (formerly Cass), City University of London, London, United Kingdom; [2]Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, [3]INSEAD, Fontainebleau, France. Contact: philippe.blaettchen@city.ac.uk

Modern traceability technologies promise to make food supply chains safer and more transparent. However, benefits depend on supply chain-wide technology adoption. Hence, traceability initiatives need to subsidize some early adopters within a network of supply chains. We address the problem of identifying the most cost-effective set of firms to target for technology to diffuse broadly. While the problem is hard even to approximate, we introduce an LP algorithm that identifies exact solutions in polynomial time under some assumptions on the network structure. We establish that supply chain networks in practice tend to follow these assumptions. We then use our algorithm to derive key managerial insights into targeting based on structural properties, validating approaches taken by initiatives in practice. Finally, we derive heuristics for lower and upper bounds.

3 On the Management of Premade Foods

Jae-Hyuck Park[1], Erica Plambeck[2], Dan Andrei Iancu[2], [1]The Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [2]Stanford University, Stanford, CA, Contact: jaehyuck@ust.hk

We examine a grocery retailer's management of a premade food product whose goal is to maximize a weighted sum of direct profit and customer welfare. Considering the deterioration, the retailer chooses the shelf life, whether to issue items in FIFO or LIFO, and whether to use a timestamp. With timestamps, customers decide whether to purchase based on each item's age; without timestamps, they decide based on the average quality of purchased items. First, we find that LIFO outperforms FIFO when shelf life and issuance are jointly optimized. Second, our analysis suggests that the retailer should timestamp items only if customers have heterogeneous preferences and the disposal cost is sufficiently low or the retailer cares substantially about customer welfare. Lastly, we show how a mandate to donate unsold food can harm shoppers and reduce the quantity and quality of donated items.

4 Informal Cross-Border Trade in Africa: Operations, Policy, and Opportunities

Michael Lim[1], Jimin Park[2], Karthik Murali[3], [1]Seoul National University, Seoul, NA, Korea, Republic of; [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Oregon State University, Corvallis, OR

We seek to develop insights to understand the informal cross-border trade (ICBT) value chain and offer policy recommendations to successfully integrate it into the formal economy. Using a game-theoretic model, we analyze the operations and key market dynamics of ICBT, and examine implications of three representative UN policy directives. We apply our model to a case study based on Uganda's agricultural exports over an 11 year horizon to obtain insights on the efficacy of these policies and the tradeoffs that must be considered.

Sunday, 11AM–12:15 PM

SB34

CC - Room 145

MSOM Student Paper Finalists I

Award Session

Session Chair

Dragos Florin Ciocan, INSEAD, Fontainebleau, France.

Session Chair

Ersin Korpeoglu, University College London, London, United Kingdom.

Session Chair

Nikos Trichakis, MIT, Cambridge, MA

1 Spatial Price Integration in Commodity Markets with Capacitated Transportation Networks

Ian Yihang Zhu[1], Timothy C. Y. Chan[1], John R. Birge[2], Michael Pavlin[3], [1]University of Toronto, Toronto, ON, Canada; [2]University of Chicago, Chicago, IL, [3]Wilfrid Laurier University, Waterloo, ON, Canada.

Spatial price integration is extensively studied in commodity markets as a means of examining the degree of integration between regions of a geographically diverse market. Many commodity markets are supported by stable and well-defined transportation networks. In this paper, we analyze the relationship between the spatiotemporal distribution of prices and the features of the underlying transportation network. We characterize this relationship and show that price integration is strongly influenced by the characteristics of the network, especially when there are capacity constraints on links in the network. Our results are summarized using a price decomposition that explicitly isolates the influences of market forces (supply and demand), transportation costs, and capacity constraints among a set of equilibrium prices. We use these theoretical insights to develop a unique discrete optimization methodology to capture spatiotemporal price variations indicative of underlying network bottlenecks. We apply the methodology to gasoline prices in the southeastern United States, where the methodology effectively characterizes the price effects of a series of well-documented network and supply chain disruptions, providing important implications for operations and supply chain management.

2 Improving Drinking Water Access and Equity in Rural Sub-Saharan Africa

Chengcheng Zhai, Kurt Bretthauer, Alfonso Pedraza-Martinez, Kelley school of Business, Bloomington, IN

In 2020, 771 million people lacked basic drinking water access (UNICEF and WHO 2021). Building new water projects such as hand-pumps and small piped systems is the primary operational response by many non-governmental organizations (NGO) to bring people their first access to clean water in the rural areas of developing countries. Our research studies where to optimally build new water projects. To close the loop between practice and research, we collaborate with a local NGO and an international NGO working in rural Sub-Saharan Africa and conduct field research in Ethiopia. We first develop a decentralized water project location optimization model based on the current practice of a decentralized decision-making and project management system in the field and an equal per-beneficiary budget structure. We further identify that we can leverage groundwater distribution characteristics to improve water access equity. Groundwater, as a natural resource, is unevenly distributed within each community and across different communities, which leads to a naturally inequitable drinking water access. We propose three new models to improve both water access and access equity: a minimax model, an equitable budget structure, and a centralized model that leverages the existing community involvement. Through numerical studies, we compare the model solutions and generate recommendations for NGOs. Lastly, motivated by the current armed conflict in Ethiopia, we develop a stochastic model to study how to improve drinking water access while mitigating the negative impact of water project supply shocks. Our work studies a previously over- looked problem of drinking water access in rural areas of developing countries. It also provides a scalable methodology and managerial insights to NGOs building new water projects by combining large geo-coded data sets and field data.

3 Learning from Observational Commerce Data

Tianyi Peng, Vivek Farias, Massachusetts Institute of Technology, Cambridge, MA

Sunday, 11AM–12:15 PM

SB35

CC - Sagamore 1

Management of Service Systems

General Session

Session Chair

Wei Liu, University of North Carolina at Chapel Hill, Chapel Hill, NC

1 Joint Admission and Service Rate Control of an Unobservable Queue

Wei Liu, University of North Carolina at Chapel Hill, Chapel Hill, NC

Managers of call centers and healthcare centers need to decide the right number of customers to admit and the right value of service rate to use in the queueing system. We call this the joint admission and service rate control problem and study it in an unobservable single server queueing system. We focus on a general reward structure where the system earns an award from serving a customer under a general queueing system. Considering the general reward structure under a general queueing system is highly relevant for the system manager to do admission control in the industry like call center and healthcare. We show that when the server cost is less than or equal to the server value, we should admit all the customers, otherwise, we should not operate the queueing system. This policy would help the customer behave in a socially optimal way with self-regulation.

2 The Effects of Information Granularity on Abandonment and System Performance in Observable Priority Queues

Philipp Afeche[1], Junqi Hu[2], Rouba Ibrahim[3], Vahid Sarhangian[1], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto, TORONTO, ON, Canada; [3]University College London, London, United Kingdom. Contact: junqijh.hu@utoronto.ca

Motivated by empirical studies of the abandonment behavior of customers in service systems, we propose new priority queueing models with time-varying arrivals and state-dependent abandonment depending on the granularity of state information available to the customers. We investigate the performance under three levels of information granularity (no, partial, and full information) by exploiting a fluid model of the system. For each information level, we establish the existence, uniqueness, and stability of an equilibrium. Then, we compare the equilibria under the three information designs and provide insights on the effects of information granularity on queue length and abandonment rate.

3 Value of Return Time Windows when Selling Experience Goods to Heterogeneously Informed Consumers

Punya Chatterjee[1], Aydin Alptekinoglu[2], Nicholas C. Petruzzi[3], [1]Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, [3]University of Wisconsin-Madison, Madison, WI, Contact: pxc85@psu.edu

We study a profit-maximizing retailer's optimal return policy when selling an experience good to a market of heterogeneously informed consumers. The retailer offers either a return time window at full price (and full refund in the event of a return) or no returns at a price discount or both. We focus on the effect of learning through consumption in the consumers' return behavior and the attendant return policy decisions by the retailer. We find that salvage value of returns is a crucial factor in whether the retailer's optimal return policy would employ return windows and if it offers consumers a choice between a return window at full price and no-return at a discounted price.

Sunday, 11AM–12:15 PM

SB36

CC - Sagamore 2

Optimization Society's Award Session

Award Session

Session Chair

Alper Atamturk, IEOR, UC Berkeley, Berkeley, CA

Session Chair

Andy Sun, MIT, Cambridge, MA

1 Khachiyan Prize - Solving QCQPs

Daniel Bienstock, Columbia University, New York, NY

QCQPs (quadratically constrained quadratic programs) are becoming increasingly prevalent, arising in multiple engineering domains. A prime example is provided by the ACOPF problem, which models the operation of an electric power network under steady state -- ACOPF instances can be quite large and quite intricate and also display highly nonlinear behavior, in the sense that slightly infeasible solutions can also prove visibly superoptimal. The current state-of-the-art for QCQPs relies on two complementary and distinct techniques, one for proving bounds through relaxations (spatial branch-and-bound) and another for computing good feasible "local" solutions (nonlinear solvers). While both techniques, in particular NLP, can be successful, both can be challenged by large, complex instances.A project that I have been interested in for some time focuses on developing a generic technique, based on linear integer programming, for addressing both upper and lower bounds, with quality guarantees, and with good opportunistic performance. In this talk we will discuss our current efforts. This is joint work with current and former students: Mark Zuckerberg, Gonzalo Munoz and Matias Villagra.

2 Khachiyan Prize - Improved Data-driven Decision-making via Optimization: Models, Algorithms, and Applications

David B. Shmoys, Cornell University, Ithaca, NY

Khachiyan's paper on LP stands as a landmark achievement in the history of optimization, with impact far beyond its theoretical implications. In this talk, I will give a personal perspective on the interplay between theory & practice in optimization research, and how this integration has led to the best work in each, with ever greater challenges in this data-rich world. Modeling decision-making settings, developing effective algorithms, & addressing real-world problems are intertwined elements: I will touch upon work that exemplifies these aspects, using problem structure in the analysis of algorithmic efficiency & effectiveness, with applications in the sharing economy, congressional districting, & even Covid-19 mitigation.

3 Farkas Prize - An Accelerated Coordinate Gradient Descent Algorithm for Non-Separable Composite Optimization

Beck Amir, Tel Aviv University, Tel Aviv, Israel.

We define a monotone accelerated coordinate gradient descent-type method for problems consisting of minimizing f+g, where f is quadratic and g is prox-tractable nonsmooth and non-separable. The algorithm utilizes the forward-backward envelope that constitutes an exact smooth reformulation of f+g. We prove the algorithm achieves a convergence rate of O(1/k^1.5) in terms of the original objective function, improving current coordinate descent-type algorithms. In addition, we describe an adaptive variant of the algorithm that backtracks the spectral information and coordinate Lipschitz constants of the problem. We examine our algorithms on various settings, including two-dimensional total-variation-based image inpainting problems.

Sunday, 11AM–12:15 PM

SB37

CC - Sagamore 6

Distributionally Robust Learning and Optimization - II

General Session

Session Chair

Hamed Rahimian, Clemson University, Clemson, SC

Session Chair

Harsha Gangammanavar, Southern Methodist University, Dallas, TX

1 Contextual Expected-Value-Constrained Stochastic Programming

Hamed Rahimian, Clemson University, Clemson, SC, Contact: hrahimi@clemson.edu

Unlike classical stochastic programming models that often describe uncertain parameters independent of side information, we study a contextual expected-value-constrained stochastic programming formulation that incorporates features. We propose a tractable and fully data-driven approximation model that relies on weighted sums of random variables, and we present finite-sample and asymptotic feasibility and optimality guarantees of the data-driven optimal solution. We illustrate our findings on real and synthetic data.

2 Robust Markov Decision Processes with Data-Driven, Distance-based Ambiguity Sets

Siva Ramani, Archis Ghate, University of Washington, Seattle, WA

We consider MDPs where the true state-transition probabilities are unknown. We assume that they belong to certain ambiguity sets, and pick actions that maximize the worst-case expected total discounted reward over all transition probabilities from these sets. In our setup, the ambiguity set for the whole problem is a Cartesian product of ambiguity sets. Specifically, it includes all pmfs within a certain distance from an empirical transition pmf. We show that the optimal values of the robust MDPs converge to the optimal value of the true MDP, as the sample-size tends to infinity. A rate of convergence result is also derived. We also establish that the robust optimal value provides a lower bound on the value of the robust optimal policy in the true MDP, with a high probability. These results rely on two sufficient conditions that several commonly used distances satisfy.

3 Robust Contextual Portfolio Optimization with Gaussian Mixture Models

Grani Adiwena Hanasusanto[1], Yijie Wang[1], Chin Pang Ho[2], [1]The University of Texas at Austin, Austin, TX, [2]Imperial College London, London, United Kingdom.

We consider the portfolio optimization problem with contextual information that is available to better quantify and predict the uncertain returns of assets. Motivated by the regime modeling techniques for the finance market, we consider the setting where both the uncertain returns and the contextual information follow a Gaussian Mixture distribution. This problem is shown to be equivalent to a nominal portfolio optimization problem where the means and the covariance matrix are adjusted by the contextual information. We then apply robust optimization and propose the robust contextual portfolio optimization problem, which reduces the sensitivity of model parameters used in the Gaussian Mixture model. Finally, we conduct a numerical experiment in the US equity markets and demonstrate the advantage of the proposed method against other benchmark methods.

4 Sequential Sampling-based Methods for Distributionally Robust Optimization

Harsha Gangammanavar, Southern Methodist University, Dallas, TX

Predominant approaches to solving distributionally robust optimization problems are based on reformulation to equivalent convex programs. These reformulations are specific to the ambiguity set descriptions. We present an alternative approach that involves constructing ambiguity sets in a data-driven manner. Such ambiguity sets result in statistical approximations of the worst-case expectation function. This flash talk presents a sketch of a sampling-based algorithm design for two-stage distributionally robust optimization (DRO).

Sunday, 11AM–12:15 PM

SB38

CC - Sagamore 7

Algorithms for Assortment Optimization
General Session

Session Chair
Omar El Housni, Cornell Tech, New York, NY

Session Chair
Bradley Sturt, University of Illinois at Chicago, Chicago, IL

1 Joint Assortment Optimization and Customization Under a Mixture of Multinomial Logit Models: On the Value of Personalized Assortments

Omar El Housni, Huseyin Topaloglu, Cornell Tech, New York, NY, Contact: oe46@cornell.edu

We consider a joint customization and assortment optimization problem under a mixture of MNL models. A firm faces customers of different types, each making a choice according to a different MNL model. In the first stage, the firm picks an assortment of products to carry subject to a cardinality constraint. In the second stage, a customer of a certain type arrives into the system. Observing the type of this customer, the firm customizes the assortment that it carries by, possibly, dropping products from the assortment. We study the complexity of this problem, present tight bounds on the value of customization and design a novel algorithm that gives $\Omega(1/\log m)$-approximation to the problem, where m is the number of customer types. The problem has obvious connections to assortment optimization under a mixture of MNL models, which can only admit a $O(1/m)$-approximation.

2 Dynamic Pricing for a Large Inventory of Substitutable Goods

Vineet Goyal[1], Garud N. Iyengar[1], Rajan Udwani[2], [1]Columbia University, New York, NY, [2]UC Berkeley, Berkeley, CA

We consider a dynamic pricing problem for a large inventory of substitutable products over a finite planning horizon. When every good in stock must have a feasible price i.e., one cannot show only a subset of available goods, previous results do not apply. By defining and characterizing a novel property of choice models namely, chain convex decomposability, we give near-optimal pricing algorithm for MNL and (1-1.e) approximate pricing algorithm for general random utility choice models.

3 The Value of Robust Assortment Optimization Under Ranking-based Choice Models

Bradley Sturt, University of Illinois at Chicago, Chicago, IL

The ranking-based choice model is a popular model in revenue management for predicting demand for a firm's products based on the assortment of products that the firm offers to their customers. Because this model has a huge number of parameters, many different ranking-based choice models can be consistent with the historical sales data generated by a firm's past assortments. Motivated by the use of ranking-based choice models in assortment planning, we consider the following *identification question*: Is it possible to identify an assortment with an expected revenue that is strictly greater than the expected revenues of the firm's past assortments under all ranking-based choice models that are consistent with the firm's historical sales data? In this talk, we present the first answers to the identification question by using robust optimization.

4 Approximation Schemes for Joint Assortment and Pricing Problems with Opaque Products

Yukai Huang[1], Jacob Feldman[2], Xingxing Chen[3], [1]Olin Business School, St. Louis, MO, [2]Olin Business School, Saint Louis, MO, [3]University of Richmond, Richmond, VA, Contact: yukaihuang@wustl.edu

We study a dynamic joint assortment and pricing problem, wherein each product can either be offered as a traditional "transparent" product or as part of a group of products offered together as a single "opaque" product. Opaque product is a collection of products that customers are promised to receive one of them upon the retailer's choice. In each period, depending on the current inventory level, the decision-maker must decide a subset of transparent products and their price, as long as the price, make-up, and delivered item for opaque products.
We first consider a simplified version in that only the opaque product is offered. Our LP-based fluid approximation yield a 1-1/e approximation scheme. Next, we add back in the possibility to offer transparent products alongside an opaque product. In this more general setting, we provide a simple and elegant 1/3 approximation scheme.

Sunday, 11AM–12:15 PM

SB39

CC - Room 201
Optimization under Uncertainty: Theory and Applications (ii)
General Session

Session Chair
Robert Mahari, MIT, Cambridge, MA

1 **Adjusted Portfolio Selection Models Reflecting the Macroeconomic Variables**

Jihye Yang, Seongmoon Kim, Yonsei University, Seoul, Korea, Republic of. Contact: jihyeyang89@gmail.com

This study suggests improved investment strategy based on Markowitz's portfolio selection model reflecting the macroeconomic variables of our interest: Inflation rate and Money supply. We propose portfolio selection models reflecting the macroeconomic indicators respectively. First, the portfolio selection models actively adjust the total proportion of capital invested in risky assets conservatively or aggressively on the rebalancing date depending on the macroeconomic factors respectively. Secondly, the models actively adjust the proportion of capital invested in each risky asset depending on the macroeconomic variables' sensitivity of each stock. We empirically evaluate the performance of the proposed models in 12 different stock markets.

2 **Performance of Active Portfolio Managers when the Benchmark is Not Observed**

Luis Chavez-Bedoya, ESAN University, Lima, Peru. Contact: lchavezbedoya@esan.edu.pe

In the framework of active portfolio management, we propose a methodology to evaluate the performance of active portfolio managers when the benchmark portfolio cannot be either observed or determined by the agent performing the analysis. This suggested methodology assesses performance with respect to a combination of funds that minimizes residual risk; and, it is well-suited for evaluating the performance of pension-fund managers in defined-contribution pension systems, especially those operating in Latin America. We also provide numerical results when our methodology is applied to appraise the historical performance of the pension fund administrators of the Peruvian Private Pension System.

3 **The Economics of Litigation Finance**

Sandro Lera[1,2], Robert Mahari[3,4], Moris Simon Strub[5], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Southern University of Science and Technology, Shenzhen, China; [3]Massachusetts Institute of Technology, Cambridge, MA, [4]Harvard Law School, Cambridge, MA, [5]Southern University of Science and Technology, Shenzhen, China. Contact: rmahari@mit.edu

We study the economics of litigation with a particular focus on litigation finance. Based on a data set of 489,383 U.S. civil lawsuits, we present stylized empirical facts about lawsuits at the trial phase. Grounded in these insights, we build a base model for a lawsuit and a model extension that includes litigation finance. Using these models, we arrive at three main insights. First, compared to law firms, litigation funders prefer high-risk litigation, which can enable access to justice but also challenges the legal system by increasing the number of lawsuits. Second, litigation finance disproportionately benefits small law firms and plaintiffs in non-contingency arrangements. Third, the presence of litigation finance increases the amount spent on litigation and these costs are carried by the funder alone as cost sharing between funders and law firms is sub-optimal.

Sunday, 11AM–12:15 PM

SB40

CC - Room 202
Modeling the Environment
Contributed Session

Session Chair
Xavier Brusset, SKEMA Business School, Suresnes, France.

1 **Multi-objective Decision Making Framework for Smart Municipal Solid Waste Management**

Seyed Omid Hashemi Amiri, George Mason University, Fairfax, VA, Contact: ohashem@gmu.edu

Due to the explosion of waste generation rate and acceleration of environmental degradation worldwide, waste management turns into one of the critical urban services and a great deal of attention has been devoted to municipal solid waste issues. To address the main sustainability issues (e.g., circular economy, environmental problems, adverse social impacts) and measure the influence of modern technologies on municipal solid waste system, this research aims to introduce a new smart municipal solid waste framework.
In this study, a multi-objective stochastic programming model is developed to improve the resiliency of the system against high priority or emergency demands and reduce the environmental impacts while providing financial advantages to the waste system and society.

2 **Classification Machine Learning Methods Applied to Predict Sea Level Variations**

Kassandra Hernandez, Aaron Hoskins, Fresno, CA, Contact: hernandezkassandra@mail.fresnostate.edu

The goal of this study was to apply the classification methods to solve the problem of predicting sea level variations. The specific variables used in the classification model were sea-level, sea-level-risk, wave height, wave risk, tide height, tide risk, erosion, erosion risk, waves, and tide. The classification methods used were the decision trees, random forests, and k nearest neighbor. The results demonstrate a statistically significant difference in the performance of each algorithm applied to the sea level data utilized.

3 The Federal Emergency Management Agency'S National Exercise Division: Improving National Resilience and Readiness Through Data-informed Management

Tiffany Wimenta, FEMA - National Exercise Division, Washington DC, DC, Contact: tiffany.wimenta@fema.dhs.gov

Federal Emergency Management Agency's (FEMA) National Exercise Division (NED) is committed to advancing and improving the efficiency of business practices to meet the emerging threats our Nation faces. To do so, the NED has leveraged data-informed decision making to guide policy implementation, business processes, and human capital planning. We will share best practices NED used to integrate data science into its operational culture and make actionable recommendations for using data analytics in other organizations. Specifically, we'll explore types of data science and analytical capabilities that organizations can use to allocate resources and support strategic decision making.

4 Modelling Ripple Effect Propagation and Global Supply Chain Workforce Productivity Impacts

Xavier Brusset[1], Morteza Davari[1], Aseem Kinra[2], Davide La Torre[1], [1]SKEMA Business School, Paris, France; [2]Bremen University, Bremen, Germany. Contact: xavier.brusset@free.fr

Disruptions in ports, plants and warehouses have generated ripple effects impacting supply networks. The spread of the pandemic explains the ripple effect by reducing the workers' participation to production.

Our model of the spatio-temporal dynamics of the propagation of pandemics on supply networks contributes to ripple effect visualization and quantification by combining the flow of goods and materials through a supply chain with an epidemiological model. The model enables what-if analyses to be performed to simulate the impact on the workforce and production in each node. We present useful tools for managers and scholars. Results from this research will mitigate the impact and the spread of a pandemic in a particular region and on the ability of a supply network to overcome the ripple effect.

A stylised case study of a supply chain illustrates the ripple effect.

Sunday, 11AM–12:15 PM

SB41

CC - Room 203

Optimization under Uncertainty: Applications in Healthcare

General Session

Session Chair

Hrayer Aprahamian, Texas A&M University, College Station, TX

Session Chair

Hadi El-Amine, George Mason University, Fairfax, VA

1 An Optimization-based Framework for Problems with Time-dependent Uncertainty, with Application to Infectious Disease Screening

Marwan Shams Eddin[1], Hadi El-Amine[2], Hrayer Aprahamian[3], [1]George Mason University, Manassas, VA, [2]George Mason University, Fairfax, VA, [3]Texas A&M University, College Station, TX, Contact: mshamsed@gmu.edu

We consider a setting in which a decision-maker has partial information on the variation of system parameters over a finite time horizon. The decision-maker would like to determine optimal points in time to make a minimal number of decision adjustments due to operational constraints. We provide a novel mathematical framework that determines robust solutions. We then present refinements to significantly reduce computational time. Our case study on large-scale population screening demonstrates that the proposed framework can lead to significant reductions in costs and misclassification errors.

2 A Two-stage Stochastic Formulation for Targeted Mass Screening with Uncertain Symptomatic Cases

Jiayi Lin[1], Hrayer Aprahamian[2], George Golovko[3], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, [3]The University of Texas Medical Branch, Galveston, TX, Contact: jiayilin@tamu.edu

Mass screening is an essential tool that arises in a number of important settings (e.g., infectious outbreaks). Under limited budget, testing facilities need to allocate a portion of the budget to target sub-populations (proactive screening) while reserving the remaining budget to screen future symptomatic cases (reactive screening). We study this problem and formulate it as a two-stage stochastic program with endogenous uncertainty. By analyzing the resulting model, we provide two solution approaches: (i) a re-parameterization-based scheme and (ii) a linearization-based scheme. Our COVID-19 case study reveals substantial benefits over conventional approaches, highlighting the importance of data-driven policies.

3 Optimizing Stochastic Systems via Finite Approximation with an Application to Equitable Capacity Sizing in Transplant Waiting Lists

Shukai Li, Sanjay Mehrotra, Northwestern University, Evanston, IL, Contact: shukaili2024@u.northwestern.edu

We study capacity sizing in multiple transplant waiting lists to maximize fairness and meanwhile enforce a series of quality-of-service constraints. We consider the system with a possibly limited scale due to organ shortage as well as possible service-line abandonment (i.e., patients may die while calling for organ donations). Specifically, we model each waiting list as a queueing system in which a patient abandons if her patience time elapses before her transplant service is accomplished. Patients' inter-arrival time, service time, and patience time are independent and follow general distributions. We propose a finite approximation method to evaluate the system performance as an alternative to asymptotic analyses that rely on a large market assumption. We compute the optimal capacity level at each waiting list by solving a mixed-integer program.

4 Optimizing the Pre-positioning and Transportation of Medical Emergency Supplies Under the Uncertainty of Epidemic Breakouts

Zeyu Liu[1], Jia Shu[2], Anahita Khojandi[1], Xueping Li[1], [1]University of Tennessee, Knoxville, TN, [2]Southeast University, Nanjing, China. Contact: zeyu.liu@utk.edu

The Covid-19 pandemic has inflicted tremendous economic losses to countries around the world. To alleviate the disastrous impacts of epidemic breakouts, it is vital to set up relief systems with emergency medical supplies. However, due to the uncertainty in epidemic breakouts, optimizing the pre-positioning of supplies before the outbreak, as well as the transportation of supplies during the outbreak, faces great challenges. In this study, we utilize a novel sequential decision-making framework to optimize the inventory management of emergency supplies, considering resource distribution and stochastic demand in a long horizon. To solve the model efficiently, we implement a decomposition algorithm that provides significant computational advantages. Further, we draw insights and provide suggestions to practitioners via a case study using real-world data.

Sunday, 11AM–12:15 PM

SB42

CC - Room 204

Black-box Optimization: Algorithms and Applications

General Session

Session Chair

Nikolaos Sahinidis, Georgia Institute of Technology, Atlanta, GA

Session Chair

Kaiwen Ma, Carnegie Mellon University, Pittsburgh, PA

1 Full-low Evaluation Methods for Bound and Linearly Constrained Problems

oumaima Sohab, Lehigh University, BETHLEHEM, PA, Contact: ous219@lehigh.edu

Full-low evaluation methods are a class of DFO methods that considers two types of iterations. The first type is expensive in function evaluations (Full-Eval) but exhibits good performance in the smooth, non-noisy case. The second type is cheaper (Low-Eval), and more appropriate in the presence of noise or non-smoothness. Motivated by its performance in the unconstrained case, we extend this framework to the bound and linearly constrained case by making use of approximate tangent cones identified by nearby active constraints. The instance we consider for the Full-Eval step is a line-search where the step is a projection of the BFGS step on the approximate tangent cone and the Low-Eval step is a direct-search based on probabilistic feasible descent. We analyze the convergence and complexity of the resulting method for these particular iteration instances.

2 Linewalker: Line Search for Black Box Derivative Free Optimization and Surrogate Model Construction

Dimitri Papageorgiou[1], Jan Kronqvist[2], Krishnan Kumaran[3], [1]ExxonMobil Research & Engineering, Annandale, NJ, [2]KTH Royal Institute of Technology, Stockholm, Sweden; [3]Accenture, Raritan, NJ

We present a simple, but effective sampling method for learning the extrema of a discrete approximation of a multi-dimensional function along a one-dimensional line segment of interest. The method does not rely on derivative information and the function to be learned can be a "black box" function that must be queried via simulation or other means. We assume that the underlying function being approximated is noise-free and smooth. However, the algorithm can still be effective when the underlying function is non-differentiable and possibly discontinuous. Numerous examples are shown to illustrate the algorithm's competitiveness and potential superiority relative to state-of-the-art methods like NOMAD and Bayesian optimization.

3 Branch-and-Model: A Derivative-free Global Optimization Algorithm

Kaiwen Ma[1], Luis Miguel Rios[2], Atharv Bhosekar[3], Nikolaos Sahinidis[4], Sreekanth Rajagopalan[5], [1]Carnegie Mellon University, Pittsburgh, PA, [2]End-to-End Analytics, Lima, Peru; [3]GAMS Development Corporation, New York, NY, [4]Georgia Institute of Technology, Atlanta, GA, [5]The Dow Chemical Company, Lake Jackson, TX, Contact: kaiwenm@andrew.cmu.edu

Derivative-free optimization (DFO) is an important class of optimization algorithms that solve problems based on objective and function evaluations. DFO methods have enormous practical potential to address problems where derivatives are unavailable, unreliable, or only available at a significant cost. In this work, we present a novel derivative-free global algorithm *Branch-and-Model (BAM).* The BAM algorithm utilizes a flexible partition scheme and model-based search techniques, which exploit the local trend and speed up the convergence in solution refinement. The BAM algorithm is guaranteed to converge to the globally optimal function value under mild assumptions. Extensive computational experiments over 500 publicly open-source test problems show that BAM outperforms state-of-the-art DFO algorithms, especially for higher-dimension problems.

4 Derivative-Free Optimization of a Rapid-Cycling Synchrotron

Jeffrey Eldred[1], Jeffrey Larson[2], Misha Padidar[3], Eric Stern[1], Stefan Wild[4], [1]Fermi National Accelerator Laboratory, Batavia, IL, [2]Argonne National Laboratory, Argonne, IL, [3]Cornell University, Ithaca, NY, [4]Argonne National Laboratory, Lemont, IL

We develop and solve a constrained optimization model to identify an integrable optics rapid-cycling synchrotron lattice design that performs well in several capacities. Our model encodes the design criteria into 78 linear and nonlinear constraints, as well as a single nonsmooth objective, where the objective and some constraints are defined from the output of Synergia, an accelerator simulator. We detail the difficulties of optimizing within the 32-dimensional, simulation-constrained decision space and establish that the space is nonempty. We use a derivative-free manifold sampling algorithm to account for structured nondifferentiability in the objective function. Our numerical results quantify the dependence of solutions on constraint parameters and the effect of the form of objective function.

Sunday, 11AM–12:15 PM

SB43

CC - Room 205

Recent Advances in Nonlinear and Stochastic Optimization

General Session

Session Chair

Baoyu Zhou, Lehigh University, Bethlehem, PA

Session Chair

Albert Solomon Berahas, University of Michigan, Ann Arbor, MI

1 Recent Progress in Stochastic and Deterministic Derivative-free Nonsmooth Optimization

Luis Nunes Vicente, Lehigh University, Bethlehem, PA

We focus on the minimization of a nonsmooth black-box function, without assuming access to (generalized) derivatives and without knowledge of function nonsmoothness.
In the deterministic case, we propose a trust-region model that is the sum of a max-linear term with a quadratic one. Our trust-region methods enjoy the same global convergence of directional methods, provided the vectors for the max-linear term are densely generated. The numerical results show that our approach is efficient and robust.
In the stochastic case, we use tail bounds to define a tailored probabilistic condition for function estimation that eases the theoretical analysis of both direct-search and trust-region methods. Our condition is posed on the estimate of the difference between the function at current and potential iterates.
Joint work with F. Rinaldi, G. Liuzzi, S. Lucidi, and D. Zeffiro.

2 Worst-case Complexity of Trace with Inexact Subproblem Solutions for Nonconvex Smooth Optimization

Qi Wang[1], Frank E. Curtis[2], [1]Lehigh University, Bethlehem, PA, [2]lehigh university, Bethlehem, PA, Contact: qiw420@lehigh.edu

An algorithm for solving nonconvex smooth optimization problems is proposed, analyzed, and tested. The algorithm is an extension of the Trust Region Algorithm with Contractions and Expansions (TRACE) [Math.~Prog.~162(1):132, 2017]. The extension allows inexact subproblem solutions, in favor of solving large-scale problems. The algorithm maintains the optimal iteration complexity of $\mathcal{O}(\epsilon^{-3/2})$ for attaining an ϵ-approximate first-order stationary point and improves the worst-case complexity of Hessian-vector products as compared to the original TRACE. Numerical experiments show the benefits of allowing inexact subproblem solutions and that the algorithm compares favorably to a state-of-the-art technique.

3 An Outer Nonlinear Programming Approach for Constrained Derivative-free Optimization

Melody Qiming Xuan, Jorge Nocedal, Northwestern University, Evanston, IL, Contact: qxuan@u.northwestern.edu

Interpolation-based optimization methods have been extensively studied for unconstrained derivative-free optimization due to their robustness and efficiency in terms of function evaluations. Yet extending these methods to general constrained optimization is not straightforward and such approach has received limited attention. To provide insights into the design of constrained derivative-free optimization solvers, we study DFO problems with analytically available constraints. We extend IBO methods and refer to such approach as OuterDFO as it requires an outer solver to compute the next iterate. We argue that this seemingly expensive approach can be quite efficient if the objective is much more expensive to evaluate than the constraints and if the number of variables is small. We provide such evidence in this work and demonstrate the difficulties of this approach.

Sunday, 11AM–12:15 PM

SB44

CC - Room 206

Nonconvex Nonsmooth Optimization

General Session

Session Chair

Andy Sun, MIT, Catonsville, MD

Session Chair

Jiawei Zhang, 1</sup

1 Riemannian Optimization for Projection Robust Optimal Transport

Shiqian Ma, University of California - Davis, Davis, CA

The optimal transport problem is known to suffer the curse of dimensionality. One way to mitigate this is to project the sampled data from the high dimensional probability distribution onto a lower dimensional subspace, and then compute the optimal transport between the projected data. However, this requires to solve a max-min problem over the Stiefel manifold, which is very challenging in practice. In this talk, we propose a Riemannian block coordinate descent (RBCD) method to solve this problem. We analyze the complexity of arithmetic operations for RBCD to obtain an eps-stationary point, and show that it significantly improves the corresponding complexity of existing methods. Numerical results on both synthetic and real datasets demonstrate that our method is more efficient than existing methods, especially when the number of sampled data is very large.

2 Scalable Nonconvex Min-max Optimization and Applications in Fair Machine Learning

Meisam Razaviyayn, Dmitrii Ostrovskii, Andrew Lowy, University of Southern California, Los Angeles, CA

Min-max optimization problems have been extensively studied in the convex-concave regime. In the nonconvex regime, on the other hand, most problems cannot be solved to any reasonable notion of stationarity. In this talk, we present different classes of smooth nonconvex min-max problems that can be solved efficiently up to first-order stationarity of its Moreau envelope. We propose efficient algorithms for finding (first-order) stationary solutions to nonconvex min-max problems classes when the inner maximization problem is concave or when the diameter of the constraint set for the inner maximization problem is “small”. We also discuss the validity of our assumptions in various applications and evaluate the performance of our algorithms on different applications including training adversarially robust neural networks and fair machine learning.

3 What is a Good Metric to Study Generalization of Minimax Learners?

Sarath Pattathil, Massachusetts Institute of Technology, Cambridge, MA

A fundamental question for minimax problems remains elusive: What is a good metric to study generalization of minimax learners? We aim to answer this question by first showing that primal risk, a universal metric to study generalization in minimization problems, fails in simple minimax problems. Another popular metric, the primal-dual risk, also fails to characterize the generalization behavior for minimax problems with nonconvexity, due to non-existence of saddle points. We thus propose a new metric to study generalization of minimax learners: the primal gap, to circumvent these issues. Next, we derive generalization bounds for the primal gap in nonconvex-concave settings. Finally, we leverage this new metric to compare the generalization behavior of two popular algorithms - gradient descent-ascent (GDA) and gradient descent-max (GDMax) in minimax optimization.

4 A Decomposition Algorithm for Two-stage Stochastic Programs with Nonconvex Recourse

YING Cui, University of Minnesota, Minneapolis, MN

We consider a decomposition method for solving a class of nonconvex two-stage stochastic programs, where both the objective and constraints of the second-stage problem are nonlinearly parameterized by the first-stage variable. Due to the failure of the Clarke regularity of the nonconvex recourse function, classical decomposition approaches such as Benders decomposition and Lagrangian-based algorithms cannot be directly generalized to solve such models. By exploring an implicitly structure of the recourse function, we introduce a novel decomposition framework based on the partial Moreau envelope. The algorithm successively generates convex quadratic approximations of the recourse function based on the solutions of the second-stage subproblems and adds them to the master problem. Convergence under both fixed scenarios and interior samplings is established.

Sunday, 11AM–12:15 PM

SB45

CC - Room 207

Lot Sizing Problems

General Session

Session Chair

Hugh Richard Medal, 1</sup

1 Lower Bound on Size of Branch-and-bound Trees for Solving Lot-sizing Problem

Santanu Subhas Dey[1], Prachi Shah[2], [1]ISyE Georgia Tech, Atlanta, GA, [2]ISyE, Georgia Tech, Atlanta, GA, Contact: prachi.shah@gatech.edu

We show that there exists a family of instances of the lot-sizing problem, such that any branch-and-bound tree that solves them requires an exponential number of nodes, even in the case when the branchings are performed on general split disjunctions. This result is of interest since there exists dynamic programming algorithms that solve lotsizing in polynomial-time. To the best of our knowledge, this is the first study that shows that dynamic programming can be exponentially faster than general branch-and-bound.

2 Stochastic Lot-sizing with Substitution and Service Level Constraints

Jim Luedtke[1], Narges Sereshti[2], Merve Bodur[3], [1]University of Wisconsin-Madison, Madison, WI, [2]HEC Montreal, Montreal, QC, Canada; [3]University of Toronto, Toronto, ON, Canada. Contact: jim.luedtke@wisc.edu

We consider a multi-stage stochastic lot-sizing problem with service level constraints and product substitution. A firm has multiple products and when meeting demand has the option to meet demand from substitutable products at a cost. Considering the uncertainty in future demands, the firm wishes to make ordering decisions in every period such that the probability that all demands can be met in the next period is at least a given target. We propose a rolling horizon policy in which a two-stage joint chance-constrained stochastic program is solved to make decisions in each time period. We demonstrate how to effectively solve this formulation, and compare the resulting policy to policies based on deterministic approximations. We also demonstrate the value of product substitution in this model.

3 Algorithms for a Two-level Multi-item Lot-sizing Problem with All-units Quantity Discounts

Hugh Medal[1], Samuel Affar[2], [1]University of Tennessee, Knoxville, TN, [2]University of Tennessee, Knoxville, Knoxville, TN

We study a two-level multi-item lot-sizing problem with all-units quantity discounts and an inventory capacity constraint. To enable orders of larger quantities, inventory of each item can be held at the supplier for a limited amount of time. The goal is to find an order plan that minimizes the total purchasing cost over the planning horizon. Other side constraints include minimum shipment quantities, minimum inventory levels, and minimum order quantities. We test an extended mixed-integer programming formulation using a piecewise linear function to model quantity discounts. We also test a Lagrangian relaxation approach along with speedups.

4 The Effects of Variable Demand Rate on Supplier Selection and Product Pricing

Gianni A. Di Carlo[1], Jose A. Ventura[2], [1]The Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, Contact: gad5170@psu.

edu

We study a supplier selection and lot-sizing problem in a two-stage supply chain composed of a set of potential suppliers and a single buyer/retailer trading one product. The suppliers manufacture the product with negligible differences among them. The market demand at the buyer's stage is price-sensitive, and suppliers have finite production rates. Unlike other papers, we evaluate the supply chain by varying the demand function, whose input is the item's price. We examine the results of a mixed integer nonlinear programming model considering two different demand functions, the standard linear demand function, and the Logit demand function. By the end, we establish which of these two functions represents the real-life demand.

Sunday, 11AM–12:15 PM

SB46

CC - Room 208

Mechanism and Market Design for Emerging Mobility Systems

General Session

Session Chair

Qi Luo, Clemson University, Clemson, SC

Session Chair

Xiaotong Sun, The Hong Kong University of Science and Technology (Guangzhou), Hong Kong, China.

1 Market and Mechanism Designs for Creating an Adaptable City

Cynthia Chen, University of Washington, Seattle, WA

Our society relies on maximizing efficiency. But COVID-19 has revealed vulnerabilities of systems designed for maximum efficiency. This has added stress to our society: what options do people, businesses and public agencies (e.g., transit) have in this evolving process of perturbation? As we anticipate that human society will face more challenges in the future, it is now time to think about creating adaptable cities that can adapt in this evolving process of perturbation. Using an urban system comprising urban space, small businesses, human behaviors, and transit as an example, this talk will focus on the roles of mechanism and market design for emerging mobility systems in creating an adaptable city. Future research directions are discussed.

2 An Equitable and Stable Two-sided Matching Problem: An Application to a Two-sided Crowd-shipping Market

Hui Shen, University of Illinois at Chicago, Chicago, IL, Contact: hshen23@uic.edu

This study proposes a matching mechanism that not only considers two sides' preferences equally, but also achieves a stable matching that no pair prefer each other to their current partners. It is the equitable and stable matching mechanism (ESMM). Egalitarian, side equality, and pair equality costs are created as equity metrics. Small, medium, and large scales of experiments are conducted to investigate its solution properties. Besides, we apply it to a designed crowdshipping (CS) market, and compare the performance of ESMM and traditional system optimization matching mechanism (SOMM) under five objectives. As a result, ESMM achieves good equity metrics. Although the matching rate by ESMM is lower than that by SOMM, it remains over 75% in experiments. And ESMM shows similar effects to SOMM on maximizing senders' benefits and social welfare in the designed CS market.

3 Robust and Resilient Equilibrium Routing Mechanism for Traffic Congestion Mitigation Built upon Correlated Equilibrium and Distributed Optimization

Yuqiang Ning, Lili Du, University of Florida, Gainesville, FL, Contact: y.ning@ufl.edu

This study develops a correlated equilibrium routing mechanism (CeRM) to alleviate traffic congestion, which drives a group of vehicles' route choices to a systematically optimal traffic condition while still satisfying individuals' selfish nature. A distributed Augmented Lagrangian algorithm (D-AL) is developed to efficiently solve the CeRM, taking advantage of the on-board computation resources of individual vehicles. Considering random communication failures, we proved the convergence robustness of the D-AL and developed the convergence rate upper bound as a function of the communication failure probability. To improve the solution algorithm's resilience in the computation performance, we further designed and proved an acceleration scheme aided D-AL (aD-AL) to expedite the convergence rate under the high likelihood of communication failures.

4 Does Equilibrium Remain a Relevant Paradigm for Modeling Connected and Automated Mobility?

Minghui Wu[1], Yafeng Yin[1], Jerome Lynch[2], [1]University of Michigan, Ann Arbor, MI, [2]Duke University, Durham, NC,

Contact: minghuiw@umich.edu
In the connected and automated mobility era, commuters (connected drivers or automated vehicles) will possess strong computation capability and their travel decisions can be algorithmic and strategic. We investigate the day-to-day travel choice evolution of such strategic commuters who are capable of long-term planning and computation. We model the process as a mean field game and examine the mean field equilibrium to derive the evolution pattern. The proposed model is general and can be applied to modeling various choices including route or departure time. Under mild assumptions, we prove the existence and uniqueness of the day-to-day equilibrium traffic evolution pattern as well as its convergence to stationarity. The physical interpretation of the stationary solution is discussed and connected to Wardropian equilibrium.

Sunday, 11AM–12:15 PM

SB47

CC - Room 209
RAS Problem Solving Competition
Award Session

Session Chair
Nikola Coviello, TrenoLab

Session Chair
marc Meketon, Oliver Wyman, Princeton, NJ

UNREGISTERED Award Presenter
Nikola Coviello, TrenoLab

2 Award Presenter
marc Meketon, Oliver Wyman, Princeton, NJ

Sunday, 11AM–12:15 PM

SB48

CC - Room 210
Transportation Science
Contributed Session

Session Chair
Amir Hossein Sadeghi, North Carolina State University, Raleigh, NC

1 Fleet Composition Optimization with Truckload and Less-than-truckload Shipping Options

Yue Wang[1], Joseph Geunes[1], Xiaofeng Nie[2], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: yuewang92@tamu.edu
We study a fleet composition problem with stochastic and bounded, periodic demand, which must be fulfilled via a combination of internal truckload (TL) capacity and external less-than-truckload (LTL) shipments. Internal capacity costs include a fixed ownership cost per truck and a fixed dispatch cost per truck trip, while LTL costs are incurred per unit shipped. We characterize the expected shipping cost per period as a function of internal fleet size for both homogeneous and heterogeneous fleets. For certain demand distributions, we explore the properties of the optimal fleet size, and the corresponding expected quantities shipped via TL and LTL, respectively.

2 An Integrated Learning and Progressive Hedging Method for Stochastic Network Design Problem

Fatemeh Sarayloo[1], Teodor Gabriel Crainic[2], Walter Rei[3], [1]Purdue University, West Lafayette, IN, [2]Université du Québec à Montréal, Montréal, QC, Canada; [3]University of Quebec-Montreal, Saint-Lambert, QC, Canada.
In this talk, we address Multicommodity Capacitated Fixed-charge Network Design problem with uncertain demands, formulated as a two-stage stochastic program. We rely on the progressive hedging algorithm where the scenarios are defined using scenario grouped. We propose an efficient matheuristic which we refer to as integrated learning and progressive hedging (ILPH). The proposed method takes advantage of a specialized learning-based matheuristic that is able to quickly produce high-quality solutions to multi-scenario subproblems. Furthermore, we propose a novel reference point definition, at each aggregation step of the PH algorithm, which leverages subproblem information regarding promising design variables. Extensive computational experiments show the interest of the proposed approach in terms of computation time and solution quality.

3 Drayage Operation with Charging Planning Using Diesel and Battery Electronic Heavy-duty Trucks

Siyuan Yao[1], Maged M. Dessouky[2], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, Contact: siyuanya@usc.edu

We study a drayage operation problem minimizing truck operating costs and emissions with a mixed fleet of diesel trucks and Battery Electronic Heavy-Duty Trucks (BEHDTs). There has been a long history of Greenhouse Gas (GHG) emission regulations in California. Battery Electronic Heavy-Duty Trucks (BEHDTs) are gradually introduced into drayage operations as a substitute for traditional diesel trucks to reduce GHG emissions. BEHDTs have range limits due to the current battery technology, making it essential to consider charging during truck routing planning.

4 Charging Network Design and Allocation of Shared Micro-scale Mobility Under Range and Equity Constraints

Amir Sadeghi, Demetra Protogyrou, Leila Hajibabai, North Carolina State University, Raleigh, NC, Contact: asadegh3@ncsu.edu

This study focuses on micro-scale mobility systems that offer short-range ride options and first-/last-mile solutions. In this research, we investigate the contributing factors that support the adoption of shared rideable robots to facilitate transportation in diverse neighborhoods and evaluate their socio-economic impacts. A mathematical model is developed that accounts for decisions of business operators along with their interactions with users. The numerical results confirm the quality of the solutions.

Sunday, 11AM–12:15 PM

SB49

CC - Room 211

Logistics Operations for Infrastructure Network Restoration

General Session

Session Chair

Bahar Cavdar, Texas A&M University, College Station, TX

1 The Flood Mitigation Problem in a Road Network

Vahid Eghbal Akhlaghi[1], Ann Melissa Campbell[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of Iowa, Iowa City, IA, Contact: vahid-eghbalakhlaghi@uiowa.edu

Floods can deteriorate and block transport systems, leading to loss of access to healthcare facilities. To mitigate these consequences, it is crucial to determine which improvements to a city's transportation infrastructure can improve access to emergency service facilities. This presentation addresses a pre-disaster planning problem that identifies the best road segments in a transportation network to strengthen to enable travel from population centers to healthcare facilities after a flood event. We examine an objective to minimize the residents' travel times subject to the available budget and facility capacity restrictions.

2 Restoration of Infrastructure Networks with Precedence Relationship Under Incomplete Information

Subhojit Biswas, Bahar Cavdar, Joseph Geunes, Texas A&M University, College Station, TX, Contact: subhojit.biswas@tamu.edu

A rise in the frequency and magnitude of natural disruptions (e.g., earthquakes, snowstorms, hurricanes) has increasingly and negatively impacted power infrastructure networks globally. Power network restoration following such events requires deploying restoration crews under limited information about the state of the network. Although we may know that a given set of network nodes lacks power, we may not have information on whether the equipment at each such node is faulty and requires repair. Given a set of nodes without power, as well as a probability that each such node requires repair, we seek a node visit sequence that minimizes the weighted expected customer downtime in the network. We formulate this problem as an MDP and, because of the problem's complexity, propose an approximate dynamic programming heuristic solution approach.

3 Framework to Support Infrastructure Upgrades for Decarbonization of US Freight Rail

Adrian Hernandez[1], Max Ng[1], Pablo Luis Durango-Cohen[1], Hani S. Mahmassani[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: adrianhernandez2025@u.northwestern.edu

The decarbonization of the US transportation sector presents a considerable challenge for the freight railroads, whose operations are extremely energy intensive and networks span tens of thousands of track-miles. We present a hierarchical framework to address the network deployment and sizing of the refueling infrastructure required by alternative fuel propulsion technologies. This framework is applied to two railroad networks, an Eastern and a Western US railroad, for a series of scenarios. The results are analyzed with respect to cost of deployment and emissions reductions potentials.

4 Repair Crew Routing for Infrastructure Network Restoration

Bahar Cavdar[1], Qie He[2], Feng Qiu[3], [1]Texas A&M University, College Station, TX, [2]Amazon, Santa Clara, CA, [3]Argonne National Laboratory, Lemont, IL, Contact: bcavdar@tamu.

edu

We study a repair crew routing problem to restore a disrupted power network where technical crew travels to a number of sites to repair damaged equipment with minimum total service disruption time. We call this problem the Power Restoration Traveling Repairman Problem (PRTRP). The main challenge in this problem is that the service disruption time in a location depends on the interaction of the routing sequence with both networks, i.e., the road network and the power grid. To solve the problem, we develop an exact method based on bi-directional dynamic programming. We then improve the method by reducing the search space with solution upper and lower bounds, and threshold rules derived from the precedence relations in the power network. We also propose efficient heuristic variants of the method. We present computational results and compare our method with benchmark heuristics.

Sunday, 11AM–12:15 PM

SB50

CC - Room 212

eBusiness and Analytics

General Session

Session Chair

Jin Sik Kim, The University of Tennessee at Chattanooga, Chattanooga, TN

1 Catch Me if You Can! The Economic Analysis of Geofencing

Xiangjing Chen[1], Ian Ho[2], Shengjun Mao[3], [1]Arizona State University, Tempe, AZ, [2]Pennsylvania State University, State College, PA, [3]The University of Hong Kong, Hong Kong, Hong Kong. Contact: xchen328@asu.edu

Geofencing enables a firm to set a virtual fencing zone surrounding its store and entice consumers to visit it via advertising. We investigate how consumer awareness affects geofencing using a game-theoretic model. Specifically, we start by comparing geofencing and traditional advertising in various awareness conditions and obtain the optimal fencing radius and price. We show three benefits of geofencing, including market expansion, profit-margin increment, and cost savings. To further improve efficiency, we propose a novel strategy that allows the firm to choose the point of interest flexibly (i.e., no longer restricted to its store). The analyses confirm that flexible geofencing is particularly useful when consumer awareness is correlated with the distance to the store. Our findings provide advertisers with executable actions to improve advertising efficiency.

2 Pandemic in the Gaming Ecosystem: How Covid-19 Changed the Interplay Between Gaming and Live Streaming

Sung Hyun Kwon[1], Il-Horn Hann[2], [1]University of Maryland, College Park, MD, [2]University of Maryland, College Park, MD

The Covid-19 outbreak has necessitated individual behavioral changes, including social distancing. For the gaming population in Korea, this meant a significant reduction of visits to PC Cafes. We investigate how this change affected the interplay between the two central parts of the video game ecosystem: gaming and live game streaming. Live game streaming is essentially user generated content produced and consumed independently by gamers that earned a central role in the ecosystem. Using data from Korean PC Cafés and Twitch, we measure the temporal nature of the network effect and spillover within and across platforms. Our results indicate a mutually beneficial network effect between the two platforms. We also estimate the change in the size of network effects due to the exogenous shock from the pandemic and show that network effects across the platforms are not constant.

3 Goal-reward Schemes for On-demand Learning: A Field Experiment

Jaeung Sim[1], Dongwon Lee[2], Yeolib Kim[3], Jiye Baek[4], [1]KAIST College of Business, Seoul, Korea, Republic of; [2]HKUST, Kowloon, Hong Kong; [3]Ulsan National Institute of Science and Technology, Ulsan, Korea, Republic of; [4]Korea University, Seoul, Korea, Republic of.

The on-demand nature of online learning is tied to less student feedback, less face-to-face communication, and social isolation. Thus, learners are left to fend for themselves for various learning activities in an asynchronous online environment. This study proposes that goal-reward schemes allow online learners to regulate their learning time for on-demand learning. Specifically, we focus on two novel dimensions of goal design: 1) learner autonomy and 2) sub-goal granularity. We test the effectiveness of such design factors by conducting a randomized field experiment on an online education platform. We find that for the partial-autonomy condition, we observe an inverted U-shaped relationship between sub-goal granularity and its effectiveness. Notably, we observe a positive impact on non-incentivized learning behaviors only from the full-autonomy condition.

Sunday, 11AM–12:15 PM

SB51

M - Santa Fe
George Nicholson Student Paper Competition II
Award Session

Session Chair
Jing Dong, Columbia University, New York, NY

Session Chair
Paul Grigas, UC Berkeley, Berkeley, CA

On the Robustness of Second-Price Auctions in Prior-Independent Mechanism Design

Jerry Anunrojwong, Columbia University, Columbia, NY

The seller wants to sell an item to n buyers such that the buyers' valuation distribution is from a given class (i.i.d., mixtures of i.i.d., affiliated and exchangeable, exchangeable, and all distributions) and the seller minimizes worst-case regret. We derive in quasi closed form the minimax values and the associated optimal mechanism. We show that the first three classes admit the same minimax regret, decreasing in n, while the last two have the same minimax regret equal to that of the case n = 1. Across all settings, the optimal mechanisms are second-price auctions with random reserve.

The Gittins Policy is Nearly Optimal in the M/G/k under Extremely General Conditions

Ziv Scully, Isaac Grosof, Carnegie Mellon University, Pittsburgh, PA

Scheduling to minimize mean response time in the preemptive M/G/1 is a classic problem. Its solution, the Gittins policy, works for unknown job sizes, known job sizes (where Gittins reduces to SRPT), and a range of partial information settings. However, minimizing mean response time in multiserver systems, such as the M/G/k, is a much more difficult problem. We give the first analysis bounding Gittins's performance in the M/G/k, showing that it achieves mean response time close to that of Gittins in a resource-pooled M/G/1. Our bound implies that Gittins is heavy-traffic optimal in the M/G/k.

Small Shadows of Lattice Polytopes

Alexander Black, UC Davis, Davis, CA

The diameter of a d-dimensional lattice polytope contained in [0,k]^(n) is well known to be at most dk due to work of Kleinschmidt and Onn. However, the question of finding a pivot rule for the simplex method that is guaranteed to trace a path on the surface of a polytope satisfying that bound or even a bound in polynomial in d and k remains open. We prove many partial results in this direction including finding a pivot rule that a satisfies a bound of dnk||A||_{\infty}, where A is an integral constraint matrix for the polytope.

Sunday, 11AM–12:15 PM

SB52

M - Lincoln
Undergraduate Operations Research Prize 1
Award Session

Session Chair
Trilce Encarnacion, University of Missouri- St. Louis, Saint Louis, MO

The Probability Mass Function of the Kaplan-Meier Product-Limit Estimator

Yuxin Qin, William and Mary, Williamsburg, VA

Kaplan and Meier's 1958 paper developed a nonparametric estimator of the survivor function from a right-censored data set. Determining the size of the support of the estimator as a function of the sample size provides a challenging exercise for students in an advanced course in mathematical statistics. We devise two algorithms for calculating the support size and calculate the associated probability mass function for small sample sizes and particular probability distributions for the failure and censoring times.

The Non-Markovian Nature of Nested Logit Choice

Selena Li, University of California, Berkeley, Santa Barbara, CA

Discrete choice models are widely used to model how customers choose between substitutable goods. We study the relation between two well studied choice models, Nested Logit (NL) and Markov. Both models generalize the Multinomial Logit model and admit tractable algorithms for assortment optimization. Past evidence indicates that NL may be well approximated by, or be a case of, Markov. We show that generally, NL cannot be represented by Markov. Further, we describe a family of instances of NL with choice probabilities that cannot be approximated to within a constant error by any Markov model.

Sunday, 11AM–12:15 PM

SB53

M - Denver
Service Operations
Contributed Session

Session Chair
Yudi Huang, [1]</sup

1 A Model for Servicizing Operations

Yinshi Agnes Gao[1], Saurabh Bansal[2], V Daniel R Guide[1], [1]Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, State College, PA, Contact: yzg115@psu.edu

The study focuses on a servicizing OEM who provides a product to customers on lease, remanufactures the product at the end of the lease, and then re-leases the product. We discuss properties of lease parameters, cost and profit implications for the OEM.

2 The Impact of Work Hours on Performance of Gig Workers in Online Retail

Reeju Guha[1], Daniel S. Corsten[2], [1]IE Business School, Madrid, Spain; [2]IE Business School, Madrid, Spain. Contact: reejuguha@student.ie.edu

Companies operating under gig-contractor models have shifted towards offering full-time jobs to meet the demand-supply gap and ensure better productivity through longer work availability. However, several online platforms still operate in the gig-contractor model, where demand surges can be met only if gig workers work longer durations. This, however, raises the issue of adverse effects of longer work hours on performance. We argue that *voluntary* longer work availability resulting from schedule flexibility ameliorates the negative effects of longer workhours. Using panel data from an online grocery retailer, we observe that longer workhours improves productivity, and service quality. We further find that experience of performing similar tasks can moderate the effect of work hours on performance, after controlling for worker and task-specific characteristics.

3 A Survey of Reinforcement Learning Tools in Ride-hailing Platforms

Yudi Huang[1], Sebastien Martin[2], [1]Northwestern university, Kellogg School of Management, Evanston, IL, [2]Northwestern University, Kellogg school of management, Cambridge, MA, Contact: yudi.huang@kellogg.northwestern.edu

Ride-hailing markets rely heavily on the efficiency of operational decisions. Over the past few years, RL-based tools have been proven to be powerful approaches to get outperforming policies in the industry. In this talk, we will give a brief overview of the motivations under a variant of RL frameworks. We will also present some seminal works and discuss the most prominent open questions in the RL application in the ride-hailing markets.

Sunday, 11AM–12:15 PM

SB54

M - Marriott 1
Recent Advancement of Stochastic Modeling for Service Systems
General Session

Session Chair
Yue Hu, Columbia University, New York, NY

1 Steady-state Performance Approximations of Many-server Queueing Networks

Anton Braverman, Northwestern University, Evanston, IL, Contact: anton.braverman@kellogg.northwestern.edu

Motivated by the need for decision support tools for workload prediction and capacity planning in hospitals under the COVID-19 pandemic, we consider a queueing network consisting of two many-server stations, which models the flow of patients between medical/surgical and intensive care unit wards. We approximate the steady-state customer count using the stationary distribution of the associated diffusion model, which can be computed efficiently and be used as a real-time decision support tool.

2 Modeling and Analysis of Queues with Strategic Agents

Yueyang Zhong[1], Raga Gopalakrishnan[2], Amy R. Ward[1], [1]The University of Chicago Booth School of Business, Chicago, IL, [2]Smith School of Business at Queen's University, Kingston, ON, Canada.

Service system design is often informed by queueing theory, which traditionally assumes that customers and servers work at constant speeds. However, when customers and servers are people, design decisions influence their behavior. First, we focus on the impact of only strategic servers using a game-theoretic model, where servers' (state-independent) choice of work speed depends on managerial decisions regarding (i) how many servers to staff and how much to pay them, and (ii) whether and when to turn away customers. We then highlight the challenges of extending our model to also incorporate strategic customers' joining decisions (and then the manager's decision (ii) above might instead become, e.g., how much to charge customers for service) and analyzing joint equilibria. We conclude with an open discussion on modeling state-dependent work speed choices by the servers.

3 Observation-driven Abandonment in Congested Systems

Costis Maglaras[1], Ran Snitkovsky[2], Assaf Zeevi[3], John J. Yao[4], [1]Columbia Business School, New York, NY, [2]Tel Aviv University, Tel Aviv - Jaffa, Israel; [3]Columbia University, New York, NY, [4]University of Miami, Coral Gables, FL

We introduce a queueing model of a congested service system in which delay-sensitive customers make abandonment decisions; Customers naively estimate their remaining waiting time based on their queue position and on service-time realizations they observe, and abandon when the estimate exceeds their patience threshold. These abandonment decisions are coupled via common service-time observations, and lead to abandonment 'waves' triggered by long service times. We study this phenomena with the aid of a suitable fluid model, corresponding to the limit of a scaled queueing process. We reveal some surprising results about the scaled process, particularly, that abandonment waves result in a queue length negligibly smaller than the system scale.

4 Dynamic Load Balancing in Parallel Queueing Networks

Timothy Chan, Jangwon Park, Vahid Sarhangian, University of Toronto, Toronto, ON, Canada. Contact: jangwon.park@mail.utoronto.ca

Motivated by the problem of guiding interfacility patient transfers in a hospital network, we study dynamic load balancing in a network of parallel queues. We investigate policies for transferring customers between queues at discrete points in time by analyzing an associated fluid control problem and characterizing the structure of its optimal solution. Our results provide insights for design of guidelines for transferring patients in a hospital network, aimed at mitigating imbalances in congestion between hospitals and reducing the adverse effects of high congestion.

Sunday, 11AM–12:15 PM

SB55

M - Marriott 2

(Stochastic) First-order Methods for Convex and Nonconvex Problems in Machine Learning

General Session

Session Chair

Digvijay Boob, Southern Methodist University, Dallas, TX

1 On the Projection Complexities of Convex Optimization

Yuyuan Ouyang[1], Jimmy Zhang[2], [1]Clemson University, Clemson, SC, [2]Georgia Institute of Technology, Atlanta, GA, Contact: yuyuano@clemson.edu

We study the projection complexity of first-order methods for solving convex optimization problems. Our problem of interest is to minimize a convex function over a feasible set on which we can perform projection operations. We assume that the objective function is either nonsmooth or differentiable with Holder gradients. Matching lower and upper complexities on the number of projections are presented.

2 Approximation Approaches for the Cardinality Minimization Problem

Miju Ahn, Southern Methodist University, Dallas, TX

We study a cardinality minimization problem (CMP) which penalizes the number of violations of soft constraints by the indicator function. Our approach reformulates the discrete CMP as continuous problems; we present an equivalent formulation of mathematical program with complementarity constraints and an approximate difference of convex program. The alternative formulations' stationary solutions are investigated, emphasizing the recovery of the local solutions of the CMP. The results of our numerical study demonstrate the effectiveness of our method for enforcing soft conditions on several suitable applications.

3 Level Constrained First-order Methods for Function Constrained Optimization

Digvijay Boob[1], Qi Deng[2], Guanghui Lan[3], [1]Southern Methodist University, Dallas, TX, [2]Shanghai University of Finance and Economics, Shanghai, China; [3]ISyE Ga Tech, Atlanta, GA, Contact: dboob@smu.edu

In this talk, we present a new level constrained proximal gradient method for composite nonconvex function constrained optimization. The algorithm converts the original problem into a sequence of convex subproblems. By carefully increasing this constraint level parameter, we provide a simple solution to overcome a challenge in bounding the Lagrangian multipliers, and show that the algorithm asymptotically converges to a stationary point. Finally, we develop a simple, proximal gradient descent type analysis, showing that the complexity bound of this new algorithm is comparable to gradient descent for unconstrained setting which is new in the literature. Our algorithms can be extended to stochastic, finite-sum and structured nonconvex cases. Our complexity results match with proximal gradient method for unconstrained problems.

4 **A Randomized Block Coordinate Prima-dual Method for Large-scale Saddle Point Problems**

Erfan Yazdandoost Hamedani[1], Afrooz Jalilzadeh[2], Necdet Serhat Aybat[3], [1]University of Arizona, Tucson, AZ, [2]The University of Arizona, Tucson, AZ, [3]Penn State University, State College, PA

In this talk, we consider a stochastic convex-concave saddle point problem with high-dimensional decision variables that arises in various machine learning problems, e.g., robust classification, kernel matrix learning, and generative adversarial network. To contend with the challenges in computing gradients, we employ a stochastic block-coordinate primal-dual scheme in which randomly selected primal and dual blocks of variables are updated using sample partial gradients at each iteration. We investigate the convergence of the proposed under different blocking strategies and provide the corresponding complexity results. Finally, for both single and increasing sample size scenarios, almost sure convergence of the iterate sequence to a saddle point is shown.

Sunday, 11AM–12:15 PM

SB56

M - Marriott 3

Data-driven decisions and applications

General Session

Session Chair

Jackie W. Baek, MIT, Cambridge, MA

1 **Fairness and Efficiency in Covid-19 Lockdowns: Intervening in Network Games when Local Public Goods Have Unequal Impact**

Hamsa Sridhar Bastani[1], Tsai-Hsuan Chung[1], Kenneth Moon[2], [1]Wharton School, Philadelphia, PA, [2]University of Pennsylvania, Philadelphia, PA, Contact: angelchung841025@gmail.com

The economic costs and health benefits of lockdowns during COVID-19 pandemic were disparately borne by disadvantaged communities. Our matching-based analyses have found that, when low-income counties implement lockdown policies, they blunt new case rates by more than for high-income counties, but at the expense of significantly diminished work hours not suffered by high-income counties. However, we also find that in low-income areas, locked down residents seek to lessen the economic impact by significantly increasing economic activity in neighboring counties without locked down. Overall, we find evidence of economic spillover effects between localities based on socioeconomic status. This work empirically assess the unequal impacts of lockdown policies on networks of neighborhoods and design policies which incorporate these findings and fairness metrics.

2 **Exploration Optimization for Dynamic Assortment Personalization Under Linear Preferences**

Sajad Modaresi[1], Fernando Bernstein[2], Denis Saure[3], [1]UNC Chapel Hill, Kenan-Flagler Business School, Chapel Hill, NC, [2]Duke University, Durham, NC, [3]University of Chile, Santiago, Chile.

We study efficient real-time data collection approaches for an online retailer that dynamically personalizes assortments based on customers' attributes. We study the structure of efficient exploration in this setting, prove a performance lower bound, and propose efficient learning policies. We test the performance using a dataset from a large Chilean retailer.

3 **Improving TB Treatment Adherence Using Targeted Behavioral Interventions**

Jackie W. Baek, MIT, Cambridge, MA

Lack of adherence to treatment protocols is a major barrier to eliminating the global disease burden of tuberculosis (TB). We partner with a platform operating in Kenya that requires patients to verify their treatment adherence daily. The platform can reach out to a subset of patients each day to encourage them to comply with their treatment. Using observational data from this platform, we derive a simple policy that decides which patients to reach out to, and we show that this policy significantly increases the effect of each outreach. Our work demonstrates the huge potential gain from targeting interventions through learning personalized patient behaviors.

4 **Fast Rates for Contextual Linear Optimization**

Yichun Hu[1], Nathan Kallus[1], Xiaojie Mao[2], [1]Cornell University, New York, NY, [2]Tsinghua University, Beijing, China. Contact: yh767@cornell.edu

Incorporating side observations in decision making can reduce uncertainty and boost performance, but it also requires we tackle a potentially complex predictive relationship. While one may use off-the-shelf machine learning methods to separately learn a predictive model and plug it in, a variety of recent methods instead integrate estimation and optimization by fitting the model to directly optimize downstream decision performance. Surprisingly, in the case of contextual linear optimization, we show that the naive plug-in approach actually achieves regret convergence rates that are significantly faster than methods that directly optimize downstream decision performance. While there are other pros and cons to consider as we discuss and illustrate numerically, our results highlight a nuanced landscape for the enterprise to integrate estimation and optimization.

Sunday, 11AM–12:15 PM

SB57

M - Marriott 4

QSR Best Student Paper Competition

Award Session

Session Chair

Lulu Kang, Illinois Institute of Technology, Chicago, IL

Session Chair

Xiao Liu, 1</sup

Session Chair

Ran Jin, Virginia Tech, Blacksburg, VA

1 Design and Analysis of Finite Element Simulations

Shaowu Yuchi, Roshan V. Joseph, C F Jeff Wu, ISyE Georgia Tech, Atlanta, GA

Numerical accuracy of Finite Element Analysis depends on the number of finite elements used in discretization of the space, which can be varied using mesh size. We develop a method to optimally find the mesh sizes for each simulation and satisfy same time constraints as a single/double mesh size experiment.

2 Ensemble Active Learning by Contextual Bandits for AI Training in Manufacturing

Yingyan Zeng[1], Xiaoyu Chen[2], Ran Jin[3], [1]Virginia Tech, Blacksburg, VA, [2]University of Louisville, Louisville, KY, [3]Virginia Tech, Blacksburg, VA

It is challenging but important to save annotation efforts in streaming data acquisition to maintain data quality for supervised learning base learners. We propose an ensemble active learning method to actively acquire samples for annotation by contextual bandits, which will enforce the exploration-exploitation balance and improve the AI modeling performance.

3 Tensor-based Temporal Control for Partially Observed High-dimensional Streaming Data

Zihan Zhang, Shancong Mou, Kamran Paynabar, Jianjun Shi, ISyE Georgia Tech, Atlanta, GA

In advanced manufacturing processes, high-dimensional (HD) streaming data (e.g., sequential images or videos) are commonly used to provide online measurements of product quality. Though numerous research has been done for monitoring and anomaly detection of HD streaming data, little research is conducted to perform feedback control based on HD streaming data to improve product quality, especially in the presence of incomplete responses. To address this challenge, this work proposes a novel partially observed tensor-based automatic control (poTAC) method for missing HD streaming data, which consists of two stages: offline training and online control. In the offline training stage, we propose a one-step method integrating parameter estimation of the system model and missing value imputation for the response data, which (i) improves the accuracy of parameter estimation, and (ii) maintains a stable and superior imputation performance in a wider range of the rank or missing ratio for the data to be completed, compared to the existing data completion method. In the online control stage, the new partial observation is imputed by balancing its low-rank information and the one-step-ahead prediction result based on the control action from the last time step. Furthermore, we conduct two sets of simulations and a case study of the semiconductor photolithography process to validate the superiority of the proposed framework.

4 A Supervised Tensor Dimension Reduction-Based Prognostic Model for Applications with Incomplete Imaging Data

Chengyu Zhou, North Carolina State University, Raleigh, NC

Most image-based prognostic models have two common limitations. First, they require degradation images to be complete. Second, they usually employ an unsupervised dimension reduction method. To address these challenges, this article develops a supervised tensor dimension reduction-based prognostic model. The model first proposes a supervised dimension reduction method for tensor data. It uses historical TTFs to guide the detection of a tensor subspace to extract low-dimensional features. Next, the extracted features are used to construct a prognostic model based on (log)-location-scale regression. An optimization algorithm is proposed for parameter estimation and closed-form solutions are derived under certain distributions. Simulated data and a real-world data set are used to validate the performance of the proposed model.

Sunday, 11AM–12:15 PM

SB58

M - Marriott 5
Interpretability and Explainability via Human Behavior and Performance Modeling
General Session

Session Chair
Xiaoyu Chen, 1</sup

1 **Explaining Machine Learning Predictions to Human Decision Makers**
Xiaomei Wang, University of Louisville, Louisville, KY, Contact: xiaomei.wang@louisville.edu
There is increasing interest in applying machine learning (ML) techniques on supporting challenging decisions in complex situations such as manufacturing and healthcare. Generally, ML models can be developed for any domain wherever there is data. However, it is a long way to go before the models positively impact a real-world decision. Because of the black box nature of most ML models, even system developers are incapable of fully tracking and manipulating how models learn and generate results, which creates many problems for human-centered computing. To realize the promised benefits of ML on decision making, the following questions need to be considered while designing, implementing, and using ML-based decision support tools: What needs to be explained? What can be explained? What most effectively support users' judgments?

2 **VLP: A Visual Language Processing Modeling Framework via an Attention-on-attention Mechanism**
Xiaoyu Chen[1], Ran Jin[2], [1]University of Louisville, Louisville, KY, [2]Virginia Tech, Blacksburg, VA, Contact: xiaoyu.chen@louisville.edu
Quantitatively understanding human visual searching process in interactive and intelligent systems will not only advance the knowledge preservation of human expertise, but also enhance the AI modeling performance by imitating the human visual searching process. A general visual language processing (VLP) modeling framework is proposed to provide computational attention on visual attention (AonA) based on eye movements. Specifically, VLP defines the transition of fixations (i.e., visual attention) as a visual sentence; it then correlates the visual sentence with the visual searching decision by identifying the significant words in the visual sentence (i.e., computational attention). This VLP modeling framework is expected to explain visual searching decisions via AonA even for counter-intuitive scenarios when cognitive threats bias human decision making.

3 **Models and Algorithms for Demand Response Under Bounded Rationality in Residential Electricity Distribution**
Guanxiang Yun[1], Qipeng Phil Zheng[1], Lihui Bai[2], [1]University of Central Florida, Orlando, FL, [2]University of Louisville, Louisville, KY, Contact: lihui.bai@louisville.edu
Instead of choosing the optimal electricity consumption profile, which are often prescribed by traditional game theory or optimization models, in reality electricity consumers tend to simply pick solutions that are acceptable in terms of cost or convenience. This paper proposes Boundedly Rational User Equilibrium models to study residential electricity consumption in a smart grid. Particularly, we study a new time-of-day pricing framework to reduce the system peak in residential electricity usage while considering consumers' boundedly rational behaviors. Several best- and worst- case scenarios are formulated as bi-level optimization models, for which theoretical results on hidden convexity are obtained. Lagrangian dual methods are developed and are shown to outperform other solution methods through extensive numerical experiments.

4 **Influence Network Design via Multi-level Optimization Considering Boundedly Rational User Behaviours in Social Media Networks**
Qipeng Phil Zheng[1], Guanxiang Yun[1], Vladimir Boginski[1], Eduardo Pasiliao[2], [1]University of Central Florida, Orlando, FL, [2]Air Force Research Laboratory, Eglin AFB, FL
Social media networks have been playing an increasingly vital role for both socialization and information dissemination. To build the optimal network structure to influence the whole, this paper studies mathematical models to simulate the users' behaviors interacting with others in the information provider's network. Linear threshold propagation model is used to determine the re-posting actions, Boundedly Rational User Equilibrium (BRUE) models are used to determine the following or unfollowing actions. Hence, the topology of the network changes and depends on the information provider's plan to post various kinds of information. A three-level optimization model is proposed to maximize total number of connections. Exact algorithms are used to solve a small-scale synthetic network to demonstrate the efficacy of the models.

Sunday, 11AM–12:15 PM

SB59

M - Marriott 6
Artificial Intelligence and Optimization for Energy Systems
General Session

Session Chair
Chenang Liu, Oklahoma State University, Stillwater, OK

Session Chair
Chaoyue Zhao, University of Washington at Seattle, Stillwater, OK

1 **Stochos: An Opportunistic Maintenance Scheduling Approach Under Uncertainty for Offshore Wind Farms**
Petros Papadopoulos, Rutgers University, Piscattaway, NJ
Operations and Maintenance (O&M) constitute a major contributor to offshore wind's cost of energy. Offshore wind turbines typically have high capacities, are installed in remote locations, and operate under harsh environmental conditions. In addition, the decision-making process of O&M scheduling typically involves multiple sources of uncertainty, including offshore weather parameters, site accessibility constraints, electricity prices, and turbine degradation. In response, we propose a holistic maintenance optimization model, which is centered around the idea of seizing cost-optimal "maintenance opportunities" whenever they arise, while considering the aforementioned sources of uncertainty. Tested on real-world data from the U.S. North Atlantic region, significant margins of improvements, across several O&M metrics, are realized.

2 **Model-informed Generative Adversarial Network (MI-GAN) for Optimal Power Flow (OPF) Problem**
Yuxuan Li[1], Chaoyue Zhao[2], Chenang Liu[1], [1]Oklahoma State University, Stillwater, OK, [2]University of Washington, Seattle, WA, Contact: chenang.liu@okstate.edu
The optimal power flow (OPF) problem remains challenging due to variability, intermittency, and unpredictability of renewable energy brought to power system. The capability of existing optimization approaches is insufficient when the problem scale is large. Hence, this work proposed a novel model-informed GAN (MI-GAN) method to handle the OPF problem, which can ensure optimality, flexibility, and efficiency by a proposed new model-informed generator with a developed recursively iterative algorithm. The numerical experiments using the IEEE test systems showed this method is very promising.

3 **Distributionally Robust Multi-Stage Virtual PowerPlant Scheduling**
William Yang[1], Chaoyue Zhao[2], [1]University of Washington, Seattle, WA, [2]University of Washington, Seattle, WA, Contact: wtyang15@uw.edu
The Virtual Power Plant (VPP) is a portfolio of heterogeneous distributed energy resources (DER) that can participate in the wholesale energy market. Scheduling VPPs is challenging since dynamic scheduling decisions for various components are required to respond to system uncertainties. We present a multi-stage distributionally robust optimization (MSDRO) approach that utilizes the dynamic influx of information to aid real-time scheduling decisions. The MSDRO produces a risk-averse but not overly-conservative scheduling strategy to cope with uncertainty from renewable energy and customer demand, under unreliable distributional information. To solve our model efficiently, a dynamic programming algorithm is developed. Numerical experiments show our approach outperforms a traditional stochastic model when imperfect distributional information is used.

4 **Optimization Layer Embedded Deep Neural Network for Optimal Power Flow Problem**
Yang Chen[1], Byungkwon Park[2], Kai Sun[3], Zhenping Guo[4], Xiaowen Su[4], [1]Oak Ridge National Laboratory, Oak Ridge, TN, [2]Oak Ridge National Laboratory, Oak Ridge, TN, [3]University of Tennessee at Knoxville, Knoxville, TN, [4]University of Tennessee at Knoxville, Knoxville, TN
AC optimal power flow problem (AC-OPF) is an essential, and yet challenging power system operation problem due to its nonlinearity. In this work, we construct and train deep neural network for predicting main decisions directly for AC-OPF including real/reactive power, voltage magnitude, voltage angle. In order to reduce violation on equality/inequality constraints, very recent developed implicit layer (optimization layer) is adopted to output predictions while satisfying the constraints. The proposed deep learning model has been tested in several IEEE standard bus systems using public benchmark dataset. The results has demonstrated the effectiveness of proposed method.

Sunday, 11AM–12:15 PM

SB60

M - Marriott 7
Journal of Quality Technology Invited Session
General Session

Session Chair

L. Allison Jones-Farmer, Miami University, Oxford, OH

1 Functional Directed Graphical Models and Applications in Root-cause Analysis and Diagnosis

Kamran Paynabar[1], Ana Maria Estrada Gomez[2], [1]ISyE Georgia Tech, Atlanta, GA, [2]Purdue, West Lafayette, IN, Contact: kamran.paynabar@isye.gatech.edu

Directed graphical models aim to represent the probabilistic relationships between variables in a system. Learning a directed graphical model from data includes parameter learning and structure learning. Nowadays, in many applications, the variables are infinite-dimensional signals that need to be treated as functional random variables. This presentation proposes a novel method to learn directed graphical models in the functional setting. When the structure of the graph is known, function-to-function linear regression is used to estimate the parameters of the graph. When the goal is to learn the structure, a penalized least square loss function with a group LASSO penalty, for variable selection, and an L2 penalty, to handle group selection of nodes, is defined. Through simulations and a case study, the advantage of the proposed method is proven.

2 Robust Experimental Designs for Model Calibration

Arvind Krishna, Northwestern University, Evanston, IL

A computer model can be used for predicting an output only after specifying the values of some unknown physical constants known as calibration parameters. These parameters can be estimated by conducting physical experiments. This paper presents an approach to optimally design such an experiment. The problem of optimally designing a physical experiment, using a computer model, is similar to the problem of non-linear optimal design. However, the problem is more challenging because of the possibility of model discrepancy. Therefore, we propose an optimal design approach that is robust to potential model discrepancies. We show that our designs are better than the commonly used physical experimental designs that do not make use of the information contained in the computer model and other nonlinear optimal designs that ignore potential model discrepancies.

3 Complex Geometries in Additive Manufacturing: A New Solution for Lattice Structure Modeling and Monitoring

Bianca Maria Colosimo, Marco Grasso, Politecnico di Milano, Milan, Italy.

The production of novel types of complex shapes is nowadays enabled by new manufacturing paradigms such as additive manufacturing, also known as 3D printing. The continuous increase of shape complexity imposes new challenges in terms of inspection, product qualification and process monitoring methodologies. The paper presents an innovative solution for modeling the deviation between the nominal geometry (the originating 3D model) and the real geometry (measured via x-ray computed tomography) by converting 3D deviation maps into 1D deviation profiles enabling the use of a profile monitoring scheme for local defect detection. The feasibility and potential of this method are demonstrated focusing on a novel category of complex shapes known as lattice structures, or metamaterials.

Sunday, 11AM–12:15 PM

SB61

M - Marriott 8

Solving Large-scale Power System Optimization Problems

General Session

Session Chair

Feng Qiu, Argonne National Laboratory, Lemont, IL

1 Power Grid Restoration Optimization Considering Decision Maker's Risk Tolerance on Parameter Uncertainty

Gino J. Lim[1], Behnam Sabzi[2], Jian Shi[1], Saeedeh Abbasi[3], Masoud Barati[4], [1]University of Houston, Houston, TX, [2]University of Houston, Houston, TX, [3]University of Houston, HOUSTON, TX, [4]Univesity of Pittsburgh, Pittsburgh, PA, Contact: ginolim@uh.edu

This paper presents two optimization models and introduces the concept of degree of conservativeness providing the decision-makers the flexibility of customizing the restoration plan according to the planner's risk tolerance (i.e., risk-averse or risk-prone) on unknown status of transmission lines. First, a mixed-integer programming (MIP) model (GPP) is formulated under the assumption that all parameters are known. Second, the uncertainty of transmission line status is considered through a worst-case robust optimization (RCP). The degree of conservativeness concept is discussed and the proposed models are tested and analyzed with three IEEE case studies of 14, 39 and 118- bus test systems.

2 A Joint Chance-Constrained Game Framework for Coordinating Active Distribution Networks in Energy and Reserve Market

Yifu Ding, University of Oxford

Active distribution networks (ADNs) incorporate distributed energy resources (DERs) and flexible loads, which can provide energy services such as reserves for the upstream utility. In the energy and reserve market, ADN as an independent entity can proactively adjust their bids and compete with each other. However, due to the uncertainty of renewable power sources and demands, their service provision is not firmly secured. In this work, we design a joint chance-constrained (JCC) game theory framework considering the net load uncertainty and network constraints to coordinate ADNs in the energy and reserve market. The optimized Bonferroni approximation is employed to solve the JCC problem so that both the reserve quantity and provision failure rate regulations can be optimized.

3 Parallel Power System Restoration

Sangho Shim[1], Sunil Chopra[2], Feng Qiu[3], [1]Robert Morris University, MoonTwp, PA, [2]Northwestern University, Evanston, IL, [3]Argonne National Laboratory, Lemont, IL, Contact: shim@rmu.edu

Power system restoration is an essential activity for grid resilience, where grid operators restart generators, re-establish transmission paths, and restore loads after a blackout event. The core decisions in restoration planning are to partition the grid into a few sub-networks, each of which has an initial power source for black-start (called sectionalization problem), and then restart the generators and pick up the loads in each network (called generator startup sequencing problem or GSS) in a parallel fashion, aiming to restore electric service in shortest time. Due to the significant complexity of each problem, the sectionalization and GSS problems are usually solved separately, resulting in a sub-optimal solution. In this work, we develop models and computational methods to solve the two problems simultaneously.

4 A Polyhedral Study on Fuel-Constrained Unit Commitment

Ming Zhao, University of Delaware, Newark, DE

The electricity production of a thermal generator is often constrained by the available fuel supply. These fuel constraints impose a maximum bound on the energy output over multiple time periods. Fuel constraints are increasingly important in electricity markets, due to two main reasons. First, as more natural gas-fired generators join the deregulated market, there is often competition for natural gas supply from other sectors (e.g., residential and manufacturing heating). Second, as more environmental and emission regulations are being placed on fossil fuel-fired generators, fuel supply is becoming more limited. However, there are few studies that consider the fuel constraints in the unit commitment problem from the perspective of computational analysis. To address the challenge faced by an independent power producer with a limited fuel supply, we study a fuel-constrained self-scheduling unit commitment (FSUC) problem where the production decisions are coupled across multiple time periods. We provide a complexity analysis of the FSUC problem and conduct a comprehensive polyhedral study by deriving strong valid inequalities. We demonstrate the effectiveness of our proposed inequalities as cutting planes in solving various multistage stochastic FSUC problems.

Sunday, 11AM–12:15 PM

SB62

M - Marriott 9

Optimization Models in Electric Power and Transportation Systems

General Session

Session Chair

Miguel F. Anjos, University of Edinburgh, Edinburgh, United Kingdom.

1 The Value of Long-duration Energy Storage and Its Interaction with a Zero-emissions Electricity Grid

Patricia Hidalgo-Gonzalez, [1</sup]

Long-duration energy storage (LDES) is a key resource in enabling zero-emissions electricity grids. Using the SWITCH capacity expansion model with high temporal and geographical resolutions, we model a zero-emissions Western Interconnect to understand how the value of LDES changes under different scenarios. We find that a) LDES is most valuable in majority wind-powered regions and regions with diminishing hydropower generation, b) the seasonal operation of storage becomes cost-effective if storage capital costs fall below 5 $/kWh, and c) mandating the installation of enough LDES would reduce electricity price surges by over 70%. Our results provide policy makers with a broad understanding of the need for LDES and impacts of storage mandates.

2 **A Multinational Carbon-Credit Market Integrating Distinct National Carbon Allowance Strategies**

Miguel F. Anjos[1], Felipe A. Feijoo[2], Sriram Sankaranarayanan[3], [1]University of Edinburgh, Edinburgh, United Kingdom; [2]Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile; [3]IIM Ahmedabad, Ahmedabad, India. Contact: anjos@stanfordalumni.org

We propose a multinational carbon-credit (CC) market allowing countries to procure CCs and allocate them to their electricity producers via national strategies that may include taxes on emissions or subsidies for fossil fuel-based production. We compare the cases of producers accessing the market directly versus through their government. Rrecent mathematical optimization methods are used to compute the relevant market outcomes. Using historical data and 2050 EIA projections for the USA, we confirm that acting as intermediaries, countries can adjust their production and mitigate the impacts of high CC prices. We evaluate the impact of imposing renewable portfolio standards on the government versus on the producer, and observe that while output remains similar, the cash flows are favorable for producers if they are responsible for meeting the standards.

3 **Heuristic Methods for Finding Optimal Evcharging Station Placement**

Steven Lamontagne[1], Emma Frejinger[2], Margarida Carvalho[3], Miguel F. Anjos[4], Bernard Gendron[5], [1]Université de Montréal, Montréal, QC, Canada; [2]Universite de Montreal, Montreal, QC, Canada; [3]University of Montreal & CIRRELT, Montreal, QC, Canada; [4]University of Edinburgh, Edinburgh, United Kingdom; [5]Universite de Montreal (DIRO), Montreal, QC, Canada. Contact: steven.lamontagne@umontreal.ca

Effective placement of public charging infrastructure can increase the number of electric vehicles (EVs), as highlighted by the importance of recharging access in the existing literature. We consider the problem of selecting which stations to open and the number of outlets to install over a multi-period time span, with the objective to maximise EV adoption. The demand of users is estimated via a random utility maximisation model, examining if the charging infrastructure is sufficient to allow for recharging. Under the assumption that the stations have no capacity limits, we propose a maximum covering formulation of the problem. However, the maximum covering formulation is intractable for larger instances, necessitating the use of heuristics. Various heuristic methods are proposed and compared for solving this model.

4 **ADMM-based Unit and Time Decomposition for Price Arbitrage by Cooperative Price-Maker Electricity Storage Units**

Miguel F. Anjos[1], James R. Cruise[2], Albert Solà Vilalta[1], [1]University of Edinburgh, Edinburgh, United Kingdom; [2]Heriot-Watt University, Edinburgh, United Kingdom. Contact: albert.sola@ed.ac.uk

We propose a solution method for the optimal control of multiple price-maker electric energy storage units that cooperate to maximize their total profit from price arbitrage. The proposed method can tackle the nonlinearity introduced by the price-maker assumption. The main novelty is the combination of a decomposition by unit and a decomposition in time. The decomposition by unit is based on the Alternating Direction Method of Multipliers (ADMM) and breaks the problem into several one-unit subproblems. Every subproblem is solved using an efficient algorithm for one-unit problems from the literature that exploits an on the fly decomposition in time. This results in a time decomposition for the whole solution method. Our numerical experiments show very promising performance in terms of accuracy and computational time.

Sunday, 11AM–12:15 PM

SB63

M - Marriott 10

Emerging Energy Technologies

General Session

Session Chair

Alexandra M. Newman, Colorado School of Mines, Golden, CO

1 **Estimating the Value of Concentrating Solar Power with Ancillary Services**

Karoline M. Hood, Colorado School of Mines, Golden, CO, Contact: khood@mines.edu

Extant studies on the economic value of concentrating solar power focus on metrics such as levelized cost of energy, which fails to adequately consider dispatchability. We employ an existing mixed-integer program to capture the nuances of plant operations and employ a price-taker approach in the wake of recent technological advancements. Economic value estimates arise not only from the value from energy services and storage, but also from the provision of spinning reserves. We use historical market price data, and demand for spinning reserves, in the case studies we present.

2 Characterizing the Relatedness of Offshore and Onshore Wind Using Patent Analysis

Yiwen Wang, Anna Goldstein, Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA, Contact: yiwwang@umass.edu

As a promising technology for efficient clean power generation, offshore wind energy remains more costly than onshore wind energy due to less learning experience accumulated. This research aims at answering to what degree offshore wind technology is an offshoot of onshore wind technology and to what degree it is novel. We quantify the relatedness between offshore and onshore wind technologies by investigating their patenting activities.

3 Real-time Dispatch Optimization for Concentrating Solar Power with Thermal Energy Storage

Alexander Zolan[1], John Cox[2], William Hamilton[3], Alexandra M. Newman[2], Michael J. Wagner[4], [1]National Renewable Energy Laboratory, Austin, TX, [2]Colorado School of Mines, Golden, CO, [3]National Renewable Energy Laboratory, Wheat Ridge, CO, [4]National Renewable Energy Laboratory, Golden, CO, Contact: alexander.zolan@nrel.gov

Concentrating solar power (CSP) plants, especially those using a central receiver configuration and paired with thermal energy storage, present a promising path towards utility-scale dispatchable renewable energy. However, the variable nature of the solar resource and the conservatism with which the receiver is operated prevent perfect control over the receiver outlet temperature. To support operator decisions in a real-time setting, we develop a revenue-maximizing non-convex mixed-integer, quadratically-constrained program which determines a dispatch schedule with 5-minute time fidelity and considers temperature-dependent power cycle efficiency. We present exact and inexact techniques to improve problem tractability that include a hybrid nonlinear and linear formulation. Our results demonstrate usability for decision support in a real-time setting.

4 High Temporal Resolution Capacity Expansion Planning for Power System Decarbonization

Todd Levin, Argonne National Laboratory, Lemont, IL, Contact: tlevin@anl.gov

In order to ensure that mixed-integer capacity expansion problems are computationally tractable a representative subset of hours in each day and/or days in each year are typically selected. As wind, solar and storage technologies become more prevalent it will be more important to consider intra-hour resource availability and inter-hour state of charge management with high fidelity. We present analyses of the impacts of consider 1) 5-minute dispatch intervals and 2) an increasing number of representative days in a capacity expansion problem of an ERCOT-like system. We find that both these parameters impact the least-cost investment plan; specifically considering 5-minute dispatch resolution increases investment in battery storage capacity.

Sunday, 11AM–12:15 PM

SB64

M - Indiana A

Responsible, Ethical, and Socially Aware Operations I

General Session

Session Chair

Vahideh Manshadi, Yale University

Session Chair

Rad Niazadeh, Chicago Booth School of Business, Stanford, CA

1 The Value of Returning Donors for Online Matching on Nonprofit Crowdfunding Platforms

Vahideh Manshadi[1], David Simchi-Levi[2], Sabrina Chen Wen Zhai[2], [1]Yale University, New Haven, CT, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: zhai@mit.edu

Motivated by philanthropic crowdfunding platforms like DonorsChoose, we study an online matching problem where sequentially arriving donors must be matched to a fixed set of projects requiring funding. Empirical studies have shown that (i) donors have heterogeneous preferences over the projects, and (ii) many return to make more than one donation. Facing such donors, the platform's aim is to match each donor to one of their preferred projects so as to maximize the total donation without over-funding any projects and without knowing the arrival pattern. We show that a simple and return-agnostic algorithm achieves a performance guarantee that improves with the number of returning donors without differentiating between the original and return donors. We also establish upper bounds on the performance of any algorithm to shed further light on the value of returning traffic.

2 Performative Power

Moritz Hardt[1], Meena Jagadeesan[2], Celestine Mendler-Dünner[1], [1]Max Planck Institute for Intelligent Systems,

Tübingen, Germany; [2]UC Berkeley, Berkeley, CA, Contact: mjagadeesan@berkeley.edu

We introduce the notion of *performative power*, which measures the ability of a firm operating an algorithmic system, such as a digital content recommendation platform, to steer a population. We relate performative power to the economic theory of market power. Traditional economic concepts are well known to struggle with identifying anti-competitive patterns in digital platforms--a core challenge is the difficulty of defining the market, its participants, products, and prices. Performative power sidesteps the problem of market definition by focusing on a directly observable statistical measure instead. High performative power enables a platform to profit from *steering* participant behavior, whereas low performative power ensures that *learning* from historical data is close to optimal.

3 Designing Policies for Allocating Housing to Persons Experiencing Homelessness

Bill Tang[1], Cagil Kocyigit[2], Phebe Vayanos[1], [1]University of Southern California, Los Angeles, CA, [2]University of Luxembourg, Luxembourg, Luxembourg. Contact: yongpeng@usc.edu

We study the problem of allocating scarce housing resources of different types to individuals experiencing homelessness based on their observed covariates. Our goal is to leverage administrative data collected in deployment to design an online policy that maximizes mean outcomes while satisfying budget requirements. We propose a policy in which an individual receives the resource maximizing the difference between their mean treatment outcomes and the resource bid price, or roughly the opportunity cost of using a resource. Our approach has nice asymptotic guarantees and is easily interpretable.

4 Fairer Algorithms for Sortition

Bailey Flanigan, Carnegie Mellon University, Pittsburgh, PA, Contact: bflaniga@andrew.cmu.edu

Citizens' assemblies are a method of policymaking where randomly selected citizens, rather than elected representatives, make policy decisions. Citizens' assemblies are increasingly popular worldwide, being administered by more than 40 organizations in over 25 countries. Our line of work on citizens' assemblies considers their fairness, transparency, manipulability, and more. In this talk, I will discuss our paper *Fair algorithms for citizens' assemblies*, in which we present a sampling algorithm that gives all volunteers a maximally fair chance at being chosen for the assembly, while also ensuring approximate demographic representation. This algorithm uses ideas from fair division and optimization to make significant improvements in fairness over the previous state-of-the-art. It has now been deployed by major groups of assembly organizers worldwide.

Sunday, 11AM–12:15 PM

SB65

M - Indiana B

Emerging Topics in Sustainable Operations

General Session

Session Chair

Somya Singhvi, USC Marshall School of Business, Los Angeles, CA

1 Understanding the Drivers of Service Quality in the Context of Cloud Kitchens - Empirical Evidence from India

Maya Ganesh[1], DEBJIT ROY[2], [1]Indian Institute of Management Ahmedabad, Ahmedabad, India; [2]Indian Institute of Management Ahmedabad, Ahmedabad, India. Contact: mayag@iima.ac.in

Cloud-kitchen model has seen a steep increase in its presence in the last few years. The goal of quality standardisation becomes challenging when freshly cooked food is the product. The cloud kitchen model has added complexities, as the food prepared travels longer distances compared to a traditional dine-out model where it travels from the restaurant kitchen to the restaurant table. Insights related to aspects of service quality valued by customers will aid managers to improve customer experience. In the context of a large Indian cloud-kitchen company, we use order level data in two cities for a period of six months to determine the factors that drive food and delivery quality. Further, we classify the drivers of service quality into material, operational and personnel aspects and examine the relationship between quality-of-service experience and reordering behavior.

2 Enhancing Digital Road Networks for Better Operations in Developing Countries

Valentijn Stienen, Tilburg University, Tilburg, Netherlands.

Data scarcity in developing countries often significantly complicates the use of analytics to address development challenges. One of the most fundamental data structures needed in operations management is digitized road data; a poorly digitized road network significantly reduces our ability to optimize, for instance, trade of micro-enterprises (SDG 8) and placement of hospitals (SDG 3). Here, we introduce a method that accurately extends and combines large, existing road network representations, for regions with sparse geospatial data. Our method significantly improved the digital road network for smallholder farmers in Indonesia, and, in a case study of optimized geospatial accessibility to healthcare in Timor-Leste, it improved the detection of people located in the vicinity of a hospital.

3 Designing Payment Models for the Poor

Bhavani Shanker Uppari[1], Sasa Zorc[2], [1]Singapore Management University, Singapore, Singapore; [2]University of Virginia, Darden School of Business, Charlottesville, VA, Contact: bhavaniu@smu.edu.sg

Some life-improving technologies for the poor are unaffordable to them, as their limited liquidity puts the purchase costs out of reach. Thus, business models have emerged where the consumers pay a fraction of the price upfront to acquire the technology and make a series of payments for continued access, at the end of which the ownership of the technology may be gained by the consumers. This offers flexibility to sometimes pay low/no amounts (alleviating cash constraints), and at the same time, disciplines consumers by remotely turning off the technology when they lag behind on payments (reducing default risk). Using the optimal contracting approach, we investigate the payment mechanisms that balance flexibility, discipline, and ownership incentives. Several implementable features that improve both the firm's profits and the consumers' welfare emerge from our analysis.

Sunday, 11AM–12:15 PM

SB66

M - Indiana C

Operations Research Methods in Wildfire Response and Mitigation Planning

General Session

Session Chair

Brittany Segundo, TAMU, College Station, TX

1 Predicting Demand for Wildfire Suppression Resources

Yasser Zeinali[1], Ilbin Lee[1], Mostafa Rezaei[2], [1]University of Alberta, Edmonton, AB, Canada; [2]ESCP Business School, Paris, France. Contact: yzeinali@ualberta.ca

From 2011 to 2021, there were an average of 62,425 wildfires annually, and an average of 7.47 million acres were impacted each year in the U.S. The Forest Service spends about $2 billion per year on suppression, and statistics show that this cost is growing. Wildfire management agencies are under intense pressure to devise an effective resource allocation strategy to fight the fires. Forest fire centers dispatch firefighters, air tankers, helicopters, and other equipment to suppress the wildfires. We develop models to predict demand for these resources in the coming days, allowing managers to make better resource allocation decisions.

2 Risk-averse Stochastic Programming Model for Wildfire Fuel Treatment Planning

Lina M. Villa Zapata, Texas A&M University, College Station, TX, Contact: lina.villa@tamu.edu

Every few months fire managers must consider fuel treatment options to minimize wildfire risk under limited budgets and uncertain weather conditions. In this work, we devised a two-stage risk-averse stochastic programming model for multiperiod fuel treatment planning in grassland regions. We model this problem using a rolling horizon framework to capture dynamic data uncertainties in vegetation growth, weather, and wildfire risk. We apply this model to a case study based on data for west Texas.

3 Multistage Stochastic Programming Approaches to Escaped Wildfire Response Planning

Brittany Segundo[1], Lewis Ntaimo[2], [1]The National Academies of Sciences, Engineering, and Medicine, Washington, DC, [2]Texas A&M University, College Station, TX

In this work we allocate resources to an escaped wildfire already in the extended attack phase. Because the time until containment is unknown, we approximate multistage stochastic decision-making using a rolling horizon framework. The aim of this program is to contain the wildfire through the construction of discrete firelines. We incorporate endogenous uncertainty by modeling the interaction between constructed firelines and growing firefronts. Parameters are gathered from forecasted and actual wind data and simulated fire behavior in eastern Texas.

Sunday, 11AM–12:15 PM

SB67

M - Indiana D

Recent Developments of Online Optimization in RM

General Session

Session Chair

Jiashuo Jiang, New York Uniersity, New York, NY

Session Chair
Zikun Ye, 1</sup

1 Optimal Algorithm for Minimizing Compositions of Convex Functions and Random Functions and Its Applications in Network Revenue Management

Zikun Ye[1], Xin Chen[1], Niao He[2], Yifan Hu[1], [1]University of Illinois at Urbana Champaign, Urbana, IL, [2]ETH Zürich, Zürich, Switzerland. Contact: zikunye2@illinois.edu

We solve network revenue management problems under booking limit control, which can be formulated as nonconvex stochastic optimization problems. The objective function is a composition of convex function and random function (booking limit truncated by random demand). We proposed an online algorithm Mirror Stochastic Gradient Descent to obtain an approximate global optimal solution with provable optimal sample and gradient complexities. Furthermore, we show the superior performance of the booking limit control policy in both passenger and complicated air-cargo network revenue management problems with extensive numerical experiments.

2 Online Learning for Dual Index Policies in Dual Sourcing Systems

Jingwen Tang[1], Cong Shi[2], Boxiao Chen[3], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, [3]University of Illinois, Chicago, IL, Contact: tjingwen@umich.edu

We consider a periodic review dual sourcing inventory system. Even with complete information on the demand distribution, it is well known that the optimal inventory replenishment policy is complex and state-dependent. We consider a class of heuristic policies called the dual-index policy. When the demand distribution is unknown, we develop a nonparametric online learning algorithm that learns the demand distribution using historical data and converges to the optimal dual-index policy. Our algorithm integrates stochastic bandits and sample average approximation techniques in an innovative way, and it admits a cumulative regret bound of $O(\sqrt{T}(\log T)^{2})$, which matches the regret lower bound for any feasible learning algorithms up to a logarithmic factor. We explicitly prove that the underlying Markov chain is ergodic and converges to its steady state exponentially fast via coupling arguments. Our work provides practitioners an easy-to-implement and provably-good online decision support for managing a dual sourcing inventory system.

3 Limiting Actions over Time in the Prophet Inequality

Sebastian Perez Salazar[1], Mohit Singh[2], Alejandro Toriello[2], [1]Rice University, Houston, TX, [2]ISyE Georgia Tech, Atlanta, GA, Contact: swps3@gatech.edu

Consider the setting where a seller is selling one item to buyers. The seller offers a price, and if the buyer's valuation is higher than the offered price, then the item is sold to the corresponding buyer. Changing the price too frequently could be considered unfair in many settings. The literature has studied two extremes: fixed price and fully adaptive pricing. This work examines the middle situation where we allow restricted adaptivity by offering at most k prices over the time horizon. Using the framework of the iid prophet problem, we present asymptotic results in k and results for small values of k. From a technical standpoint, we use a linear program formulation to show the guarantees of our approach.

4 Online Resource Allocation with Samples

Negin Golrezaei[1], Patrick Jaillet[2], Zijie Zhou[3], [1]Massachusetts Institute of Technology, Lexington, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: zhou19981107@gmail.com

The problem of online allocation of scarce resources is one of the most important problems faced by governments, hospitals, e-commerce, etc. We study the problem where we have uncertainty about demand and the reward of each type of demand for resources. The lack of knowledge about agents' rewards is inspired by the problem of allocating new resources with unknown effectiveness/value. We assume that we can test the market before the allocation period starts. We study how to exploit the sample information under adversarial arrival processes. We present an asymptotically optimal algorithm that achieves $1-\Theta(1/\sqrt{m})$ competitive ratio, where m is the number of resources, and show that it is tight. We further demonstrate the efficacy of our proposed algorithm using a dataset that contains the number of COVID-19 related hospitalized patients across different age groups.

Sunday, 11AM–12:15 PM

SB68

M - Indiana E
Assortment Optimization and Inventory Planning
General Session

Session Chair
Omar Mouchtaki, Columbia University, New York, NY

Session Chair
Antoine Desir, INSEAD

1 Joint Placement, Delivery Promise and Fulfillment in Online Retail

Yicheng Bai[1], Huseyin Topaloglu[2], Paat Rusmevichientong[3], [1]Cornell Tech, New York, NY, [2]Cornell Tech, New York, NY, [3]USC Marshall School of Business, Los Angeles, CA

We consider placement, delivery promise and fulfillment decisions faced by an online retailer. We have a set of products with given numbers of units to be placed at different fulfillment centers with capacity constraints. Once we make the placement decisions, we face random demand for the products from different demand regions. In response to each demand, we need to pick a delivery promise to offer, which determines the probability that the demand converts into sale, as well as choose a fulfillment center to use to serve the demand. Our goal is to decide where to place the units to maximize the total expected profit from the sales over a finite selling horizon. We give a general approximation framework for this joint placement, delivery promise and fulfillment problem and provide a 1/(4+�) performance guarantee for any �>0.

2 Joint Assortment and Inventory Planning Under Markov Chain Choice Model

Omar El Housni[1], Omar Mouchtaki[2], Guillermo Gallego[3], Vineet Goyal[2], Salal Humair[4], Sangjo Kim[5], Ali Sadighian[6], Jingchen Wu[7], [1]Cornell Tech, New York, NY, [2]Columbia University, New York, NY, [3]Hong Kong University of Science and Technology, Hong Kong, China; [4]Amazon, Inc., Sammamish, WA, [5]SUFE, Shanghai, China; [6]Uber, New York, NY, [7]Amazon, Seattle, WA

We study a joint assortment and inventory optimization problem faced by an online retailer who needs to decide on both the assortment and the inventories of a set of N substitutable products before the start of a selling season of length T to maximize the expected profit. We model dynamic stock-out based substitution by proposing a Markov Chain choice model and present a near-optimal algorithm for the problem achieving a O(√(NT)) regret with respect to an LP upper bound. Our algorithm balances between expected revenue and inventory costs by identifying a subset of products that can pool demand without significantly cannibalizing the revenue in the presence of dynamic substitution. We conduct computational experiments that show that our algorithm empirically outperforms natural approaches both on synthetic and realistic instances.

3 Demand Estimation Under Uncertain Consideration Sets

Srikanth Jagabathula[1], Dmitry Mitrofanov[2], Gustavo J. Vulcano[3], [1]NYU Stern School of Business, New York, NY, [2]Boston College, Chestnut Hill, MA, [3]Universidad Torcuato di Tella, Ciudad Autónoma Buenos Aires, Argentina.

Consider-then-Choose (CTC) models have gained significant popularity recently within operations. But, in practice, we do not observe consideration sets, making it difficult to estimate these models.
This raises the following question: when firms only collect transaction data, do CTC models offer any predictive advantage over the classic choice models? In this work, we study a general class of CTC models. We propose techniques to estimate these models efficiently and compare them against the classic approach which ignores consideration sets. We find that CTC models outperform classic models when there is noise in the offer set information and the noise is asymmetric across the training and test offer sets, but otherwise offer no particular predictive advantage . We demonstrate the benefits of using the CTC models in real-world retail and online platform settings.

4 Pricing Multiple Products and Competition Analysis Under the Threshold Utility Model

Guillermo Gallego[1], Zhuodong Tang[1], Ruxian Wang[2], [1]Hong Kong University of Science and Technology, Hong Kong, China; [2]Johns Hopkins University, Carey Business School, Kensington, MD, Contact: ztangai@connect.ust.hk

We consider pricing and competition problems arising from the threshold utility model (TUM). Under the TUM, consumers purchase all products whose net utility exceeds a non-negative threshold selected to maximize the expected consumer surplus subject to a bound on the number of products purchased in expectation. For the monopolistic problem, we identify conditions under which the multi-product price optimization can be efficiently solved. We also show the joint concavity of revenue function with respect to market shares holds. In the oligopolistic setting, we establish the existence of a Nash equilibrium under multiple-product price competition. We further analyze the competition in market shares and show the existence and uniqueness of Nash equilibrium under which fewer consumers are served. The key results hold even when product’s utility is non-linear in the price.

Sunday, 11AM–12:15 PM

SB69

M - Indiana F

Advances in Revenue Management

General Session

Session Chair

Tarek Abdallah, Northwestern University, Kellogg School of Management, Chicago, IL

1 Disclosing Low Product Availability: An Online Retailer's Strategy for Mitigating Stockout Risk

Dmitry Mitrofanov[1], Benjamin Knight[2], [1]Boston College, Chestnut Hill, MA, [2]Instacart, San Francisco, CA

In this paper, we investigate how sharing information regarding the low availability of certain items can influence customers' purchase decisions.

In a field experiment, we exogenously share low item availability information with a random subset taken for a sample of more than 840K customers using Instacart. We find evidence that customers are 25% less likely to purchase low availability items when item availability information is disclosed. In addition, we show that low product availability disclosure leads to higher customer satisfaction and positively affects the platform's fundamentals in the context of our field experiment. More specifically, our results indicate that this innovative and cost-free approach leads to a 5.33% increase in revenue per customer and a 4.9% increase in order frequency over the long term.

2 Assortment Optimization with Multi-item Basket Purchase Under the Multivariate MNL Model

Chengyi Lyu[1], Stefanus Jasin[2], Sajjad Najafi[3], Huanan Zhang[1], [1]University of Colorado Boulder, Boulder, CO, [2]University of Michigan, Ann Arbor, [3]HEC Paris, VERSAILLES, France. Contact: chengyi.lyu@colorado.edu

Assortment selection is one of the most important decisions faced by retailers. Most existing papers in the literature assume that customers select at most one item out of the offered assortment. While this is valid in some cases, it contradicts practical observations in many shopping experiences, both in online and brick-and-mortar retail, where customers may buy a basket of products instead of a single item. In this paper, we incorporate customers' multi-item purchase behavior into the assortment optimization problem. We consider both uncapacitated and capacitated assortment problems under the so-called Multivariate MNL (MVMNL) model, which is one of the most popular multivariate choice models used in the marketing and empirical literature.

3 Additional Luggage Pricing Without Price Variation

Ruijiu Mao, National University of Singapore, Singapore, Singapore.

We study the additional luggage pricing problem in airlines, where the historical unit price remains the same for a long time. The lack of price variation presents a major challenge in identifying the demand pattern, which is the basis of the pricing problem. In this work, we utilize the variation in usage to reveal the demand pattern in the absence of price variation. Specifically, we formulate a discrete-continuous choice model which captures the heterogeneity of both the usage sensitivity and the price sensitivity. Based on the analysis of the choice model, an MLE framework is applied to calibrate the parameters. We also present an application to validate the effectiveness of the framework and demonstrate our pricing strategy.

4 Estimating Demand with Unobserved No-purchases on Revenue-managed Data

Anran Li[1], Kalyan Talluri[2], Müge Tekin[3], [1]The Chinese University of Hong Kong (CUHK), Hong Kong, Hong Kong; [2]Imperial College Business School, London, United Kingdom; [3]Erasmus University Rotterdam, Rotterdam, Netherlands.

This paper investigates the joint estimation of the consumer arrival rate and choice model parameters when ``no-purchasers” are not observable. Estimating demand even with the simplest discrete-choice model such as the MNL becomes challenging. Some previous approaches have proposed using market-share to pin down the parameter; however, market-share data are difficult to obtain in practice. Another complication is the sales are ``revenue-managed”, that is, optimized nearly continuously by analysts and algorithms. In this paper we propose a two-step GMM based robust method when the firm cannot observe no-purchases, has no market-share information, and the data has been revenue-managed.

Sunday, 11AM–12:15 PM

SB70

M - Indiana G

Complexity of Neural Networks

General Session

Session Chair

Christoph Hertrich, London School of Economics, United Kingdom.

1 **New Structural Results in Linear Threshold Neural Networks**

Sammy Khalife, Johns Hopkins University, Baltimore, MD, Contact: khalife.sammy@jhu.edu

In this talk I will present new results on neural networks with linear threshold activation functions. The class of functions that are representable by such neural networks can be fully characterized, and
two hidden layers are necessary and sufficient to represent any function in the class. This is a surprising result in the light of recent exact representability investigations for neural networks using other popular activation functions like rectified linear units. I will discuss precise bounds on the sizes of the neural network, and I present an algorithm to solve the empirical risk minimization (ERM) problem to global optimality for these neural networks with a fixed architecture. The algorithm's running time is polynomial in the size of the data sample, if the input dimension and the size of the network architecture are considered fixed constants.

2 **Training Fully Connected Neural Networks is R-complete**

Daniel Bertschinger[1], Christoph Hertrich[2], Paul Jungeblut[3], Tillmann Miltzow[4], Simon Weber[1], [1]ETH Zurich, Zurich, Switzerland; [2]London School of Economics, London, United Kingdom; [3]Karlsruhe Institute of Technology, Karlsruhe, Germany; [4]Utrecht University, Utrecht, Netherlands. Contact: c.hertrich@lse.ac.uk

We consider the algorithmic problem of finding the optimal weights and biases for a two-layer fully connected neural network to fit a given set of data points. This problem is known as empirical risk minimization in the machine learning community. We show that the problem is R-complete. This complexity class is widely believed to be a strict superset of NP. It can be defined as the set of algorithmic problems that are polynomial-time equivalent to finding real roots of a polynomial with integer coefficients. Our results hold even for very simple architectures, showing that they are already difficult to train. The result offers an explanation (though far from a complete understanding) on why only gradient descent is widely successful in training neural networks in practice. We generalize a recent result by Abrahamsen, Kleist and Miltzow [NeurIPS 2021].

3 **The Hidden Convex Optimization Landscape of Deep Neural Networks**

Tolga Ergen, Stanford University, Stanford, CA, Contact: ergen@stanford.edu

Since deep neural network training problems are inherently non-convex, their recent dramatic success largely relies on non-convex optimization heuristics. Therefore, understanding the reasons behind the success of these highly complex non-convex architectures remains an open problem. To this end, we introduce exact convex formulations of ReLU network training problems and prove that shallow networks can be globally trained via convex programs with polynomial time complexity. Our results provide an equivalent characterization of neural networks as sparse locally linear models. We also discuss extensions to convolutional networks, batch normalization, and deeper architectures. Finally, we present numerical simulations illustrating the efficiency and effectiveness of our convex training approach over standard local search heuristics such as SGD.

Sunday, 11AM–12:15 PM

SB71

M - Arizona

Power Systems Expansion Planning

General Session

Session Chair

Joaquim Dias Garcia, PSR, Brazil.

Session Chair

Tiago Coutinho Carneiro de Andrade, PSR-inc

1 **An Integrated Progressive Hedging and Benders Decomposition with Multiple Master Method to Solve the Brazilian Generation Expansion Problem**

Alessandro Soares[1], Alexandre Street[2], Tiago Coutinho Carneiro de Andrade[3], Joaquim Masset Lacombe Dias Garcia[3], [1]PSR, Rio de Janeiro, Brazil; [2]University of Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil; [3]PSR, Rio de Janeiro, Brazil. Contact: alessandro@psr-inc.com

This talk exploits the decomposition structure of the generation expansion planning problem with an integrated modified Benders Decomposition (BD) and Progressive Hedging (PH) approach. We represent the multistage stochastic nature of the optimal hydrothermal operational policy through co-optimized linear decision rules for individual reservoirs. Therefore, we ensure investment decisions compatible with a nonanticipative (implementable) operational policy. To solve the large-scale optimization problem, we propose an improved BD with multiple instances of the master problem, strengthened by primal cuts and new Benders cuts generated by each master's trial solution. Additionally, our new approach allows using

PH penalization terms for accelerating the convergence of the method. We present real data from the Brazilian power system as a case study.

2 Climate-aware Generation and Transmission Expansion Planning: A Three-stage Robust Optimization Approach

Alexandre Moreira[1], David Pozo[2], Alexandre Street[3], Enzo E. Sauma[4], Goran Strbac[5], [1]Lawrence Berkeley National Laboratory, Berkeley, CA, [2]Skolkovo Institute of Science and Technology, Moscow, Russian Federation; [3]University of Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil; [4]Pontificia Universidad Catolica de Chile, Santiago, Chile; [5]Imperial College London, London, United Kingdom. Contact: alexandremoreirads@gmail.com

We propose a three-stage robust generation and transmission expansion planning model considering generation profiles of renewable energy sources (RES) affected by different long-term climate states. Essentially, we extend the broadly utilized two-stage modeling approach to properly consider partial information of climate states with conditional short-term scenarios of RES output and outages. The proposed model is formulated as a five-level optimization problem. Within this multi- level structure, the optimal investment plan considers a more realistic decision setting, where system operators adapt RES forecasts based on the observed climate conditions before planning the operational schedule. To solve the problem, a variant of the nested column-and-constraint-generation algorithm is proposed with global-optimality guarantee in a finite number of steps.

3 Flexible Network Expansion with N-1 Security Constraints

Tiago Coutinho Carneiro de Andrade, Bruno Bernhardt, Joaquim Garcia, PSR-inc, Rio de Janeiro, Brazil. Contact: tiago.andrade@psr-inc.com

We propose a power system expansion with a flexible network and solved by Benders decomposition. The first stage is the investment problem modeled as an integer problem. The second stage is an operations problem modeled as multistage stochastic programming and solved by stochastic dual dynamic programming (SDDP). We consider equipment investments to gain flexibility in the network as flow controllers controlling the circuit susceptances, phase shifters, and battery using typical days. Moreover, it considers N-1 security constraints with efficient computation of the line outage distribution factor (LODF) matrixes and lazy constraints for circuit capacities. We test the proposed approach using real-world data.

Sunday, 11AM–12:15 PM

SB72

M - California
Social Media and Data-driven Analytics
General Session

Session Chair
Lu (Lucy) Yan, Indiana University, Bloomington, IN

1 Learning to be Proficient? A Structural Model of User Dynamic Engagement in e-Health Interventions

Tongxin Zhou[1], Yingfei Wang[2], Lu (Lucy) Yan[3], Yong Tan[2], [1]Arizona State University, Tempe, AZ, [2]University of Washington, Seattle, WA, [3]Indiana University, Bloomington, IN

User attrition has been a major challenge confronted by eHealth interventions. In this study, we aim to examine how individuals dynamically engage in eHealth interventions to shed light on users' continued participation. In the participation process, users' intervention perceptions play an important role in affecting their subsequent participation decisions. To capture the updates in individuals' intervention perceptions and the associated behavior dynamics, we establish a hierarchical Bayesian learning framework to structurally characterize individuals' decision-making processes. Through analysis of a 4-month dataset collected for users' intervention participation in an online weight-loss platform, our study provides empirical evidence for individuals' learning behaviors in online health management.

2 Tweet in Unison? Examining Content Coordination and Social Media Engagement During Disasters

Eunae Yoo[1], Changseung Yoo[2], Alfonso J. Pedraza-Martinez[1], [1]Indiana University, Bloomington, IN, [2]McGill University, Montreal, QC, Canada. Contact: yooeun@iu.edu

Many disaster relief organizations (DROs) post social media content via multiple accounts within a single platform. Each account represents a distinct operational entity and is managed independently. A natural question is whether this strategy is more effective vs. a strategy where accounts under the same DRO produce content in unison. Our study answers this question by examining how engagement is affected by the agreement of content creation decisions across a DRO's accounts. Using Twitter data collected in partnership with the Canadian Red Cross, we show that engagement experiences a negative spillover effect when accounts under the same DRO make identical content creation decisions. Our findings provide actionable guidelines for DROs' internal coordination of content production in order to better deliver information to those that need it during disasters.

3 The Ownership Economy: How Stock Rewards Shape Consumer Spending

Ziyi Cao[1], Tingting Nian[2], Arun Sundararajan[3], [1]University of California, Irvine, Irvine, CA, [2]University of California, Irvine, CA, [3]New York University, New York, NY, Contact: zcao6@uci.edu

Behavioral theories pose loyalty programs such as cash rewards trigger reciprocity and affect towards the brand. It has been well documented that loyalty programs can promote good customer relationships and customer retention, yet little has been done in understanding the effect of stock rewards. We leverage transaction-level data from a FinTech company and investigate the impact of stock rewards on consumer spending. We find users increase spending by 23.3% after receiving stock rewards and the effect does not vanish until three months later. The effectiveness of stock rewards is documented as 503%, greater than 32% of cash rewards, revealing possible motivating effects besides monetary benefit, which can be explained by the sense of ownership. Our research is among the first to study the impact of stock reward on individual investors' consumption tendencies.

4 You Say, Firm Says: An Empirical Study on Online Employer Brand and Firm Performance

Lorin Hitt[1], Fujie Jin[2], Bowen Lou[3], [1]University of Pennsylvania, Philadelphia, PA, [2]Kelley School of Business, Indiana University, Bloomington, IN, [3]University of Connecticut, Storrs, CT, Contact: jinf@indiana.edu

We use a large-scale multiyear dataset to examine how various digital communication channels jointly provide signals of the quality of a firm as an employer, build up its online employer brand, and affect firm market value.

Sunday, 11AM–12:15 PM

SB73

M - Colorado

Recent Advances in using ML for Supply Chain and Revenue Management

General Session

Session Chair

Divya Singhvi, 1</sup

1 Inventory Management in Omnichannel Supply Chains

Pavithra Harsha[1], Ali Koc[2], Chandra Narayanaswami[1], Brian Quanz[3], Mahesh Ramakrishna[1], Dhruv Shah[1], Shivaram Subramanian[1], [1]IBM Research, Yorktown Heights, NY, [2]IBM TJ Watson Research Center, Yorktown Heights, NY, [3]IBM, Yorktown Heights, NY, Contact: pharsha@us.ibm.com

We study the multi-period inventory replenishment problem for an omnichannel retailer that aims to optimally position inventory across its warehouses and stores to meet its uncertain omnichannel demand that includes walk-ins at stores as well as online demand that can be fulfilled from any location. We present a robust optimization-based heuristic and discuss different variations to solve this problem. Using real-data from a retailer, we perform network-based simulations and compare the impact of this and other typical heuristics on various KPIs of interest.

2 Deep Policy Iteration with Integer Programming for Inventory Management

Brian Quanz[1], Pavithra Harsha[2], Ashish Jagmohan[3], Jayant Kalagnanam[3], Divya Singhvi[4], [1]IBM, Yorktown Heights, NY, [2]IBM Research, Pleasantville, NY, [3]IBM Research, Yorktown Heights, NY, [4]New York University, New York, NY, Contact: blquanz@us.ibm.com

Reinforcement learning has led to considerable break-throughs in diverse areas such as robotics, games and many others, but its application in complex real-world decision making problems remains limited. Many problems in OM are characterized by large action spaces and stochastic system dynamics, providing a challenge for existing RL methods that rely on enumeration techniques to solve per step action problems. To resolve these issues, we develop Programmable Actor Reinforcement Learning (PARL), a policy iteration method that uses techniques from integer programming and sample average approximation. We demonstrate its effectiveness on a variety of multi-echelon inventory management settings.

3 Improving Product Availability to Reduce Customer Attrition in Clothing Rental Subscriptions

Lennart Baardman, Xuening Wang, University of Michigan, Ann Arbor, MI, Contact: baardman@umich.edu

Customer attrition is a serious challenge for subscription services. Often, customers leave the service within the first few months of signing up. Using data from a clothing rental service, we create a machine learning method to understand why customers leave. One major issue is the lack of variety in clothing styles, which is partially caused by products being unavailable. We develop an optimization algorithm that controls inventory by managing which products are displayed to the customer in order to maximize product availability while minimizing the risk of customers not receiving their products.

4 Safe: A Supervised Approach for Feature Engineering

Tamar Cohen-Hillel[1], Georgia Perakis[2], Ioannis Spantidakis[3], Leann Thayaparan[4], [1]UBC Sauder School of Business, Vancouver, BC, Canada; [2]Massachusetts Institute of Technology, Belmont, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, [4]Massachusetts Institute of Technology, Somerville, MA, Contact: georgiap@mit.edu

In the age of data availability, being able to analyze high-dimensional data is crucial for decision-making. Nevertheless, accounting for a large number of features can introduce several challenges and dimensionality reduction techniques are necessary to improve both the speed of the machine learning algorithm as well as its accuracy. To address this concern, in this research we develop a new dimensionality reduction algorithm called Supervised Approach for Feature Engineering (SAFE). Our proposed approach identifies a projection that best explains, not the variance in features, but how well those features are correlated with the dependent variable, facilitating any future supervised machine learning algorithms.

Sunday, 11AM–12:15 PM

SB74

M - Florida

Decision Making under Information Acquisition

General Session

Session Chair

Renyuan Xu, University of Oxford, Oxford, United Kingdom.

1 Recover Utility of Rational Inattentive Agent and Applications on Robo-advising

Hao Xing, Zeyu Zhu, Boston University, Boston, MA, Contact: haoxing@bu.edu

We consider a rational inattentive agent who acquires costly signal to make decisions. By observing agent's actions, we formulate an inverse reinforcement learning problem to recover agent's utility. We propose an efficient numeric algorithm and prove its convergence. The framework is applied to robo-advising problems to recover investors' utilities by observing their investment strategies.

2 Parallel Search for Information in Continuous Time

Wenpin Tang, Columbia University

We consider the problem of a decision-maker searching for information on multiple alternatives when information is learned on all alternatives simultaneously. The decision-maker has a running cost of searching for information, and has to decide when to stop searching for information and choose one alternative. The expected payoff of each alternative evolves as a diffusion process when information is being learned. After establishing the well-posedness of the equation, we show that the optimal boundary where search is stopped (free boundary) is star-shaped, and present an asymptotic characterization of the value function and the free boundary. We show that the distance between the free boundary and each point on the diagonal is logarithmic in the number of alternatives.

3 The Cost of Regret

Luhao Zhang, The University of Texas at Austin, Austin, TX

We study a learning decision-making problem over an infinite horizon. In this problem, the decision-maker (DM) can choose between two products, a well-known product A anda new product B, where the return of product A is deterministic (fully observable) while the return of the new product B, denoted as ⍰ {l, h}, is unknown to the DM. We consider a framework where the DM can make an initial decision after learning for some time and change her mind later on at a cost. This is formulated as a sequential decision-making problem in two periods. In the first period (up to a stopping time picked by the DM), the DM collects information and learns about the return of the unknown product B. At stopping time ⍰, the DM makes an initial choice between product A and product B, and the DM is able to continue observing the return signals of product B and has one opportunity to change to the alternative at a cost.

4 Independent and Decentralized Learning in Markov Potential Games

Manxi Wu, Cornell University, ORIE, Ithaca, NY

We propose a multi-agent reinforcement learning dynamics, and analyze its convergence property in infinite-horizon discounted Markov potential games. We focus on the independent and decentralized setting, where players do not know the game model and cannot coordinate. In each stage, players update their estimate of a perturbed Q-function at a fast timescale, and update their policies using a smoothed optimal one-stage deviation strategy at a slow timescale. We prove that our learning dynamics converge to a stationary Nash equilibrium in Markov potential games with probability 1.

Sunday, 11AM–12:15 PM

SB76

M - Michigan
Operations Management and Marketing Flash Session I
Flash Session

Session Chair
Patrick Moder, Kühne Logistics University, Hamburg, Germany.

1 Optimal Decisions for the Innovative Enterprise Considering Brand Goodwill and Consumers' Quality Expectation
Xiaoya Han[1], Huichen Zhang[1], Xin Liu[2], [1]University of Shanghai for Science and Technology, Shanghai, China; [2]Elon University, Elon, NC, Contact: xliu3@elon.edu
This study investigates product pricing and quality strategies by considering the brand goodwill of the innovative enterprise and the consumers' quality expectation. pricing. Under the framework of the Bertrand game, we analyze the competitive pricing problem of the innovative enterprise. We also extend the competition problem under consideration of information asymmetry and the Stackelberg game framework.

3 Fast Rescheduling Method for Semiconductor Assembly Lines with Reentrance and Constrained Time Windows
Yutong Su[1], Bala Krishnan[2], Husam Daoud[3], Nital Patel[3], Feng Ju[4], [1]Arizona State University, Tempe, AZ, [2]Intel, Bangalore, India; [3]Intel, Chandler, AZ, [4]Arizona State University, Tempe, AZ, Contact: yutongs1@asu.edu
In semiconductor manufacturing, a master schedule over several weeks' time horizon is typically created to optimize production. However, machine failures may cause the master schedule to be infeasible by violating the time window constraint or suboptimal due to delays. In this work, considering the reentrant structure and time window constraint, we develop a decentralized approach based on a series of mixed-integer programming models to adjust the master schedule. The experiment results show that the proposed method can respond to machine failures much faster than the master scheduler and heuristic-based methods.

4 The Price of Friction in Multi-channel Retail: Insights for Retail Operations Managers
Aneesh Banerjee[1], Sabrina Gottschalk[1], Joerg Ries[2], [1]City University London, London, United Kingdom; [2]City University London, London, United Kingdom. Contact: aneesh.banerjee@city.ac.uk
Manufacturers use multiple sales channels: own physical and online stores, as well as third party physical and online stores. In such an environment, manufacturers can control channel characteristics such as experience and friction, only on some channels. However, as these channel characteristics and prices influence consumers' purchase decisions as well as the profitability of the channel, the development of a multichannel strategy requires understanding consumers' channel choices as well as the operational implications of the fulfilment process. Using a choice-based conjoint experimental design we study how customers' utility is affected by price, friction and experience. We offer important new insights about consumer switching behaviour between channels and implications for operations managers to optimize their channel fulfilment process.

5 Overconfidence in Context: The Moderating Role of Demand Distributions in the Newsvendor Problem
Dahai Cai[1], Sam Kirshner[2], MENG WU[1], Lushuang Yang[1], [1]Sichuan University, Chengdu, China; [2]UNSW Business School, Sydney, Australia. Contact: s.kirshner@unsw.edu.au
This talk explores how demand can moderate the influences of overconfidence in decision-making in the newsvendor problem. We posit that an individual's overconfidence depends on their cognitive load, which increases with greater demand ranges. Accordingly, we hypothesize that a wider demand range will lead to a more substantial pull-to-center effect due to greater reliance on overconfident estimates of the demand distribution. We test and find support for our hypothesis in two experimental studies.

6 The Visible Hand: Name-based Rationing System for Mitigating Strategic-purchasing and Panic-buying
Jiuh-Biing Sheu[1], Vivi Kuo[2], [1]National Taiwan University, Da An Qu, Taiwan; [2]National Taiwan University, Taipei, Taiwan.
This paper presents a conceptual model to investigating the causal relationship between supply chain resilience and its causes under government deployed a name-based rationing

system (NBRS) amid Covid-19 outbreaks. Grounded upon resource dependency theory and supply chain disruption risk management strategies, one of the distinctive features of the proposed model is that a name-based rationing system (NBRS) is treated as a moderator on the effect of retailer strategic purchasing and consumer panic buying on supply chain resilience.

7 When Do Human Decision Makers Beat Computerized Support? - A Field Experiment in Retailing

Anna-Lena Sachs[1], Michael Becker-Peth[2], Stefan Minner[3], Ulrich Thonemann[4], [1]Lancaster University, Lancaster, United Kingdom; [2]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands; [3]Technical University of Munich, München, Germany; [4]Universitat zu Koln, Köln, Germany. Contact: a.sachs@lancaster.ac.uk

Retail managers face the challenging task of placing orders for perishable products. Central tools can support them by providing model-based order quantities, but if local managers have additional market information, it might be beneficial to decentralize decisions. However, human decision makers are prone to biases. To assess the benefit of decision support, we conducted a field experiment at a European retail chain. We randomly assigned stores to four groups and provided different levels of support. We find that decision makers are prone to the pull-to-center bias, but the bias is reduced for store managers receiving model-based order quantities. Store managers can outperform the central system in terms of total cost by incorporating local information, but higher levels of decision support can hinder the implementation of local information.

8 What Drives Your Customer Nuts? Predicting Complaints in Semiconductor Order Fulfillment

Patrick Moder, Kai Hoberg, Kühne Logistics University gGmbH, Hamburg, Germany. Contact: patrick.moder@the-klu.org

Late or insufficient order fulfilment creates the risk of bad publicity, customer churn and lost sales. In a semiconductor B2B setting, we predict customer complaints when shipped orders deviate from the initial commitment. We apply machine learning models to approximate the complaint prediction problem and find that extreme gradient boosted trees perform best for the imbalanced target variable on hand. We show that sampling approaches only contribute limited performance improvements, study the impact of cutoff selection on absolute prediction outcomes, and investigate the importance of input features using SHAP values.

Sunday, 11AM–12:15 PM

SB77

M - Texas

Nudging to Improve Decision-making in Operations

General Session

Session Chair

Karen L. Donohue, University of Minnesota, Minneapolis, MN

Session Chair

Yeonjoo Lee, Minneapolis, MN

1 Nudging Green but Slow Shipping Choices in Online Retail

Yeonjoo Lee, Karen L. Donohue, University of Minnesota, Minneapolis, MN, Contact: yjlee@umn.edu

While fast delivery helps retailers to stay competitive, it often leads to worse environmental outcomes. We study how to nudge online retail customers to voluntarily choose slower but greener delivery in two logistical contexts: no-rush and consolidated shipping. Drawing from current practice and research on nudging sustainable behavior, we develop a theory on what types of information will be most effective in which context and why. Through a series of experiments, we find that the effectiveness of information strategies varies by logistical context. In particular, green signaling is critical for no-rush shipping but less useful for consolidated shipping. Also, process information is most effective for consolidated shipping, while outcome information is most effective for no-rush shipping. Effects can be explained by the reduction of psychological barriers.

2 Nudging Patient Choice by Messaging

Jiayi Liu[1], Diwas S. KC[2], [1]Emory University, Atlanta, [2]Emory University, Atlanta, GA

Patient no-show has been a chronic problem in outpatient clinics. In this study, we use text-based nudges to reduce no-shows. Through a field experiment in the clinic, we find that certain message framing designed to make future wait time salient has greatly boosted patient attendance.

3 Improving Customer Compatibility with Tradeoff Transparency

Ryan Buell, MoonSoo Choi, Harvard Business School, Boston, MA, Contact: rbuell@hbs.edu

Through a large-scale field experiment with customers considering opening a credit card with a nationwide retail bank, we investigate how providing transparency into an offering's tradeoffs affects subsequent rates of customer acquisition and engagement. We find tradeoff transparency to have an insignificant effect on acquisition rates, but customers who were shown each offering's tradeoffs selected different products than those who were not. Moreover, prospective customers who experienced transparency and subsequently chose to open an account went on to exhibit higher quality service relationships over time. Monthly spending was 9.9% higher and cancellation rates were 20.5% lower among those who experienced tradeoff transparency. Providing tradeoff transparency may be an effective strategy for informing customer choices, leading to better outcomes.

4 Automation or Collaboration? Machine Learning vs Integrated Demand Planning Methods

Rebekah Brau[1], John Aloysius[2], Enno Siemsen[3], [1]Brigham Young University, Provo, UT, [2]University of Arkansas, Fayetteville, AR, [3]University of Wisconsin-Madison, Madison, WI, Contact: bbrau@byu.edu

Our research compares integrated forecasts (human judgment and algorithms) with machine learning forecasts absent of human input. We use a laboratory experiment in combination with a field study involving over five million product-store forecasts to compare two integrated methods: interactive learning (IL) and human-guided learning (HGL) with unsupervised machine learning. The two integrated methods represent supervised learning; they allow the algorithm to make use of human judgment to train the model using iterative linear weighting of human judgment and model predictions. Our studies demonstrate that human judgment benefits demand planning processes as the two learning methods are more accurate than machine learning without human input.

Sunday, 11AM–12:15 PM

SB78

M - Utah

The Advancement of Machine Learning and Data-driven Decision Making

General Session

Session Chair

Xuan Bi, University of Minnesota, Minneapolis, MN

1 Offline Reinforcement Learning with Instrumental Variables in Confounded Markov Decision Processes

Zhengling Qi, The George Washington University, Washington D.C., MD

We study offline reinforcement learning (RL) in the confounded Markov decision processes (MDPs). Due to the lack of online interaction with the environment, offline RL is facing the following two significant challenges: (i) the agent may be confounded by the unobserved state variables; (ii) the offline data collected a prior does not provide sufficient coverage for the environment. To tackle the above challenges, with the aid of instrumental variables, we propose various policy optimization algorithms with the finite-sample regret guarantee for finding an optimal in-class policy under mild data coverage assumptions. Our extensive theoretical investigations and one numerical study motivated by kidney transplantation demonstrate the promising performance of the proposed algorithms.

2 Economic Impact of New Category Recommendations: Evidence from Randomized Field Experiments

Meizi Zhou[1], Ravi Bapna[2], Gediminas Adomavicius[2], Jonathan Hershaff[3], [1]Boston University, Boston, MA, [2]University of Minnesota, Minneapolis, MN, [3]University of Michigan, Ann Arbor, MI

New category introduction is an intensive-margin-oriented strategy. There is a lack of studies explicitly designed to guide users to unexplored product categories, and evaluating the real-world causal economic impact of category expansion. Thus, we design and evaluate new category introduction approaches and their economic impact using ML-based recommendation techniques and field experiments. We firstly show the impact of recommending a new category on consumers' purchase behaviors. Furthermore, providing multiple choices further amplifies the impact. We show that ML-based personalization techniques utilizing granular information about users' online activities can help locate the most relevant categories for individual customers. Critically and finally, we show the causal economic impact of new category recommendations in a real-world setting.

3 Heterogeneous Task Segmentation & Acquisition Tree: Learning Multidimensional Wisdom of Crowd on Crowdsourcing Marketplace

Junyu Cao[1], Yan Leng[2], [1]The University of Texas at Austin, Provo, [2]University of Texas at Austin, Austin, TX, Contact:

yan.leng@mccombs.utexas.edu

Crowdsourcing platforms have emerged as a practical paradigm for enabling the wisdom of crowd. This study formulates a new data acquisition problem to learn worker skills and heterogeneous task skill requirements. We propose an interpretable tree-based adaptive data acquisition algorithm to predict top workers. The proposed algorithm allows for two practical considerations: (1) the transient nature of workers may naturally lead to a transductive setting; (2) workers in the exploration period subject to availability constraint. We adaptively segment tasks based on skill requirement similarity and then learn a transductive bandit policy for each task segment. We evaluate the algorithm on the real-world Yoloka data for two transductive settings, and improves both for more than 50% in the task completion accuracy than state-of-the-art benchmarks.

4 Fix the Issue! A Contextual Bandit Approach for Open Source Software Feedback Triage

Zisu Wang, University of Arizona, Tucson, AZ, Contact: zisuwang@email.arizona.edu

The continuous development and eventual success of open source software (OSS) hinge on the timely resolution of community feedback (i.e., feedback triage). However, feedback triage has become an increasingly challenging task due to the informational richness of community feedback, rapid growth of contributor base, and inherent uncertainty of contributor skills. In this study, we propose a contextual bandit approach to automatically identify appropriate contributors for feedback triage. Our approach employs a fine-tuned deep learning language model to understand community feedback, and then adaptively learn contributors' skills through their past contribution history. Utilizing a novel dataset from GitHub, we demonstrate our approach's utility in generating interpretable findings and giving superior contributor recommendations over existing benchmarks.

Sunday, 11AM–12:15 PM

SB79

JWM - Room 201

Advances in New Product Development

General Session

Session Chair

Janne Kettunen, George Washington University, Washington

1 Product Development by Startups: A Behavioral Investigation

Sinan Erzurumlu[1], karthik ramachandran[2], Sreekumar R. Bhaskaran[3], [1]Babson College, Babson Park, MA, [2]Georgia Tech, Atlanta, GA, [3]Southern Methodist University, Dallas, TX, Contact: serzurumlu@babson.edu

Entrepreneurial decision makers make several operational decisions that are crucial for their startups as they continue to develop their product and search for product-market fit. They decide whether to persevere or not after failed attempts; whether to take a life-line in the form of external funding; and whether to cash-out by salvaging assets such as remaining endowments. Theory suggests that an optimal stopping framework would be useful as a decision-support tool. But there has been no behavioral test of such models. In this research, we explore these decisions with a behavioral study. We examine how decisions may be influenced by behavioral factors. We develop theoretical insights that would be helpful in supporting entrepreneurs and providing a decision framework that would account for their behavioral tendencies.

2 Prototyping in New Product Development

Gaoyu Xie[1], Janne Kettunen[2], [1]George Washington University School of Business, DC, [2]George Washington University, Washington

We adapt the binomial option pricing model to investigate (i) conditions when it is optimal to develop a prototype and (ii) what is the optimal timing to develop a prototype. The analysis is conducted under uncertainty in the outcomes of product development efforts when the decision-makers (DMs) maximize their mean-variance utility. We show that prototyping is highly beneficial when both the development uncertainty and the DMs' risk aversion are at the medium level. Furthermore, we prove that there exists a boundary in terms of the initial revenue estimate above which prototyping is optimal for DMs. The model and the derived results can be useful for DMs to support the optimal use of prototyping.

3 One Size Does Not Fit All: Strengths and Weaknesses of the Agile Approach

Evgeny Kagan[1], Tobias Lieberum[2], Sebastian Schiffels[3], [1]Johns Hopkins Carey Business School, Washington, DC, [2]Technical University of Munich, München, Germany; [3]Lancaster University, Leipzig, Germany. Contact: ekagan@jhu.edu

Agile project management techniques, such as iterative sprints and granting workers task autonomy, have become commonplace in many organizations. We experimentally examine how these techniques affect performance in two innovation settings. Our results suggest that the effects of

Agile on performance are not uniform and depend on the innovation setting and on the performance measure. Agile improves average performance in the product development setting but lowers average performance in the business model innovation setting. In both settings, Agile techniques lead to more incremental (less radical) strategies, which narrows performance variance.

4 Choice Bracketing in New Product Development

Matthias Seifert[1], Janne Kettunen[2], Gaoyu Xie[3], [1]IE Business School - IE University, Madrid, Spain; [2]George Washington University, Washington, [3]The George Washington University, Washington, DC, Contact: matthias.seifert@ie.edu

We study the effect of narrow and broad bracketing on decision behaviour in product development. Previous research has suggested that decision errors result from myopic behaviour when decision-makers overly focus on a single alternative (narrow bracketing) instead of assessing all available alternatives concurrently (broad bracketing). We conducted laboratory experiments (N=384) using a 2x2x3 factorial design, where we varied (i) the modes of task information (aggregated vs segregated), (ii) product evaluation (simultaneous vs sequential), and (iii) the target threshold for profit to be reached (high vs low vs zero target). Contrary to past research, we find decision performance to be systematically superior under narrowly bracketed tasks. That is, subjects earned higher profits when product alternatives were assessed sequentially and with less information.

Sunday, 11AM–12:15 PM

SB80

JWM - Room 202

Human, Machines, and Algorithms Session 2

General Session

Session Chair

Kyuhan Lee, 1</sup

1 Is Transparency the Best Policy? Impact of (im) plausible AI Transparency on Human Adoption of AI for Fake News Detection

Kyuhan Lee[1], Jihae Suh[2], Jinsoo Park[3], [1]Arizona State University, Tempe, AZ, [2]Seoul National University of Science and Technology, Seoul, Korea, Republic of; [3]Seoul National University, Seoul, Korea, Republic of. Contact: klee264@asu.edu

The growing application of AI, especially in fake news moderation, raises an important quandary for humans to understand its working mechanism. While, recently, there has been a burst of research in this vein due to the hype of AI transparency, generally, no agreement has been made among previous studies regarding its impact on humans' AI attitudes. To fill the research gap, we propose a new, unexplored dimension, plausibility, of AI transparency. Based on this, we investigate the heterogeneous effects of AI transparency on users' attitudes towards AI for fake news detection. Additionally, we take account of AI reliability as a factor moderating the impact of plausible (and implausible) AI transparency on users' AI attitudes. Our study paves the way for future studies in theorizing the human-AI interaction and suggests practical implications regarding the use of AI.

2 Bias Mitigation in AI

Reihane Boghrati[1], Amir Sepehri[2], Jonah Berger[3], [1]Arizona State University, Tempe, AZ, [2]ESSEC, Paris, France; [3]University of PA- Wharton, Philadelphia, PA

Minority groups often need to overcome invisible barriers to achieve higher professional goals. This phenomenon which is referred to as glass ceiling, is mostly studied in organization settings but could also extend to other contexts. We demonstrate that while organizations try to be equality conscious and even use machine learning to avoid human biases, male entrepreneurs are prequalified for higher loan amounts compared to female entrepreneurs. Machine learning methods can improve prediction accuracy, and sometimes reduce human errors, but we show that they often carry over biases against unprivileged groups (e.g., women) and can even intensify such biases. Our findings demonstrate the glass ceiling phenomena in a novel setting, provide a comprehensive framework for quantifying bias, and outline a series of steps and approaches researchers can use to mitigate bias.

3 Learning from the Data: Startup Success Prediction Using Graph Neural Networks

Yuanxia Li, Sudha Ram, University of Arizona, Tucson, AZ

Startup success prediction has important implications for investors, who spend a lot of effort trying to identify the promising startups, but still suffer from expensive errors. Human intelligence has its advantages, but falls short on learning from large amounts of information, which we believe is important for startup success prediction. In this study, we develop a Graph Neural Network (GNN) model that learns to predict startup success using a very large dataset.

4 **Credit Risk Modeling Without Sensitive Features: An Adversarial Deep Learning Model for Fairness and Profit**

Xiyang Hu[1], Yan Huang[2], Beibei Li[1], Tian Lu[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Tepper School of Business, Carnegie Mellon University, Pittsburgh, PA, [3]Arizona State University, Tempe, AZ, Contact: xiyanghu@cmu.edu

We propose an adversarial deep learning model for credit risk modeling, which can make use of sophisticated ML model's ability to triangulate, i.e. infer the sensitive group affiliation by using only permissible features, which is often deemed "troublesome" in the fair machine learning research, in a positive way to increase both borrower welfare and lender profits while improving fairness. We train and test our model on a dataset from a real-world microloan company. Our proposed model performs well on increasing borrowers' welfare and lenders' profits and improving the fairness in the allocation of financial resources. It significantly outperforms regular deep neural networks and the currently most popular credit risk model XGBoost. Our framework is ready to be customized for other microloan firms, and can be easily adapted to many other decision making scenarios.

Sunday, 11AM–12:15 PM

SB81

JWM - Room 203

Amazon Last Mile Science

General Session

Session Chair

Liron Yedidsion, Amazon, Redmond, WA

1 **Capacity and Coincidence Aware Package Assignment**

Chinmoy Mohapatra[1], Rohit Malshe[1], Jin Ye[2], LIRON Yedidsion[3], Dipal Gupta[1], [1]Amazon, Seattle, WA, [2]Amazon, Kirkland, WA, [3]Amazon.com Inc, Seattle, WA, Contact: cmohapat@amazon.com

Package delivery "coincidence" is a key metric in last mile logistics where a higher coincidence improves utilization of on-road resources. Last mile capacities are often planned in terms of package counts alone. We propose algorithmic and computational approaches to model capacities in terms of both package counts and on-road delivery times that enhance in-station and on-road resource utilization, and package delivery density.

2 **Alternating Direction Method of Multipliers (ADMM) for Centralized Labor Planning**

Mahdieh Allahviranloo[1], Gah-Yi Ban[2], Rohit Malshe[3], [1]City College New York, CUNY, New York, NY, [2]Robert H. Smith Business School, University of Maryland, Maryland, MD, [3]Amazon LLC, Seattle, WA

Sub-organizations within a large organization often deviate from centralized planning objectives, leading to bottlenecks and additional costs. In order to minimize costs and produce a consensus amongst the participating agents, consensus planning methods such as the alternating direction method of multipliers (ADMM) may be useful. In this paper, we talk about how ADMM can be used for planning labor in a large organization such as Amazon.

3 **Newsvendor Approach Capacity Planing at Amazon**

Liron Yedidsion[1], Rohit Malshe[2], Chinmoy Mohapatra[3], Abhilasha Katariya[4], Tolga Cezik[5], Tamar Cohen-Hillel[6], [1]Amazon, Redmond, WA, [2]Amazon, Bellevue, WA, [3]Amazon, Arlington, TX, [4]Amazon, Issaquah, WA, [5]Amazon.com, Seattle, WA, [6]UBC Sauder School of Business, Vancouver, BC, Canada. Contact: lirony@amazon.com

Labor planning is done well in advance of realizing the actual workload. A Newsvendor approach solution is shown in this work, demonstrating how to minimize handling costs. We may have more than one lever to tackle underage or overage. Hence, we would like to use them in an escalating manner up to their respective capacities. Unlike the classic Newsvendor model, with multiple overage and underage options and costs, the target percentile is not constant and may shift significantly depending on the distribution.

Sunday, 11AM–12:15 PM

SB82

JWM - Room 204

Academic Job Search

Panel Session

Session Chair

Diana Gineth Ramirez-Rios, Rensselaer Polytechnic Institute, Troy, NY

Session Chair

Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY

1 **Moderator**

Diana Gineth Ramirez-Rios, University at Buffalo, Buffalo, NY, Contact: dgramire@buffalo.edu

The purpose of this session is to bring visibility to the students and postdocs looking for academic positions. Panelists from both business and engineering schools will share their experiences. This panel discusses the academic interview process and do's and don'ts associated with the job search.

2 **Panelist**

Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA

3 **Panelist**

Daniel F. Silva, Auburn University, Auburn, AL

4 **Panelist**

Shima Mohebbi, George Mason University, Fairfax, VA, Contact: smohebbi@gmu.edu

5 **Panelist**

Michelle M. Alvarado, University of Florida, Gainesville, FL

Sunday, 11AM–12:15 PM

SB83

JWM - Room 205

DEI Award Session

Award Session

Session Chair

Ebru Korular Bish, University of Alabama, Tuscaloosa, AL

Session Chair

Lawrence V. Snyder, Lehigh University, Bethlehem, PA

1 **Split Liver Transplantation: An Analytical Decision Support Model**

Yanhan (Savannah) Tang[1], Alan Scheller-Wolf[1], Sridhar R. Tayur[1], Emily R. Perito[2], John P. Roberts[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of California, San Francisco, CA, [3]University of California, San Francisco, CA

Split liver transplantation (SLT) can save two lives using one liver. SLT may also improve equity by giving smaller candidates (e.g. children) increased access. We evaluate different ways of splitting and allocating livers within a multi-queue fluid system incorporating donor-recipient size matching, patients' dynamic health conditions, fairness, and endogenous patient acceptance decisions. Leveraging a novel decomposition result, we find the exact optimal matching. Numerical results, utilizing data from OPTN, show that increased utilization of SLT can improve both efficiency and fairness.

2 **Dropping Standardized Testing for Admissions Trades off Information and Access**

Faidra Monachou[1], Nikhil Garg[1], Hannah Li[2], [1]Harvard University, Cambridge, MA, [2]MIT, Menlo Park, CA

We study the role of information and access in capacity-constrained selection problems with fairness concerns. We develop a theoretical framework with testable implications that formalizes the trade-off between the (potentially positive) informational role of a feature and its (negative) exclusionary nature when members of different social groups have unequal access to this feature. Our framework finds a natural application to recent policy debates on dropping standardized testing in college admissions. Our primary takeaway is that the decision to drop a feature (such as test scores) cannot be made without the joint context of the information provided by other features and how the requirement affects the applicant pool composition. Dropping a feature may exacerbate disparities by decreasing the amount of information available for each applicant, especially those from non-traditional backgrounds. However, in the presence of access barriers to a feature, the interaction between the informational environment and the effect of access barriers on the applicant pool size becomes highly complex. In this case, we provide a threshold characterization regarding when removing a feature improves both academic merit and diversity. Finally, using application and transcript data from UT Austin, we illustrate that there exist practical settings where dropping standardized testing improves or worsens all metrics.

3 **Sequential Fair Allocation: Achieving the Optimal Envy-Efficiency Tradeoff Curve**

Sean Sinclair, Siddhartha Banerjee, Christina Lee Yu, Cornell University, Ithaca, NY

We tackle a problem established from a partnership with the Food Bank of the Southern Tier in optimizing their mobile food-pantry operations. We model it as an online resource allocation problem under demand uncertainty, where individuals arrive over T rounds, with each round having a random number of individuals characterized by their type. We provide an exact characterization of the achievable (envy, efficiency) pairs in this model, showing that any algorithm achieving low envy must suffer from poor efficiency, and vice-versa. Moreover, we complement this exact characterization with a simple algorithm capable of achieving any desired point along the trade-off curve.

Sunday, 11AM–12:15 PM

SB84

JWM - Room 206
Dynamic Data Driven Applications Systems
Panel Session

Session Chair
Nurcin Celik, University of Miami, Coral Gables, FL

1 **Panelist**
Frederica Darema, 1</sup

2 **Panelist**
Chun-Hung Chen, George Mason University, Fairfax, VA

3 **Panelist**
William Caballero, US Air Force Academy, CO

UNREGISTERED Panelist
Salim Hariri, 1</sup

Sunday, 11AM–12:15 PM

SB85

JWM - Room 207
Teaching Innovations in Management Analytics
General Session

Session Chair
Vahid Roshanaei, 1</sup

Session Chair
Opher Baron, 1</sup

Session Chair
Neil Desnoyers, Saint Joseph's University, Upper Darby, PA

1 **How to Effectively Teach Collaborative Filtering and AI Recommendation Systems Algorithms to MBA Students?**
Abraham Seidmann, Boston University, Newton, MA
Recommender systems have been introduced to help users navigate large sets of feasible alternatives. They usually lead to improved marketing, or decision making in general. However, teaching the internal logic of these systems turned out to be rather challenging. In this talk, we introduce the 3rdFriday Collaborative Filtering (Movie Recommendation) system simulation. It allows students to interactively fine tune some of the 'choice logic' parameters and functions, and by doing so - to reenforce their learning by doing. Experience have shown that students gain important technical insights by using our tool.

2 **An Interactive Spreadsheet Model for Teaching Classification Using Logistic Regression**
Vahid Roshanaei, University of Toronto, Toronto, ON, Canada.
We present an interactive spreadsheet model to teach essential concepts in binary classification using the Logistic Regression (LR) model. This spreadsheet reinforces concepts like probabilities, likelihoods, and the usage of likelihoods to optimize the LR model's parameters. Students will learn how to dynamically convert probabilities into classification using the Decision Boundary (DB), impact classification outcomes by varying DBs, and determine the classification accuracy based on various performance measures. These performance measures are depicted and dynamically adjusted when the DB changes. We also reiterate the usage of these measures in the context of cross-validation and imbalanced data sets. We provide a case study that implements LR with multiple predictors. We discuss pedagogical aspects of this spreadsheet.

3 **A Hands-on, White-box Approach to Decision Tree Teaching**
Gerhard Trippen, University of Toronto, Rotman School of Management, Toronto, ON, Canada.
Using Decision Trees, we demonstrate our teaching approach to ML Algorithms through a variety of different tools allowing the students a deeper understanding of the subject. Accompanied by a visual example, notes introduce the basics. A handout with a toy example enables us to do the calculations easily by hand to practice the more technical steps. We write Python code using scikit-learn to construct a decision tree for a larger data set. The decision tree is then visualized. Students can easily modify the code to tune hyperparameters. Individual assignments test the students' understanding through conceptual and calculated questions, and applied group project assignments requires the students to run the algorithms on larger data sets.

Sunday, 11AM–12:15 PM

SB86

JWM - Room 208

Collaborative Routing and Planning of Aerial and Other Vehicles

General Session

Session Chair

Fanruiqi Zeng, GEORGIA TECH, Atlanta

1 Cost and Emissions Tradeoff of Integrated Drone Delivery Systems

Juan Zhang, University of Wisconsin–Eau Claire, Eau Claire, WV

This research examines the tradeoffs between delivery costs and lifecycle greenhouse gas emissions of an integrated drone delivery system. We consider multi-stop truck delivery routes, along with two types of drone delivery strategies: drone-only delivery where drones travel out-and-back from a depot to make each delivery, and truck-drone delivery where a truck and drone, in tandem, make parallel deliveries with the drone launched and recovered by the truck as the truck completes a multi-stop route. Continuous approximation models are developed to analyze optimal operations with a range of vehicle operating characteristics, delivery environments, and drone energy consumptions. Results show the tradeoffs of cost and emissions are determined by the relative values of the ratio of vehicle operating cost rate to vehicle emissions rate for the drone and truck.

2 Last-mile Drone and Truck Delivery Energy Comparisons

Taner Cokyasar, Argonne National Laboratory

One important concern is the energy efficiency of direct delivery drones compared to conventional delivery trucks at a regional systems level. In this study, we develop and apply methods to quantify the regional energy impacts of drone delivery, then we assess these impacts and compare them to the impacts of truck delivery. To study this problem, we develop an optimization model that determines an optimal set of fulfillment centers (FCs) with variable service capacities that allow drones to make direct e-commerce deliveries. We also develop another optimization model to account for the energy consumption of diesel trucks (DTs) and battery electric vehicles (BEVs). We test the models using validated simulation data for the Chicago metropolitan area to quantify the energy implications of these three delivery modes.

3 Drone Routing Problem Model for Lastmile Delivery Using the Public Transportation Capacity as Moving Charging Stations

Amir Hossein Moadab[1], Fatemeh Farajzadeh[2], Omid Fatahi Valilai[3], [1]Washington State University, Pullman, WA, [2]Worcester Polytechnic Institute, WORCESTER, MA, [3]Jacobs University Bremen, Bremen, Germany. Contact: Amirhossein.moadab@wsu.edu

This paper considers a last-mile delivery system in which a set of drones are operated in coordination with public transportation system to deliver a set of orders to customer locations. A mathematical model based on VRP is extended to solve this problem. A real-world case inspired by Bremen 2025 transportation paradigm is also developed to validate the mathematical formulation. Results show that the sequence of visiting customers and public transport stations highly impacts the remaining charge and efficiency of drone tour planning. Also, using public transport vehicles, which enables drones to charge their battery or to approach customers, can reduce the number of drones required for satisfying the demands in a service area. The results show that there are high potentials to save energy for drone-enabled last-mile delivery by using the public transportation network.

4 Risk-aware UAV-UGV Rendezvous with Chance-constrained Markov Decision Process

Guangyao Shi[1], Nare Karapetyan[2], Ahmad Bilal Asghar[2], Jean-Paul Reddinger[3], James Dotterweich[3], James Humann[3], Pratap Tokekar[4], [1]University of Maryland, College Park, MD, [2]University of Maryland, College Park, MD, [3]DEVCOM Army Research Laboratory, College Park, MD, [4]University of Maryland, College Park, MD, Contact: sgyhit@gmail.com

We study a chance-constrained variant of the cooperative aerial-ground vehicle routing problem, in which a UAV with limited battery capacity and a UGV that can also act as a mobile recharging station need to jointly accomplish a mission. Due to the limited battery capacity of the UAV, two vehicles sometimes have to deviate from their task to rendezvous and recharge the UAV. We address the challenge of stochastic energy consumption of the UAV. We are interested in finding the optimal policy that decides when and where to rendezvous such that the expected travel time of the UAV is minimized and the probability of running out of charge is less than tolerance. We formulate this problem as a Chance Constrained Markov Decision Process. The problem is solved by Linnear Programming. We demonstrate the effectiveness of our formulation in a surveillance mission.

Sunday, 11AM–12:15 PM

SB87

JWM - Room 209

Operations Management for Advanced Air Mobility

General Session

Session Chair

Syed Arbab Mohd Shihab, Kent State University, Ames, IA

1 **A Cloud-based Low Altitude Surveillance System for Advanced Air Mobility Operations: Cost-benefit Analysis for the State of Ohio**

Esrat Dulia, Kent State University, Kent, OH

Advanced Air Mobility (AAM) will enable emerging aircraft to operate efficiently in lower altitude airspace in the near future. To detect and track AAM traffic, a Low Altitude Surveillance Information Clearinghouse (LASIC) can serve a vital role as a cloud-based data collection, monitoring, and distribution center, where AAM operators handling different AAM use cases — passenger and cargo transportation, medical delivery etc. — will subscribe to receive relevant AAM traffic data to plan their operations. In this work, we present a framework for the LASIC of Ohio and perform a cost-benefit analysis. The insights gained justify investment in this infrastructure, showing that LASIC will generate revenues from subscriptions for investors and benefit AAM operators and policymakers.

2 **Deepdispatch a Deep Reinforcement Learning-based Vehicle Dispatch Algorithm for Advanced Air Mobility**

Elaheh Sabziyan Varnousfaderani, Kent State University, Kent, OH, Contact: elahe.sabziyan70@gmail.com

Advanced Air Mobility (AAM) is envisioned to use short-range electric aircraft to transport passengers between vertiports. For realizing AAM, new aircraft dispatch models are needed to 1) take into account the unique operational aspects and constraints of AAM and 2) ensure the commercial viability of AAM operations. We address this need by developing a deep reinforcement learning-based dispatch algorithm with a centralized approach to learn the optimal dispatch policy that maximizes operational profit. Real-world datasets of dynamic passenger demand and electricity prices in California have been used to evaluate the performance of the algorithm. The results are expected to show that the algorithm can learn the optimal dispatch policy and outperform our previously developed optimization-based algorithm.

3 **Bird Movement Prediction Using LSTM-RNn to Prevent Bird Strikes with Low Altitude Aircraft**

Syed Arbab Mohd Shihab, Kent State University, Kent, OH, Contact: sshihab@kent.edu

The lower altitudes of the National Airspace System are soon expected to see an increasing number of Advanced Air Mobility aircraft for various operations such as package delivery and passenger transportation. Since most bird strikes with aircraft occur in the low altitude (below 400 feet), minimizing the bird strike risk needs to be considered during flight planning to ensure safe collision-free aircraft operations. To address this problem, a Long Short Term Memory-Recurrent Neural Network (LSTM-RNN) model has been developed for predicting bird movement. A real-world data set of sparrows' movement has been used to evaluate the algorithm. The results suggest that the LSTM-RNN algorithm can provide bird movement forecast with relatively high accuracy.

4 **A Study of Social Equity Strategies in Advanced Air Mobility Development from Industry to Academia**

Christopher J. Johnson[1], Amber Woodburn McNair[2], [1]Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH, Contact: johnson.8067@osu.edu

Advanced Air Mobility (AAM) has the potential to contribute environmental and social benefits within the transportation sector, yet it is not clear how the industry's organizations articulate and understand social equity and social integration. This study implements an online questionnaire to identify trends of convergence and divergence in approaches to social equity and integration. The survey is disseminated to workforce participants in corporate, government, and academic settings, at both junior and senior levels. The results of the study contextualize perceptions of equity strategies and offer insight into how equity ranks against other relevant organizational priorities.

Sunday, 12:30 PM–1:45 PM

SC01

CC - Room 101

Reinforcement Learning in Operations Management

General Session

Session Chair

Zhengyuan Zhou, Stern School of Business, New York University, New York, NY

Session Chair

Boxiao (Beryl) Chen, University of Illinois-Chicago, Chicago, IL

1 **Cooperative Multi-player Bandit Optimization**

Ilai Bistritz, Stanford University, Stanford, CA, Contact: bistritz@stanford.edu

Consider N cooperative players that want to learn the action profile that maximizes their sum of rewards. At every turn, each player chooses an action and receives a reward that is an unknown function of all the players' actions. The players cannot observe the actions or rewards of others, and can only get partial information by communicating with their neighbors. We design a distributed learning algorithm that overcomes the informational bias players have towards maximizing the rewards of nearby players they got more information about. We prove that even if players always take actions based only on a small random subset of the rewards, our algorithm converges with probability 1 to the set of stationary points of (projected) gradient ascent on the sum of rewards function. For a concave sum of rewards, we also prove regret bounds for a game with T turns.

2 **Policy Learning with Adaptively Collected Data**

Ruohan Zhan[1], Zhimei Ren[2], Susan Athey[1], Zhengyuan Zhou[3], [1]Stanford University, Stanford, CA, [2]Chicago University, Chicago, IL, [3]Stern School of Business, New York University, New York, NY, Contact: rhzhan@stanford.edu

Learning optimal policies from historical data enables the gains from personalization in a wide variety of applications. The growing policy learning literature focuses on a setting where the treatment assignment policy does not adapt to the data. However, adaptive data collection is becoming more common in practice due to its abilities to improve inferential efficiency and evolve operations to improve performance over time (e.g. contextual bandits). In this talk, we address the challenge of learning the optimal policy with adaptively collected data. We propose an algorithm based on generalized augmented inverse propensity weighted estimators and establish its finite-sample regret bound. We further complement this regret upper bound with a lower bound, which characterizes the fundamental difficulty of policy learning with adaptive data.

3 **Regret Bounds of Cooperative Thompson Sampling**

Yan Chen, Duke University, Durham, NC, Contact: yan.chen@duke.edu

We consider the cooperative RL problem where n agents cooperatively learn to make decisions by sharing data with each other. Existing works in this area have empirically shown that Thompson sampling algorithms provide an attractive alternative for inducing cooperation. But no regret bound is known on any such algorithms. We fill this gap by considering two cases. We first study the finite-horizon episodic regret setting, where each agent samples from the joint posterior at the beginning of each episode. We then show a $\tilde{O}(HS\sqrt{\frac{AT}{n}})$ per-agent regret, where H is the horizon of the episode, S is the number of states, A is the number of actions, T is the number of episodes and n is the number of agents. The per-agent regret decreases at a rate of $O(\frac{1}{\sqrt{n}})$. This regret bound further improves to $\tilde{O}(H\sqrt{\frac{SAT}{n}})$

4 **Optimal No-regret Learning in Repeated First-price Auctions**

Zhengyuan Zhou, Stern School of Business, New York University

First-price auctions have very recently swept the online advertising industry, replacing second-price auctions as the predominant auction mechanism on many platforms for display ads bidding. This shift has brought forth important challenges for a bidder: how should one bid in a first-price auction, where unlike in second-price auctions, it is no longer optimal to bid one's private value truthfully and hard to know the others' bidding behaviors? In this paper, we take an online learning angle and address the fundamental problem of learning to bid in repeated first-price auctions. We discuss our recent work in leveraging the special structures of the first-price auctions to design minimax optimal no-regret bidding algorithms.

Sunday, 12:30 PM–1:45 PM

SC02

CC - Room 102

Causal Inference and Data-driven Decision Making

General Session

Session Chair

Zhengling Qi, The George Washington University, Potomac, MD

1 **Fairness-oriented Learning for Optimal Individualized Treatment Rules**

Lan Wang, University of Miami, Key Biscayne, FL

A notable drawback of the standard approach to optimal individualized treatment rule (ITR) estimation is that the estimated optimal ITR may be suboptimal or even detrimental to certain disadvantaged subpopulations. Motivated by the importance of incorporating an appropriate fairness constraint in optimal decision making (e.g., assign treatment with protection to those with shorter survival time), we propose a new framework that aims to estimate an optimal ITR to maximize the average value with the guarantee that its tail performance exceeds a prespecified threshold. The optimal fairness-oriented ITR corresponds to a solution of a nonconvex optimization problem. Furthermore, we extend the proposed method to dynamic optimal ITRs. (Joint work by Ethan Fang, Zhaoran Wang and Lan Wang)

2 Distribution-Invariant Differential Privacy

Xuan Bi, Xiaotong Shen, University of Minnesota, Minneapolis, MN

Differential privacy is becoming one gold standard for protecting the privacy of publicly shared data. It has been widely used in social science, public health, information technology, and the U.S. decennial census. Nevertheless, to guarantee differential privacy, existing methods may unavoidably alter the conclusion of the original data analysis, as privatization often changes the sample distribution. This phenomenon is known as the trade-off between privacy protection and statistical accuracy. In this work, we mitigate this trade-off by developing a distribution-invariant privatization method to reconcile both high statistical accuracy and strict differential privacy. As a result, any downstream statistical or machine learning task yields essentially the same conclusion as if one used the original data. Superior performance is shown on three benchmarks.

3 A Proximal Temporal Consistency Learning Approach for Infinite Horizon Dynamic Treatment Regimes

Ruoqing Zhu, University of Illinois Urbana Champaign, Champaign, IL, Contact: rqzhu@illinois.edu

Many mHealth applications involve a large number of intervention options and under an infinite time horizon setting where the number of decision stages diverges to infinity. In addition, temporary medication shortages may cause optimal treatments to be unavailable, while it is unclear what alternatives can be used. We propose a Proximal Temporal consistency Learning (pT-Learning) framework to estimate an optimal regime that is adaptively adjusted between deterministic and stochastic sparse policy models. The resulting minimax estimator avoids the double sampling issue in the existing algorithms. It can be further simplified and can easily incorporate off-policy data without mismatched distribution corrections. We study the theoretical properties of the sparse policy and establish finite-sample bounds on the excess risk and performance error.

4 Demystifying (Deep) Reinforcement Learning with Optimism and Pessimism

Zhaoran Wang, Northwestern University, Evanston, IL

Coupled with powerful function approximators such as deep neural networks, reinforcement learning (RL) achieves tremendous empirical successes. However, its theoretical understandings lag behind. In particular, it remains unclear how to provably attain the optimal policy with a finite regret or sample complexity. In this talk, we will present the two sides of the same coin, which demonstrates an intriguing duality between optimism and pessimism.
- In the online setting, we aim to learn the optimal policy by actively interacting with the environment. To strike a balance between exploration and exploitation, we propose an optimistic least-squares value iteration algorithm, which achieves a \sqrt{T} regret in the presence of linear, kernel, and neural function approximators.
- In the offline setting, we aim to learn the optimal policy based on a dataset collected a priori. Due to a lack of active interactions with the environment, we suffer from the insufficient coverage of the dataset. To maximally exploit the dataset, we propose a pessimistic least-squares value iteration algorithm, which achieves a minimax-optimal sample complexity.

Sunday, 12:30 PM–1:45 PM

SC03

CC - Room 103

Data Mining Paper Competition I

Award Session

Session Chair

Ying Lin, University of Houston, Houston, TX

Session Chair

Young Woong Park, Iowa State University, Ames, IA

1 Conjecturing-Based Discovery of Patterns in Data

Paul Brooks[1], David Edwards[1], Craig E. Larson[1], Nico Van Cleemput[2], [1]Virginia Commonwealth University, Richmond, VA, [2]Virginia Commonwealth University, Ghent, Belgium.

We propose the use of a conjecturing machine that generates feature relationships in the form of bounds involving nonlinear terms for numerical features and boolean expressions for categorical features. The proposed Conjecturing framework recovers known nonlinear and boolean relationships among features from data. In both settings, true underlying relationships are revealed. The framework is applied to patient-level data regarding COVID-19 outcomes to suggest possible risk factors that are confirmed in medical literature.

2 Learning Product Rankings Robust to Fake Users

Negin Golrezaei[1], Vahideh Manshadi[2], Shreyas Sekar[3], Jon Schneider[4], [1]Massachusetts Institute of Technology, Lexington, MA, [2]Yale School of Management, New Haven, CT, [3]University of Toronto, Toronto, ON, Canada; [4]Google Research, New York, NY

In many online platforms, customers' decisions are influenced by product rankings. This incentivizes sellers to artificially inflate their position by employing fake users. Motivated by such fraudulent behavior, we study the problem of learning product rankings when a platform faces a mixture of real and fake users who are indistinguishable from each other. We show that many popular learning algorithms are sub-optimal under manipulation. To overcome this, we develop efficient learning algorithms that converge to the optimal ranking, while being robust to the aforementioned fraudulent behavior. Our results indicate that platforms can effectively combat fraud even when they are oblivious to the number and identity of the fake users.

3 Generalized Regret Analysis of Thompson Sampling using Fractional Posteriors

Prateek Jaiswal, Debdeep Pati, Anirban Bhattacharya, Bani Mallick, Texas A&M University, College Station, TX

Thompson sampling (TS) is one of the most popular and earliest algorithms to solve stochastic multi-armed bandit problems. We consider a variant of TS, named ⍰-TS, where we use a fractional or ⍰-posterior (⍰ (0,1)) instead of the standard posterior distribution. For ⍰-TS we compute near-optimal problem-dependent and problem-independent frequentist regret bounds for general prior and reward distributions (with bounded support). Our key contribution is to deliver the near-optimal frequentist regret bounds under a very mild regularity condition on the prior distribution that only requires the prior to place positive mass in an appropriate Rényi neighborhood of the true reward distribution. Moreover, our analysis does not require additional structural properties such as closed-form posteriors or conjugate priors.

4 Improving Human Decision-Making with Machine Learning

Hamsa Bastani[1], Osbert Sinchaisri[1], Park Sinchaisri[2], [1]University of Pennsylvania, Philadelphia, PA, [2]University of California, Berkeley, Berkeley, CA

Focusing on sequential decision-making, we design a novel machine learning algorithm that is capable of extracting "best practices" from trace data and conveying its insights to humans in the form of interpretable "tips". Our algorithm selects the tip that best bridges the gap between the actions taken by humans and those taken by the optimal policy. We evaluate our approach through a series of randomized controlled experiments where participants manage a virtual kitchen. Our experiments show that the tips generated by our algorithm can significantly improve human performance relative to intuitive baselines. In addition, we discuss a number of empirical insights that can help inform the design of algorithms intended for human-AI interfaces.

Sunday, 12:30 PM–1:45 PM

SC04

CC - Room 104

Subpopulation Study in Information Retrieval

General Session

Session Chair

Yuting Ye, [1</sup]

1 Device-Cloud Collaborative Learning for Recommendation Personalization

Jiangchao Yao, Shanghai Jiao Tong University, Shanghai, China. Contact: Sunarker@sjtu.edu.cn

With the rapid development of storage and computing power on mobile devices, it becomes critical and popular to deploy models on devices to save onerous communication latencies and to capture real-time features. We are among the first attempts to study the Device-Cloud Collaborative Learning (DCCL) framework. Specifically, in DCCL, a novel MetaPatch learning approach on the device side can efficiently achieve "thousands of people with thousands of models" given a centralized cloud model. Then, with billions of updated personalized device models, we propose a "model-over-models" distillation algorithm, namely MoMoDistill, to update the centralized cloud model. Our extensive experiments over a range of datasets with different settings demonstrate the effectiveness of such collaboration, especially its superiority to model long-tailed users.

2 Whole Page Optimization on Amazon Search Page

Wenyang Liu, 1</sup

The Amazon Search page is the primary gateway for customers to search, refine, and explore the large collection of content that Amazon offers. There are various components and content types on the Search page, such as lists of products and widgets of different types (e.g., video, recommendation, and navigation). How to best optimize and display those components holistically remains challenging, especially when accounting for each customer's shopping journey. This talk gives an overview of how Amazon Search tackles this whole page optimization problem, leveraging multi-arm bandits, multi-variate testing, deep learning, and reinforcement learning.

3 Modeling for Data Heterogeneity in Page Layout Optimization for E-commerce

Pratik Lahiri, Amazon, Seattle, WA

The search page of an e-commerce website enables customers to find and discover products with ease and confidence by addressing durable customer needs. Determining the optimal layout for the search results page promotes ease and confidence of shopping for customers at various stages of their shopping journey. The preferred page layout may differ by device, shopping category, and customer profile. In this talk, we will share our learning on how we tackle this problem by modeling the various sub-populations in our data and balancing bias-variance tradeoffs.

Sunday, 12:30 PM–1:45 PM

SC05

CC - Room 105

Spatial-temporal Data Analysis for Decision-making

General Session

Session Chair

Cheng-Bang Chen, University of Miami, Miami, FL

Session Chair

Shenghan Guo, Arizona State University, Gilbert, AZ

1 Wind Turbine Faults Detection and Diagnosis on a Novel Network-based Deep Recurrence Analysis

Bo Peng[1], Cheng-Bang Chen[2], [1]University of Miami, Miami, FL, [2]University of Miami, Miami, FL, Contact: bxp547@miami.edu

Wind energy is a vital energy source for the power grid. Robust maintenance of wind turbines (WTs) to avoid unexpected breakdowns is prominent to ensure energy resilience. Due to the chaotic weather, the wear of WTs is highly dynamic. It remains a challenge to identify WT faults from the sensory data accurately. This research proposed a novel framework, utilizing the subtle recurrence characteristics of WT, to tackle this issue. We first develop a heterogeneous recurrence network (HRN) to capture the sophisticated dynamics from the sensory data. Then, we established a deep neural network to diagnose WT faults from the corresponding HRN. The experimental study shows that our proposed framework outperforms the current state-of-art methods.

2 Robust Interpretation for Covid-19 Diagnosis Using Vision Transformer

Chen Zhou[1], Soundar Kumara[2], [1]Pennsylvania State University, State College, PA, [2]Pennsylvania State University, University Park, PA, Contact: cbz5148@psu.edu

This work presents a novel mask-based training method for Vision This work presents a novel mask-based training method for Vision Transformer (ViT) on chest X-ray classification. While ViT uses an extra trainable token to capture the global information of image patch tokens, we believe it misses the rich local information contained in the patch tokens. In this work, we investigate how these token features can be leveraged to improve the ViT performance by introducing the lung masks as supervision. Our method is straightforward: we calculate the loss of patch token embeddings and the ground truth masks and aggregate it to the original classification loss, e.g., we pose a strong regularization on the loss function and force the model to pay attention to the interesting areas. We show the proposed method can consistently and robustly improve the ViT performance on chest X-ray data.

3 Deep Thermal Fusion Network Methodology for Surface Deformation Detection in Additive Manufacturing

Christian Zamiela[1], Linkan Bian[2], [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Mississippi State University, MS, Contact: cez39@msstate.edu

The objective is to develop a data fusion network methodology for deformation detection using multi-sensor thermal data. A core problem with additive manufacturing (AM) is abnormalities that commonly occur due to rapid changes in the thermal gradient. Different non-destructive in-situ thermal sensors monitor the build process but are limited by small temperature ranges and sensor field of view of the fabrication process. Various sensors are employed to mitigate problems with lost thermal gradient information, but it brings forth challenges with combining data. We develop a deep thermal fusion methodology that fills the gap in combining multiple sensors and characterizing surface deformation. Rapid thermal gradient formation and identification of deformation is a key step toward using thermal gradient data and machine learning to improve quality control in AM.

4 Clustering of Multi-channel Sequential Data Using Advanced Heterogeneous Recurrence Analysis

Cheng-Bang Chen, University of Miami, Miami, FL, Contact: cxc1920@miami.edu

Recurrence is a core property of dynamic systems. Literature indicates that Recurrence Analysis (RA) is an effective tool for characterizing complex systems. However, the conventional RA treats the recurrences homogeneously, which raises issues in clustering similar recurrence patterns in diverse states. This research presents a novel approach utilizing advanced heterogeneous recurrence analysis (HRA) to cluster multi-channel sequential data to resolve the issues. We first leverage the state-space to delineate the transitions of multi-channel sequential data. Then, we characterize the subtle dynamic characteristics of each instance with the proposed HRA. Finally, the instances are clustered through the weighted dynamic characteristics. Experimental results show that our methods can effectively cluster the multi-channel sequential data.

Sunday, 12:30 PM–1:45 PM

SC06

CC - Room 106

Sequential Decision-making in Healthcare

General Session

Session Chair

Sadjad Anzabi Zadeh, University of Iowa, Coralville, IA

1 Personalized Breast Cancer Treatment Decision Modeling Considering Patient Preferences

Ahla Ko[1], Shengfan Zhang[1], Raha Akhavan-Tabatabaei[2], Juan David Bolivar[3], [1]University of Arkansas, Fayetteville, AR, [2]Sabanci University, Istanbul, Turkey; [3]Uber, Bogota, Colombia. Contact: ahlako@uark.edu

Health-related quality of life has been an important indicator to the continuation and maintenance treatments. While patients often choose an aggressive therapy with reduced recurrence and mortality disregarding potential late toxicity and complication, they may experience long-term adverse effects or chronic conditions that negatively affect their quality of life. In breast cancer treatment, there are numerous treatment modalities with different side effects, which vary by patient age, cancer type, and cancer stage. We develop a dynamic decision model for the personalized optimal breast cancer treatment that consider not only the improved survival of the patient but also a quantitative measure of personal preferences. The effect of delayed treatment has also been investigated to maximize the quality of life in the case of initial cancer stage or older patients.

2 An Algorithm to Determine Treatment Timing in Mobile Health: Design and Evaluation

Xiang Meng, Harvard University, Cambridge, MA

HeartSteps V2 and V3 are micro-randomized trials (MRTs) that aim to increase physical activity in individuals with stage 1 hypertension. When sedentary, participants were repeatedly randomized to receive either an anti-sedentary message or not five minutes. The sampling algorithm in the MRT has two goals: 1. deliver an average of 1.5 messages and 2. produce randomization probabilities that are uniform over a user's sedentary times. We evaluate the algorithm by asking: 1. Does it meet the target of 1.5 interventions per day? 2. Is the randomization probability uniform enough? The sampling algorithm does well in general. Analysis of mean and median shows it achieves the goal of 1.5 interventions per day and its average KL divergence outperforms that of a common baseline algorithm.

3 Optimal Dosing of Warfarin Using Policy Gradient Methods

Sadjad Anzabi Zadeh[1], Nick Street[2], Barrett Thomas[2], [1]University of Iowa, Iowa City, IA, [2]University of Iowa, Iowa City, IA

Warfarin is a widely used anticoagulant with high variability in patient response and narrow therapeutic range. We showed in our previous work how Deep Q-learning can be utilized to produce effective dosing protocols. To produce a more interpretable and explainable dosing protocol for warfarin, in this work, we present our results on how policy gradient algorithms can be used in this context.

4 Test-retest and Quarantining Policies: A POMDP Approach

Zack Zhu, Steven Shechter, Woonghee Tim Huh, University of British Columbia, Vancouver, BC, Canada. Contact:

ziqian.zhu@sauder.ubc.ca
Motivated by recent debates on Covid quarantining policies, we model test-retest and quarantining policies as a partially observable Markov decision process. Costs include testing, quarantining, and spreading the virus, while the state of Covid (truly "positive" or "negative") is partially observable. Daily decisions involve whether to test and/or quarantine. We derive structural results of the optimal cost function and optimal testing/quarantining policy under different modelling assumptions. We discuss how individuals, workplaces, and governments may differ in their preferred policies.

Sunday, 12:30 PM–1:45 PM

SC07

CC - Room 107

Machine Learning Applications Involving Data with Complex Structure

General Session

Session Chair

Chen Kan, University of Texas at Arlington, Arlington, TX

1 **Bridging Vacuum Ultraviolet Spectra and Chemical Compound Structures with Machine Learning**

Yujing Yang[1], Kevin A. Schug[1], Victoria C. P. Chen[1], Chen Kan[2], [1]The University of Texas at Arlington, Arlington, TX, [2]University of Texas-Arlington, Arlington, TX, Contact: yxy9663@mavs.uta.edu

Vacuum ultraviolet (VUV) spectra are closely related to chemical compound structures and have been increasingly used for compound identification and differentiation. It is of great interest to predict the VUV spectrum from a given compound or determine the compound structure from the VUV spectrum. Achieving this using conventional regression methods, nevertheless, is hindered due to the data complexity. This study develops a new representation learning framework to fill the gap, which 1) extracts features from compound structures using a graph-based approach; 2) depicts the morphology of VUV spectra with shapelets learning; and 3) connects graph features with shapelets with a convolutional neural network. The framework is evaluated with Aromatic and Olefin compounds and their VUV spectra. Results have demonstrated the effectiveness of the developed framework.

2 **Lasso Based State Transition Modeling with Interactions in Adaptive Interdisciplinary Pain Management**

Amith Viswanatha[1], Victoria C. P. Chen[2], Jay Michael Rosenberger[1], [1]University of Texas-Arlington, Arlington, TX, [2]The University of Texas at Arlington, Arlington, TX, Contact: amith.viswanatha@mavs.uta.edu

The UT Southwestern Medical Center has an interdisciplinary chronic pain management program modeled as a two-stage adaptive treatment decision problem. In an adaptive setting, the causal treatment estimates are biased due to time-varying confounding and Inverse Probability of Treatment Weighting (IPTW) is one technique to address this issue. In this study, we address the challenge of modeling state-treatment interactions that are critical to enable personalized treatment for individual patients. It is important for the modeling method to identify the causal features and interactions. A LASSO based method named HierNet is combined with IPTW to build models that enable feature selection and modeling of interaction effects in the presence of time-varying confounding. The proposed approach is studied using a simulated case study structured on the Medical Center data.

3 **Classification for Predicting Recidivism in Criminal Justice**

Shirish Rao[1], Khan Md Ariful Haque[2], Bahar Nasirian[3], Victoria C. P. Chen[3], [1]EDP Renewables North America, Houston, TX, [2]Washington State University, Pullman, WA, [3]The University of Texas at Arlington, Arlington, TX, Contact: khanmdariful.haque@wsu.edu

In criminal justice, recidivism refers to individuals that are perpetual repeat offenders. These individuals are a small set of criminals that are costly to the policing system. An ability to predict recidivism would enable law enforcement to develop strategies that break the cycle of recidivism. In the Summer of 2021, the National Institute of Justice posted a Recidivism Forecasting Challenge. Two years of data from the State of Georgia and two performance metrics, Brier score and fair and accurate, are used. The data involved a mix of both qualitative and quantitative input variables with potentially complex relationships with the probability of recidivism. In this talk, a new classification model is presented to address this data challenge.

Sunday, 12:30 PM–1:45 PM

SC08

CC - Room 108

Statistical Machine Learning for Econometrics and Business Analytics

General Session

Session Chair

Artem Prokhorov, [1</sup]

1 Forecasting Financial Risk Using Generalized Quantile Random Forests

Robert James[1], Jessica Wai Yin Leung[2], [1]University of Sydney, Sydney, Australia; [2]Monash University, Melbourne, Australia. Contact: r.james@sydney.edu.au

This paper studies various approaches to forecast Value-at-Risk and Expected Shortfall using Generalized Random Forests. The method naturally allows for a large set of economic and financial covariates to interact non-linearly to predict financial risk. We discuss the steps associated with implementing our approach and document the forecasting performance during periods of relatively low volatility and during periods of financial distress. Finally, we outline which covariates are the most important for financial risk forecasting.

2 Sparse Frequency Severity Model Estimation and Its Applications to the Insurance Industry

Jessica Wai Yin Leung[1], Dmytro Matsypura[2], [1]Monash University, Melbourne, Australia; [2]The University of Sydney, Sydney, Australia.

We study the problem of sparse model estimation in the context of the frequency severity model. Using Fenchel duality, we present a mixed integer approach with an outer approximation algorithm to estimate the sparse frequency severity model. A preliminary comparative study shows that the performance of our method is comparable to other state-of-the-art methods within a reasonable time frame.

3 An Online Convex Optimization-based Framework for Convex Bilevel Optimization

Lingqing Shen[1], Nam Ho-Nguyen[2], Fatma Kilinc-Karzan[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of Sydney, Sydney, Australia.

We propose a new framework for solving convex bilevel optimization, where one optimizes a convex objective over the optimal solutions of another convex optimization problem. We develop two online convex optimization (OCO) algorithms, one which works under minimal convexity assumptions, and the other equipped to exploit structural information on the objective function, including smoothness, lack of first-order smoothness, and strong convexity. We then adapt the OCO algorithms to convex bilevel optimization, leading to rates of convergence in terms of both inner and outer objective functions simultaneously. We illustrate the numerical efficacy of our algorithms on standard linear inverse problems and a large-scale text classification problem.

4 Presenter

Bradley Rava[1,2], [1]University of Sydney Business School, Sydney, Australia; [2]University of Sydney, Sydney, Australia. Contact: bradley.rava@sydney.edu.au

We study fairness in classification, where one wishes to make automated decisions for people from different protected groups. When individuals are classified, the decision errors can be unfairly concentrated in certain protected groups. We develop a fairness-adjusted selective inference (FASI) framework and data-driven algorithms that achieve statistical parity in the sense that the false selection rate (FSR) is controlled and equalized among protected groups. The FASI algorithm operates by converting the outputs from black-box classifiers to R-values, which are intuitively appealing and easy to compute. Selection rules based on R-values are provably valid for FSR control, and avoid disparate impacts on protected groups. The effectiveness of FASI is demonstrated through both simulated and real data.

Sunday, 12:30 PM–1:45 PM

SC09

CC - Room 109

Data Mining Flash Session III

Flash Session

Session Chair

Zhuqi Miao, SUNY-New Paltz, New Paltz, NY

1 Matrix Auto-regressive Model with Vector Time-series Covariates

Hu Sun, University of Michigan, Ann Arborg, MI

In this talk, we propose a novel model to forecast a spatio-temporal process based on historical matrix-valued time-series and auxiliary vector-valued time-series data. In our model, a future matrix is jointly predicted by the historical data under a partially linear auto-regressive framework. The high-dimensional matrix-valued coefficients are assumed to possess low intrinsic dimensions and are related with the observed matrices in a bilinear form. The vector-valued time-series predictors, typically of low intrinsic dimensions, are involved through a set of matrix basis functions. Model estimation is discussed and validated with various simulation studies. A real data application on forecasting the spatio-temporal process of a geophysics dataset is presented. Extensions of the model to a semi-parametric setting is also discussed.

2 Operationalizing Responsible AI in Large-scale Organizations

Kinjal Basu, LinkedIn Corporation, Austin, TX

Most large-scale organizations face challenges while scaling their infrastructure to support multiple teams across multiple product domains. Due to the differences in the products, the broad use of Responsible AI techniques is a serious challenge. From different definitions of "fairness" to very different measurement and mitigation solutions, it is tough to build a generalized scalable system to measure and mitigate the unintended consequences of AI models. In this talk, we'll showcase how we can operationalize Responsible AI in large-scale organizations.

3 Detecting Power Outage status in Online News Archives using NLP

Seungho Woo[1], Roshanak Nateghi[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, Lafayette, IN

In the United States, numerous numbers of counties or cities struggle with the power outage. How do we identify which region needs to reform the transmission network? We focus on the regional online news which stores historical power outage event news. A large unstructured amount of news textual big data needs to be filtered and processed by data mining techniques. The historical power outage event information such as date, location, reported time, outage duration, affected residents, and damages were extracted by the Natural Language Processing technique. In this paper, automatic text extraction was performed in online news sources to detect the power outage events and visualize the information.

4 Statistical Inference for Low Rank Matrix Regression with Adaptively Collected Data

Qiyu Han, Yichen Zhang, Wei Sun, Purdue University, West Lafayette, IN, Contact: han541@purdue.edu

Low-rank matrix recovery through matrix regression has been widely studied in the last decades. The statistical inference of the estimation based on offline data is also explored in recent years. In this article, we conduct the statistical inference of the low-rank estimator that can be obtained in a fully online fashion. In particular, we use the adaptively collected data to construct an estimator, where such construction involves the de-biasing of the typical low-rank estimator. This de-biasing procedure uses the samples adaptively collected through the online decision-making under the linear contextual bandit framework with the reward given by the trace regression model.

5 A Unified Complexity Metric for Nonconvex Matrix Completion and Matrix Sensing in the Rank-one Case

Haixiang Zhang[1], Baturalp Yalcin[2], Javad Lavaei[2], Somayeh Sojoudi[3], [1]UC Berkeley, Fremont, CA, [2]University of California, Berkeley, Berkeley, CA, [3]University of California, Berkeley, El Cerrito, CA

We develop a new complexity metric for an important class of low-rank matrix optimization problems, where the metric aims to quantify the complexity of th nonconvex optimization landscape and the success of local search methods. The existing literature has focused on two complexity measures, namely the RIP constant and the sampling rate in terms of the incoherence. The proposed complexity metric has the potential to unify these two notions and applies to a much larger class of problems. We illustrate the usefulness of the new complexity metric from three aspects, and we establish theoretical results to provid conditions on the existence of spurious solutions in terms of the proposed complexity metric.

6 A Generalized Formulation for Group Selection via ADMM

Chengyu Ke[1], Sunyoung Shin[2], Yifei Lou[2], Miju Ahn[3], [1]Southern Methodist University, Dallas, TX, [2]The University of Texas at Dallas, Richardson, TX, [3]Southern Methodist University, Dallas, TX, Contact: cke@smu.edu

This paper studies a statistical learning model where the model coefficients have a pre-determined non-overlapping group sparsity structure. We analyze the directional stationary solution of the proposed formulation, obtaining a sufficient condition for the stationary solution to achieve optimality and establishing a bound of the distance from the solution to a reference point that is related to the ground-truth from a probabilistic interpretation. Also, we develop an efficient algorithm that adopts an alternating direction method of multiplier (ADMM), showing that the iterates converge to a directional stationary solution under certain conditions.

7 Carbon Sequestration for Sustainable Urban Environments

Levente Klein, IBM, Yorktown Heights, NY

Nature-based carbon sequestration is one of the most straightforward ways to sequester and to store carbon from the atmosphere. Urban forests hold the promise of optimized carbon storage and temperature reduction in cities. Remote sensing imagery in combination with image processing techniques can identify individual tree location and their sizes, classify trees based on their species, and track tree health. While standard machine learning models like Random Forest and Support Vector Machine can achieve accuracy of 80% in separating trees from other land cover classes, additional deep learning models using noisy labeled data can further improve tree identification maps. We demonstrate such an approach by quantifying the carbon sequestration and urban heat island mitigation for New York City and Dallas.

8 FinRL-Meta: Open-Source Financial Reinforcement Learning

Xiao-Yang Liu, Columbia University, New York City, NY, Contact: xl2427@columbia.edu

FinRL is the first open-source framework to demonstrate the great potential of financial reinforcement learning. It has evolved into an ecosystem, FinRL-Meta, which is a playground for financial reinforcement learning. We believe FinRL-Meta will reshape our financial lives and our open-source community will make sure it's for the better.

9 The Implementation Path of Search Engine Optimization Driven by Double Factors: Taking Brand Keyword Search as an Example

Zuguo Cai, Lili Fan, Southwest Jiaotong University, Chengdu, China. Contact: caizuguo@yeah.net

This article constructs a ranking model for different types of search result lists containing the same sellers, examines the impact of search engine ranking results on sellers' revenue and consumer welfare. Then we explore the mechanism of whether the implementation of search engine optimization affects the ranking equilibrium. Moreover the motivations and effects of SEO implementation are analyzed, so as to provide management enlightenment and policy recommendations for improving the retrieval efficiency and welfare of consumers. The research finds that from brand keywords without SEO, only the sorting of sponsored search result lists is in line with consumers' search willingness, while the ranking of organic search result lists is inverse to consumers' search willingness.

10 Atomic Clique: A Novel Network Model to Analyze Comorbidity Progression

Parisa Sahraeian, Zhuqi Miao, Yajun Lu, Baski Balasundaram, Oklahoma State University, Stillwater, OK

Detection of comorbidity progression is an invaluable decision aid and a prominent challenge in healthcare research and practice. Comorbidity progression can be modeled as temporal disease networks (TDNs). The objective of this study is to detect comorbidity progression patterns among TDNs. In this regard, a new network model, Atomic Clique, and an associated optimization problem, Maximum Atomic Clique problem, were proposed. To deal with the large-scale instances, two main approaches, extended formulation for the maximum atomic clique problem and reduction from the maximum atomic clique problem to the maximum clique problem were developed.

Sunday, 12:30 PM–1:45 PM

SC10

CC - Room 110

Safety and Robustness in Machine Learning

General Session

Session Chair

Brendon Anderson, University of California-Berkeley, Oakland, CA

Session Chair

Sam Pfrommer, 1</sup

Session Chair

Somayeh Sojoudi, University of California, Berkeley, El Cerrito, CA

1 Learning Under Robustness Constraints

Luiz F. O. Chamon[1], Alex Robey[2], George J. Pappas[2], Hamed Hassani[3], Alejandro Ribeiro[2], [1]University of California, Berkeley, Berkeley, CA, [2]University of Pennsylvania, Philadelphia, PA, [3]University of Pennsylvania, Philadelphia, PA

While adversarial training methods has been shown to mitigate the fragility of deep learning models to input perturbations, they are increasingly application-dependent, heuristic in nature, and suffer from trade-offs between nominal performance and robustness. Moreover, the problem of finding worst-case perturbations is non-convex and underparameterized, engendering a non-favorable optimization landscape. Thus, there is a gap between the theory and practice of adversarial training, particularly as to when and why it works. In this talk, we take a constrained learning approach to these questions leveraging semi-infinite optimization and non-convex duality to show that adversarial training is equivalent to a statistical problem over a perturbation distribution and develop a hybrid Langevin method to obtain state-of-the-art results on MNIST and CIFAR-10.

2 Safe Feedback Motion Planning with Learned Dynamics Models

Glen Chou, University of Michigan, Ann Arbor, MI, Contact: gchou@umich.edu

Trustworthy robots must be able to complete tasks safely and reliably. While traditional motion planners can achieve this if the robot's dynamics are carefully modeled a priori, these guarantees fall apart in unstructured settings, where robots need data to refine their models. Deep learning provides a means to obtain dynamics models from data, but blindly trusting these potentially unreliable models when planning can cause unsafe behavior. In this talk, I will present our work in determining where learned models can be trusted for reliable motion planning, and to what extent. Using this information and tools from contraction theory, we plan trajectories with the learned model that can be safely tracked on the true system, with provable guarantees. We show that our theory translates to empirical success in controlling a variety of high-dimensional, underactuated systems.

3 Revisiting Hilbert-Schmidt Information Bottleneck for Adversarial Robustness

Zifeng Wang, Northeastern University, Boston, MA, Contact: zifengwang@ece.neu.edu

We investigate the HSIC (Hilbert-Schmidt independence criterion) bottleneck as a regularizer (HBaR) for learning an adversarially robust deep neural network classifier. In addition to the usual cross-entropy loss, we add regularization terms for every intermediate layer to ensure that the latent representations retain useful information for output prediction while reducing redundant information. We show that the HSIC bottleneck enhances robustness to adversarial attacks both theoretically and experimentally. In particular, we prove that the HBaR reduces the sensitivity of the classifier to adversarial examples. Our experiments on benchmark datasets and architectures demonstrate that incorporating HBaR attains competitive natural accuracy and improves adversarial robustness, both with and without adversarial examples during training.

4 Certified Robustness via Locally Biased Randomized Smoothing

Brendon Anderson[1], Somayeh Sojoudi[2], [1]University of California, Berkeley, Oakland, CA, [2]University of California, Berkeley, El Cerrito, CA

Randomized smoothing remains one of the state-of-the-art methods for robustification with theoretical guarantees. We show that using uniform and unbiased smoothing measures, as is standard in the literature, relies on the underlying assumption that smooth decision boundaries yield good robustness, which manifests into a robustness-accuracy tradeoff. We generalize the smoothing framework to remove this assumption and learn a locally optimal robustification of the decision boundary based on training data, a method we term locally biased randomized smoothing. We prove nontrivial closed-form certified robust radii for the resulting model, avoiding Monte Carlo certifications as used by other smoothing methods. Experiments on synthetic, MNIST, and CIFAR-10 data show a notable increase in the certified radii and accuracy over conventional smoothing.

Sunday, 12:30 PM–1:45 PM

SC11

CC - Room 111

Applied Artificial Intelligence for Markets

General Session

Session Chair

Meizi Zhou, University of Minnesota, Minneapolis

1 "I Want to Know More!": Measuring the Impact of Consumer Curiosity in Recommender System

Pan Li, Alexander Tuzhilin, New York University, New York, NY, Contact: pli2@stern.nyu.edu

Curiosity constitutes an important factor in consumer decision-making in marketing applications. However, it has yet to be systematically studied in recommender systems. In this paper, based on the information gap theory, we present a measurement framework to quantify the level of curiosity triggered by each product, and we conduct a lab experiment to demonstrate its validity. We then propose a curiosity-aware recommendation framework by incorporating the curiosity levels into the utility function. Offline experiments show that our model significantly outperforms state-of-the-art relevance-oriented baselines, illustrating the importance of modeling curiosity in recommendations. We also conduct a large-scale online experiment at Alibaba, where our model significantly outperforms the latest production system by 25% across multiple business metrics.

2 Operation Dumbo Drop: To Airdrop or Not to Airdrop for Initial Coin Offering Success?

Jian Li[1], Xiang Wan[2], Kenny Cheng[2], Xi Zhao[1], [1]Xi'an Jiaotong University, Xi'an, China; [2]University of Florida, Gainesville, FL, Contact: xiang.wan@ufl.edu

To investigate the efficacy of token airdrop for Initial Coin Offerings (ICOs) success, we implement a regression discontinuity design by leveraging the quasi-randomization of a blockchain project's promotional airdrop campaign on the Ethereum platform. We find that the promotional airdrop leads to a 2.3 times increase of the potential investors' ICO investment probability. We further find that the airdrop is more effective in increasing the investment probability for individuals whose personality traits are dissimilar to the blockchain project than those similar to the project. Our study contributes to the literature of ICOs and provides important and useful managerial implications to blockchain companies.

3 Advertising as Information for Ranking E-commerce Search Listings

Xi Xiong[1], Navdeep Sahni[2], Joonhyuk Yang[3], Harikesh Nair[4], [1]JD.com american technologies copro, MOUNTAIN VIEW, CA, [2]Stanford University, Stanford, CA, [3]University of Notre Dame, Notre Dame, IN, [4]Stanford University, Stanford, CA, Contact: xiongxi9@gmail.com

Search engines and e-commerce platforms have substantial difficulty exposing new products to their users on account of an information problem: new products typically do not have user-engagement that enables platforms to reliably assess product quality. This paper evaluates the role of advertising in providing information to the platform regarding new product quality so as to solve this ''cold-start'' problem and engineer higher quality organic listings. Using a large-scale experiment implemented at JD.com---a large e-commerce platform in China---we show that using ad propensity information for ranking new products benefits both the platform and consumers, in the short run. Our findings showcase a new channel by which advertising can potentially improve user experience, through incorporating information to predict the quality of new products

Sunday, 12:30 PM–1:45 PM

SC12

CC - Room 113

Machine Learning in Healthcare

Contributed Session

Session Chair

Mahsa Khosravi, Iowa state university, Ames, IA

1 Mapping Feedback Mechanisms Contributing to Dental Caries in Adolescents

Fatemeh Sadjadpour[1], Niyousha Hosseinichimeh[2], Bhavna Pahel[3], Sara Metcalf[4], [1]Virginia polytechnic institute and state university, Blacksburg, VA, [2]Virginia polytechnic institute and state university, Falls Church, VA, [3]University of North Carolina, Chapel Hill, NC, [4]The State University of New York at Buffalo, Buffalo, NY, Contact: fsadjadpour@vt.edu

Dental caries is the most prevalent chronic disease among adolescents in the United States. Our objective in this research is to study factors contributing to dental caries among adolescents to hypothesize & map the causal reciprocal relationships among the multilevel factors that influence disparities in dental caries among adolescents. The methods that we use are focused literature review & a system dynamic approach for developing feedback mechanisms underlying dental caries through Causal loop diagramming. The results of this study have identified individual, family & community-level factors & their feedback loops contributing to dental caries experience in adolescents. Conclusions: our findings lead to a better understanding of the factors that shape disparities in dental caries experience of adolescents & testing interventions to reduce them.

2 Machine Learning-based Sleep Quality Prediction with Body Signal Data

Hyojeong Kang, Juheon Kwak, Wonkeun Jo, Dongil Kim, Chungnam National University, Daejeon, Korea, Republic of.

Good sleep quality is important to maintain health. In this paper, we predicted sleep quality using body signal data collected from wearable devices with machine learning methods. The body signal data were preprocessed by time series analyzation techniques such as power spectrum density and Neurokit, etc. Then we constructed four machine learning models to predict sleep quality, random forest, support vector machine, multi-layer perceptron, and k-nearest neighbor. In addition, we employed the long short-term memory to improve the prediction performance for multivariate time series data. The experimental results showed that the performance of the proposed method was satisfactory in terms of accuracy.

3 Artificial Intelligence-based Analytics for Impacts of Covid-19 and Online Learning on College Students' Mental Health

Mostafa Rezapour, Scott Elmshaeuser, Wake Forest university, Winston Salem, NC, Contact: rezapom@wfu.edu

In this presentation, we discuss how the COVID-19 pandemic and online learning impact college students' emotional wellbeing. To do this we use several machine learning and statistical models to analyze data collected by the Faculty of Public Administration at the University of Ljubljana, Slovenia in conjunction with an international consortium of universities, other higher education institutions and students'

associations. Our results indicate that learning modality (face-to-face, online synchronous, online asynchronous, etc.) is the main predictor of students' emotional wellbeing, followed by financial security. Factors such as satisfaction with their university's and government's handling of the pandemic are also important predictors.

4 A New Approach for Automating Patient Prioritization in Emergency Department Using Machine Learning Algorithms

Mahsa Khosravi[1], Sigurdur Olafsson[1], Gül E. Kremer[2], [1]Iowa State University, Ames, IA, [2]University of Dayton, Dayton, OH, Contact: mahsak@iastate.edu

Triage decisions are critical to emergency department performance, and existing decision support is usually based on the Emergency Severity Index, which may lead to long wait times. This work analyses a unique data set capturing the judgment of physicians for patient prioritization and addresses the question of if machine learning (ML) can be utilized to automate patient ranking in the emergency department. A classification problem of pair-wise comparisons is constructed and used to train a predictive model with logistics regression, decision trees and tree ensembles. Results show that correct comparisons are predicted with over 90% accuracy, validating the use of ML for the ranking prediction specially when incorporating domain-knowledge.

Sunday, 12:30 PM–1:45 PM

SC13

CC - Room 114

Operational Effectiveness for Contested Environments

General Session

Session Chair

Brian J. Lunday, Air Force Institute of Technology, Beavercreek, OH

1 Utilization of Offshore Support Vessel Deployment for Contested Logistics Fulfillment

Gary Lazzaro, United States Naval Academy, Annapolis, MD

We investigate distributing the deployment of offshore support vessels (OSVs) for the replenishment of logistics in contested locations. The Joint Chiefs of Staff predict that additional resources will be need to supplement the Military Sealift Command in order to resupply units in areas of contention. We utilize an unclassified test scenario across 30 locations the Indo-Pacific region, and a database of 1,700 commercial OSV worldwide. We categorize OSV into similar types of vessels for military logistics use. We formulate a time-based simulation that creates a feasible schedule for OSV to resupply deployed units over a 45-day period. Our goal is to minimize the time required for replenishments to occur. The model determines the effectiveness of OSVs and answers questions such as the time required to fulfill resupply, the type and number of OSVs required to meet unit demand.

2 A Mathematical Model and Solution Method for the Temporal Network Vulnerability Problem

Carson Long[1], Brian J. Lunday[2], Phillip R. Jenkins[3], Kenneth Hopkinson[1], [1]Air Force Institute of Technology, WPAFB, OH, [2]Air Force Institute of Technology, Beavercreek, OH, [3]Air Force Institute of Technology, Wright-Patterson Air Force Base, OH

Transportation of material over ground distribution networks is subject to both man-made and natural disruptions. This research sets forth a multi-objective bilevel linear program to identify, quantify, and characterize network vulnerabilities for a defender solving a multi-objective material routing problem, given an adversary conducting a limited number of arc-specific, spatiotemporal attacks. Examining an instance comprised of real-world network topology, this research examines the efficiency of a customized genetic algorithm to search the upper-level decision space and identify high quality solutions, subject to alternative assumptions about the defender's relative priorities over its multiple objective functions.

3 Satellite Constellation Design Through a String of Pearls Approach Based on Design of Experiments and Regression Modeling

Nathaniel Choo, Darryl Ahner, Air Force Institute of Technology, Wright Patterson AFB, OH

A method for selecting a satellite constellation is developed that provides continuous coverage to points of interest on the Earth's surface. The satellite constellation is designed by applying a String of Pearls approach to a single repeating ground track of a circular orbit. A Design of Experiments approach is used in conjunction with simulation and regression modeling to relate orbital parameters meeting repeating ground track orbit conditions to a coverage metric. The coverage metric is used to evaluate the coverage a single satellite provides to the points of interest. The regression model is then used to select the orbit that optimizes the coverage metric. The String of Pearls further enhances this coverage by placing satellites in orbit that start coverage as the preceding satellite coverage ends.

4 Routing Semi-autonomous Assets with Hierarchal Relationships Utilizing Clustering a Heuristic

Stephen Donnel[1], Brian J. Lunday[2], Nicholas Tyler Boardman[3], [1]Air Force Institute of Technology, WPAFB, OH, [2]Air Force Institute of Technology, Beavercreek, OH, [3]Air Force Institute of Technology, Bellbrook, OH

Setting aside assumptions of communication dominance, Mosaic Warfare leverages `tiles' of assets via distributed, decentralized command and control. This study develops a hierarchal clustering heuristic to implement this decision-centric framework to routing command and control, sensor, and strike assets (e.g., aircraft) to service point demands at fixed locations in R^2 space while maintaining required hierarchal relationships. System performance metrics inspired by the Price of Anarchy indicate the relative efficiency of Mosaic Warfare compared to optimal solutions, over several combinations of scenarios, asset densities, and user-defined parameters for the solution procedure.

Sunday, 12:30 PM–1:45 PM

SC14

CC - Room 115

Parking Management and the Sharing Economy

Joint Session

Session Chair

Tara Radvand, University of Michigan

1 A Stochastic Model for Estimating Search Time for On-street Parking

Tara Radvand[1], Mojtaba Abdolmaleki[2], Yafeng Yin[2], [1]University of Michigan, ANN ARBOR, MI, [2]University of Michigan, Ann Arbor, MI, Contact: tararad@umich.edu

Estimation of parking search time plays a vital role in planning and managing on-street parking. Supplementing previous attempts, we develop a stochastic framework to model the parking search procedure considering the competition, occupancy rate, and traffic congestion in the area. The framework yields a unique equilibrium distribution of search time, validated by a simulation study. Furthermore, our model determines a threshold for occupancy rate beyond which substantial cruising-for-parking starts. This result can replace the widely adopted rule of thumb of the 85 percent occupancy rate for parking management.

2 Power Systems and Applied Probability: Electric Vehicles

Maria Vlasiou[1,2], Angelos Aveklouris[3], Bert Zwart[4], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]University of Twente, Enschede, Netherlands; [3]University of Chicago Booth School of Business, Chicago, IL, [4]CWI, Eindhoven, Netherlands. Contact: vlasiou@gatech.edu

We model a distribution grid used by electric vehicles as a resource-sharing network driven by greedy decentralized control rules. We develop bounds and asymptotic (measure-valued fluid and diffusion) approximations for the vector process of the total number of EVs and the number of not fully charged EVs and compare these with numerical outcomes. This leads to a set of dynamic equations that consider the stochastic behaviour of EVs and bounded voltage drops. The invariant point is unique and can be computed by solving a specific ACOPF problem, which admits an exact convex relaxation. We illustrate our findings with a case study using the SCE 47-bus network and several special cases that allow for explicit computations.

3 Electric Vehicles for Distribution System Load Pickup Under Stressed Conditions: A Network Equilibrium Approach

Zhaomiao Guo, Sina Baghali, University of Central Florida, Orlando, FL

We investigate the potential effects of electric vehicles (EVs) on reducing the load shedding in heavily loaded distribution systems (DSs). We propose a network equilibrium model that integrates market clearing in DSs and traffic flow balance in transportation systems. This model captures the decentralized interactions between key stakeholders in transportation and distribution networks as well as the spatial distribution of EV traffic in response to endogenously determined incentive signals. To mitigate the computational challenges brought by the non-convex network equilibrium model, we develop an equivalent convex reformulation with guaranteed global convergence. The proposed method could provide a fundamental tool for analyzing interdependent transportation and distribution networks coupled by charging facilities and EVs.

Sunday, 12:30 PM–1:45 PM

SC15

CC - Room 120

Optimization and Large-scale Policy in Healthcare

General Session

Session Chair

Hadi El-Amine, George Mason University, Fairfax, VA

1 The Impact of Early Large-scale Screening on the Evolution of Pandemics

Marwan Shams Eddin[1], Hadi El-Amine[1], Hrayer Aprahamian[2], [1]George Mason University, Fairfax, VA, [2]Texas A&M University, College Station, TX, Contact: helamine@gmu.edu

We study the problem of large-scale screening in the early stages of a pandemic. In this setting, resources such as testing kits, budget, and hospital beds are scarce, and early-stage testing has the potential to alter the dynamics of disease spread. Thus, devising optimal screening strategies that operate within these constraints is crucial to saving lives and reducing healthcare costs. To address the issue of limited testing capacity, we study two models that focus on either individual or group (pooled) testing, and we determine conditions under which each scheme is superior. We calibrate our models using data on the ongoing COVID pandemic and demonstrate the benefits of our proposed methods.

2 Personalized Immunosuppressive Therapies for Transplant Recipients

Naoru Koizumi[1], Hadi El-Amine[2], Meng-Hao Li[1], [1]George Mason University, Arlington, VA, [2]George Mason University, Fairfax, VA, Contact: nkoizumi@gmu.edu

Use of Machine learning (ML) has become increasingly popular in the medical field in the past decade. We developed and applied ML and optimization models to the national transplant registry data to examine the optimal combination of immunosuppressive drugs administered to the living and deceased kidney transplant recipients between January 2010 and November 2021. The transplant outcomes were evaluated using the 1-year graft failure rate, as well as the number of post-transplant malignancy and infection episodes, adjusting for various demographic and clinical risk factors. We explored conventional ML algorithms including logistic regression, random forest, and artificial neural network. We embed the resulting ML model in an optimization framework in which allows us to determine optimal treatments based on donor/recipient characteristics.

3 A Network-based Optimization Framework for the Allocation of Vaccines Across Populations with Heterogeneous Risk Profiles and Non-uniform Interactions

Su Li[1], Hrayer Aprahamian[2], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: dclisu@tamu.edu

The COVID1-9 pandemic has sparked substantial interest in identifying good performing vaccine distribution and allocation strategies. When vaccines are limited, a key question arises: Who should be prioritized for vaccination and when should they be vaccinated? We establish a network-based optimization framework that incorporates the population's heterogeneity in risk and non-uniformity in interactions. We formulate this problem as a mixed integer nonlinear program. By analyzing its structure, we construct a globally convergent scheme based on a reformulation linearization technique. To handle larger instances, we construct a greedy algorithm which we embed within a coordinate descent approach. Our results highlight the substantial benefits of vaccination strategies that are tailored to the specific risk and interaction profiles of the population.

4 The Optimal Testing Sequence Problem for Living Kidney Donor Workup

Joshua Nielsen[1], Hadi El-Amine[2], Monica Gentili[1], Naoru Koizumi[3], [1]University of Louisville, Louisville, KY, [2]George Mason University, Fairfax, VA, [3]George Mason University, Arlington, VA, Contact: joshua.nielsen@louisville.edu

Living kidney donors must undergo a workup process of several medical tests to assess their eligibility and suitability for transplantation. Hence, the donor evaluation process takes time and may result in more than 50% of donor candidates either becoming ineligible or droping out in the process. As a result, it often takes a long time for a patient to secure a donor who could complete the process and actually donate. In this context, we study the Optimal Testing Sequence Problem which, given donor candidate characteristics, aims to find a personalized optimal sequence of tests to minimize the total expected cost. We study both the cases where probabilities of test outcomes are treated as either being dependent or independent of the preceding test in the sequence.

Sunday, 12:30 PM–1:45 PM

SC16

CC - Room 121

Decision-making in Healthcare

General Session

Session Chair
Vishal Ahuja, Southern Methodist University, Dallas, TX

1 A Cost-effectiveness Analysis of Lethal Ovitrap for the Prevention of Dengue Fever

Yvonne Huijun Zhu[1], Joel Aik[2], Joel Goh[1], [1]National University of Singapore, Singapore, Singapore; [2]National Environment Agency, Singapore, Singapore. Contact: huijun96@u.nus.edu

We analyze the system-level cost-effectiveness of a network of lethal ovitraps for Dengue control. Benefits are modeled using an age-stratified multiple-infection epidemiological model and measured as reductions in disability-adjusted-life-years (DALYs). We estimate labor costs by modeling the workload needed for periodic maintenance of the traps via Traveling Salesmen Problems (TSPs).

2 Machine-learning Enhanced Hospital Workload Prediction and Resource Allocation

Tianchun Li[1], Jonathan Eugene Helm[2], Pengyi Shi[1], [1]Purdue University, West Lafayette, IN, [2]Indiana University, Bloomington, IN, Contact: li2657@purdue.edu

The COVID-19 pandemic has created new opportunities to develop and deploy high-impact analytics to combat severe resource shortages in a rapidly evolving environment, particularly staffing inadequacy. At the core of solving this problem is data-driven analytics and predictions to understand the patient workload and how to most efficiently allocate resources to all patients. We leverage a suite of analytics tools to develop an integrated, comprehensive solution to support workload prediction and nurse deployment decisions. Based on a close partnership with IU Health System, the largest health system in Indiana with 16 hospitals, we launched an academia-industry venture to implement and deploy our data-driven solution as a pilot in October 2021. A retrospective study estimates annual savings of over $300K using our tool.

3 The Allocation of Funds in Healthcare: Which Hospital to Support?

Lina D. Song[1], Soroush Saghafian[2], [1]University College London School of Management, London, United Kingdom; [2]Harvard Univeristy, Cambridge, MA, Contact: s.dahye@ucl.ac.uk

We examine policies to allocate funds among U.S., hospitals, in the context of two payment programs— Medicare DSH and the CAH—where one targets urban and the other rural hospitals. We analytically suggest optimal investment policies, such as investing in (substantially) rural and (slightly) lower-quality hospitals. We then calibrate our model to a dataset of over 300,000 patients and show that (a) investing more in DSHs or (b) reducing the total number of CAHs improves social welfare.

Sunday, 12:30 PM–1:45 PM

SC17

CC - Room 122
Advances in Health Applications of OR
General Session

Session Chair
Hanie Eskandari, Pittsburgh, PA

Session Chair
Clarence Worrell, 1</sup

1 Calibrating the Transition Probabilities of Disease Progression Markov Chains with Aggregate Mortality Data

Hanie Eskandari, Jourdain Lamperski, University of Pittsburgh, Pittsburgh, PA

We consider the inverse problem of calibrating the transition probabilities of discrete-time Markov chain (DTMC) models of disease progression with aggregate mortality data. Existing work primarily considers tackling the problem with simulation techniques and has left open a number of interesting questions. In particular, it is not known under what conditions the transition probabilities of these models are identifiable. In this talk, we establish how many time periods of mortality data are needed to ensure that the transition probabilities are identifiable, and we present a method that is guaranteed to recover the parameters when they are identifiable. We also use our method to calibrate a colorectal cancer and an opioid use disorder model.

2 A Complex Agent-based Model of Opioid use Disorder

Mark S. Roberts[1], Mary Krauland[2], Hanie Eskandari[1], Amin Rahimian[1], Jourdain Lamperski[1], Antoine Douaihy[3], Kevin Kraemer[4], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, [3]University of Pittsburgh, Pittsburgh, PA, [4]University of Pittsburgh, Pittsburgh, PA

Opioid overdoses caused over 100,000 deaths last year and produced significant disability. Funding by the CDC, we have developed an agent-based simulation model that combines significant clinical detail in individual agents with a geospatially detailed representation of the population and characteristics surrounding individuals. We seek to construct a tool that can estimate the combined impact of multiple interventions for each of 3006 counties in the US. The model complexity, including multiple disease transition probabilities that vary by local characteristics has led to significant issues in calibration and validation, and computational complexities in the estimation of the impact of combinations of interventions in different counties. We present our methodologic solutions to these problems.

3 Minimizing Makespan Across Preloaded Machines

Clarence L. Worrell, Jourdain Lamperski, Lisa M. Maillart, University of Pittsburgh, Pittsburgh, PA, Contact: clw117@pitt.edu

Motivated by work balancing between pathology units in a multi-hospital setting, we consider minimizing makespan across preloaded, parallel machines when the system manager has a one-time, *a priori* opportunity to reassign any of the preloaded jobs to any of the other machines. Reassigned jobs are transported *en masse* in a fixed amount of time and must be returned to their original machine after they are processed. Processing times are deterministic, known prior to reassignment, and may be machine-specific. We develop a mixed-integer linear program to identify optimal reassignment policies, along with a list scheduling algorithm that we show achieves a 2-approximation guarantee when the machines are identical. A computational study shows that the algorithm often performs much better than this worst-case performance guarantee, even when the machines are not identical.

4 Modeling Social Contexts of Opioid Epidemics Using Aggregate Facebook Connectivity Data in a Large-scale Agent-based Model of the U.S.

Kushagra Tiwari[1], M.Amin Rahimian[1], Mary G Krauland[2], Mark S Roberts[2], David D Galloway[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, Contact: KUT20@pitt.edu

During the past two decades, the opioid epidemic has been a major cause of concern in the U.S. There has been an increasing recognition that its etiology is rooted in part in the social contexts that mediate substance use and access. Following a brief review of Spatial Point Pattern principles, we provide a detailed analysis of spatially clustered opioid overdose deaths (OOD) in the U.S. counties and their relationship with Facebook's social connectedness index (SCI). We will also discuss the use of SCI as a proxy to model social contexts of substance use (i.e., the effect of peer influence on opioid use initiation) in FRED (Framework for Reconstructing Epidemiological Dynamics) software developed at Pitt Public Health Dynamics Lab.

Sunday, 12:30 PM–1:45 PM

SC18

CC - Room 123

OR in Cancer Care

General Session

Session Chair

Taghi Khaniyev, Bilkent University, Ankara, Turkey.

1 Automated VMAT Treatment Planning Using Sequential Convex Programming

Pinar Dursun, Linda Hong, Gourav Jhanwar, Jie Yang, Masoud Zarepisheh, Memorial Sloan Kettering Cancer Center, New York, NY, Contact: dursungp@mskcc.org

Most current clinical systems for volumetric modulated arc therapy (VMAT) involve often time-consuming manual intervention by planners during the planning process. We propose an automated planning system for VMAT and integrate it with an FDA-approved treatment planning system. VMAT is a very challenging non-convex optimization problem and we solve it with a sequential convex programming (SCP) based direct aperture optimization algorithm. Tumor dose coverage is maximized first, and then dose to organs-at-risk is further minimized. Delivery efficiency is also considered by promoting aperture regularity and neighboring aperture similarity through convex objective functions. The performance of the system was tested on three different disease sites. The results show that the proposed system can automatically generate high quality and delivery efficient plans.

2 On the Value of a Multistage Approach for Radiation Therapy Planning

Doran Wood[1], Sila Cetinkaya[1], Harsha Gangammanavar[1], Weiguo Lu[2], Jing Wang[2], [1]Southern Methodist University, Dallas, TX, [2]UTSW Medical Center, Dallas, TX, Contact: doranw@smu.edu

We make a case in support of stochastic multistage radiation therapy planning formulations equipped with a generalized fractionation scheme which allow the beam intensity profile and prescription allocation to be optimized simultaneously. Updated patient CT scans revealing structural evolution between treatments represent realizations of a stochastic

process and a sequence of prostate cancer scans are used to generate numerical results. Performance evaluations reveal drastic improvements across the several metrics considered.

3 Optimal Tumor Resection Problem

Taghi Khaniyev[1], Kaan Cakiroglu[1], Asli Sena Bozkurt[1], Hanalioglu Sahin[2], [1]Bilkent University, Ankara, Turkey; [2]Hacettepe University, Ankara, Turkey. Contact: taghi.khaniyev@bilkent.edu.tr

Connectome is the representation of the structural connectivity (the physical wiring) of an organism's nervous system as a mathematical network. Given the connectome data of a human subject's brain where a number of regions are marked as "tumorous", our goal is to identify a maximal subset of contiguous tumorous regions whose removal will cause a limited disruption in the network's global efficiency. We formulate this problem as a network optimization problem, which is closely linked to the critical node/edge problem in the literature. The main challenge, after formulating the problem, is to solve real-life size problem instances with thousands of nodes for which we propose algorithmic approaches.

Sunday, 12:30 PM–1:45 PM

SC19

CC - Room 124

MSOM Student Paper Finalists II

Award Session

Session Chair

Dragos Florin Ciocan, INSEAD, Fontainebleau, France.

Session Chair

Ersin Korpeoglu, University College London, London, United Kingdom.

Session Chair

Nikos Trichakis, MIT, Cambridge, MA

1 Unmasking Human Trafficking Risk in Commercial Sex Supply Chains with Machine Learning

Pia Ramchandani[1], Hamsa Bastani[1], Emily Wyatt[2], [1]Wharton, Philadelphia, PA, [2]TellFinder Alliance, Uncharted, Toronto, ON, Canada.

The covert nature of sex trafficking provides a significant barrier to generating large-scale, data-driven insights to inform law enforcement, policy and social work. We leverage massive deep web data (collected from leading commercial sex websites) in tandem with a novel machine learning framework to unmask suspicious recruitment-to-sales pathways, thereby providing a global network view of trafficking risk in commercial sex supply chains. This allows us to infer likely recruitment-to-sales trafficking routes of criminal entities, deceptive approaches used to recruit victims, and regional variations in recruitment vs. sales pressure. These insights can help law enforcement better coordinate efforts, and target local interventions.

2 Capping Mobile Data Access Creates Value for Bottom-of-the-Pyramid Consumers ‘Äì Experimental Evidence from a Mumbai Settlement

Alp Sungu, Kamalini Ramdas, London Business School, London, United Kingdom.

We find that addictive smartphone usage increases the information isolation of the poor, and we study an operational solution to this problem. We developed a usage-tracking app and deployed it in the poorest settlement in Mumbai, India. Our data reveals that users binge on digitally addictive apps early in a data plan and face subsequent data shortages. We find that during the late-plan data shortage period, participants are unable to access internet-enabled information. In a field experiment, we randomly assigned participants to standard (i.e., monthly) data plans or to the same plans, but with daily data caps. Capping data plans increases late-plan access to information and reduces social media checking. This has real-life implications. We find that random assignment to daily data caps increases the attendance of in-person health camps that we advertised over WhatsApp by a striking 27 percent. Many low-income smartphone users prefer the capped plans (especially those with low self-control and high FOMO), indicating that capped plans offer a viable policy prescription.

3 Fair Exploration via Axiomatic Bargaining

Jackie W. Baek, Vivek Farias, MIT, Cambridge, MA

Exploration is often necessary in online learning to maximize long-term reward, but it comes at the cost of short-term ‘regret’. We study how this cost of exploration is shared across multiple groups. For example, in a clinical trial setting, patients who are assigned a sub-optimal treatment are the ones who incur the cost of exploration, and groups can be defined as the race of patients. We introduce the ‘grouped’ bandit model, and we show that any regret-optimal policy results in the least fair outcome: the most disadvantaged group bears the entire cost of exploration. We formalize an axiomatic notion of fairness using the Nash bargaining solution, and we derive policies that are optimally fair and enjoy a small 'price of fairness'. We illustrate the relative merits of our algorithmic framework with a case study on contextual bandits for warfarin dosing.

Sunday, 12:30 PM–1:45 PM

SC20

CC - Room 125
Wisdom of Crowds
General Session

Session Chair
Majid Karimi, California State University San Marcos, San Marcos, CA

1 A Blockchain-based Protocol to Elicit, Verify, and Reward Forecasts

Arthur Carvalho[1], Majid Karimi[2], [1]Miami University, Oxford, OH, [2]California State University San Marcos, San Marcos, CA, Contact: arthur.carvalho@miamioh.edu

We propose a blockchain-based protocol that enables Web 3.0 users to sell private data while ensuring privacy and transparency. Specifically, we focus on the case where a buyer is interested in a point or probabilistic forecast produced by a seller. This setting captures several realistic scenarios, from demand forecasting to predicting election results. Our proposed protocol relies on a smart contract to handle forecast elicitation, evaluation, and payments. Remarkably, by leveraging zero-knowledge proofs, that smart contract can achieve all the above without having access to the data (forecast). In other words, we provide formal guarantees that only the seller and the buyer have access to the forecast.

2 Exploiting Uncertainty in the NFL Draft

Yael Grushka-Cockayne[1], Jason R W Merrick[2], Cade Massey[3], Zach Drapkin[4], [1]Darden School of Business, Charlottesville, VA, [2]Virginia Commonwealth University, Richmond, VA, [3]University of Pennsylvania, Philadelphia, PA, [4]Wharton, Philadelphia, PA, Contact: grushkay@darden.virginia.edu

National Football League teams spend approximately $200m each year in player costs. One of the challenges in allocating that money is selecting players in the annual college draft. When making these selections teams utilize scout assessments of players' future performance. Using historical data from one NFL team over 12 years, we evaluate 64,139 forecasts from 90 scouts regarding 13,467 players. We use historical outcomes for mapping the categorical scout assessments into complete distributions. These distributions allow combining scout grade assessments while accounting for a prospect's uncertainty.

3 Combining Judgmental Forecasts with Base Rates to Improve Decision Making: A Data-driven Application to 20 Years of Drug Development Predictions

Asa Palley[1], Ville Satopaa[2], Charles Persinger[3], Yael Grushka-Cockayne[4], [1]Indiana University, Bloomington, IN, [2]INSEAD, Paris, France; [3]Eli Lilly & Company, Indianapolis, IN, [4]Darden School of Business, Charlottesville, VA

We propose a data-driven approach that leverages a simple behavioral model of belief updating in the context of a prior reference probability. The model allows for the possibility that experts either remain too close to or move too far away from this reference probability, and prescribes a context-specific degree of adjustment to counteract any such bias. We illustrate this approach by applying the method to expert forecasts of the probability of success in drug development. The experts are given a prior reference probability for the historical success rate of similar drugs in each phase of clinical trials and, after a group discussion, decide together on a probability prediction. The probability adjustments estimated by our model provide significant improvements in prediction accuracy, particularly within the costly Phase 3 trials.

4 Market Economies for Eliciting and Combining Judgemental Forecasts

Majid Karimi[1], Arthur Carvalho[2], [1]California State University San Marcos, San Marcos, CA, [2]Miami University, Oxford, OH

Judgemental forecasts are often combined to obtain a better predictive performance than individual forecasts. Researchers and practitioners often use statistical aggregation methods to find an optimal transformation of individual forecasts based on their statistical properties. Motivated by the recent advancements in the Wisdom of Crowds literature, we present market economies as an alternative for combining judgemental point forecasts. Unlike statistical aggregation methods, we argue that market economies present a practical solution for eliciting and aggregating a crowd's judgemental point forecasts. We provide a prescriptive analysis in an Inventory Planning and Control setting and illustrate the impact of our proposed market economies on inventory decisions.

Sunday, 12:30 PM–1:45 PM

SC21

CC - Room 126

Information, Learning and Incentive Management

General Session

Session Chair

Huseyin Gurkan, ESMT GmbH, Berlin, Germany.

4 Performance Evaluation Under Uncertainty Using Fuzzy Linear Physical Programming

Gazi Duman[1], Elif Kongar[2], Surendra M. Gupta[3], [1]University of New Haven, West Haven, CT, [2]Fairfield University, Fairfield, CT, [3]Department of Mechanical and Industrial Engineering,, Boston, MA

Continuous performance evaluations that utilize both qualitative and quantitative data play a significant role in sustaining efficient and effective business processes. The majority of these approaches use weighted evaluation criteria to introduce the relative importance of each weight into the problem environment. These weights are rarely generated by a data-driven process which might lead to misleading results. This study presents a linear physical programming-based performance evaluation approach that eliminates the subjectivity in weight assignment. A case study is provided demonstrating the applicability of the approach.

1 Fast or Slow? Competing on Publication Frequency

Lin Chen, Guillaume Roels, INSEAD, Fontainebleau, France.

For many information goods, longer publication cycles are more economical, but often result in less timely information. While the digitalization of publication processes makes shorter publication cycles more economically viable, not all firms choose to publish more frequently. In this paper, we build a game-theoretic model to determine how information providers should choose their publication cycles and prices under competition. We find that when the firms are *ex-ante* identical, they choose different publication cycles in equilibrium. While a reduction in the fixed cost of publication yields shorter publication cycles, it may also intensify the competitive dynamics, which lead firms to differentiate further. Our analysis also informs publishers to strategically leverage exclusive content and publication cycles to navigate a digital transformation.

2 Learning to Commit

Martino Banchio, Giacomo Mantegazza, Stanford University, Stanford, CA

Sellers generally benefit from the ability to credibly commit to a sequence of prices. In this work we ask whether online learning algorithms can earn such credibility. In a durable-good monopoly problem, we argue that reinforcement learning procedures need to be able to assess the value of reputation in order to sustain time-inconsistent policies, and we show how well-known design choices learn reputation effectively. We consider a monopolist learning to price an inventory of durable goods for patient, strategic, and heterogeneous consumers. Sustaining high prices guarantees maximal revenues, but it is irrational when facing only low-value consumers. We show that an algorithm with sufficiently long time-horizon learns to attribute the revenues earned early in the game to high prices in later periods, thus effectively learning to commit.

2 Is Your Machine Better than You? You May Never Know

Francis de Véricourt, Huseyin Gurkan, ESMT GmbH, Berlin, Germany. Contact: huseyin.gurkan@esmt.org

Artificial intelligence systems are increasingly demonstrating their capacity to make better predictions than human experts. Yet, recent studies suggest that professionals sometimes doubt the quality of these systems and overrule machine-based prescriptions. This paper explores the extent to which a decision maker (DM) supervising a machine can properly assess whether the machine produces better recommendations. To that end, we study a set-up, in which a machine performs repeated decision tasks under the DM's supervision. In this set-up, we characterize the evolution of the DM's belief and overruling decisions over time and the conditions under which learning failures occur. We also explore how mistrusting the machine affects our results.

Sunday, 12:30 PM–1:45 PM

SC22

CC - Room 127

New Advances in Procurement and Project Management

General Session

Session Chair

Vibhuti Dhingra, 1</sup

1 When Does Price-based Sourcing Hurt Performance?

Beverly Osborn[1], John Gray[2], [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH,

Contact: osborn.259@osu.edu
Excessively price-based decision-making in sourcing can contribute to subpar performance and lead to undervaluing risks and social and environmental issues. In this empirical study, we find evidence that excessively price-based sourcing is a widespread problem, and our setting allows us to infer a potential solution.

2 Developing Coalitions of Complimentary Growers and Investors to Mitigate Price and Yield Variability and Offset Risk

Miguel Peinado-Guerrero, Rene Villalobos, Rodrigo Ulloa, Arizona State University, Tempe, AZ
Matching the production of fresh fruits and vegetables to the market's demand is, in general, a complex problem. From the viewpoint of small and medium growers, what to plant and when to plant is important in the face of yield and price variability when it comes time to harvest. From the viewpoint of buyers, responsible for the procurement of product for specific markets, deciding how to aggregate sufficient amounts is the challenge. We propose the development of optimization models that automate these tasks. In particular, these models consider the complementarity of different growing regions, the stochasticity of prices and yields, and the risk tolerance of the growers along with the use of external investment to offset this risk. By considering these elements, optimal coalitions of growers can be determined to meet specific buyer requirements.

3 Behavioral Implications of Bilateral Relationships on Supply Chain Contracting

Alper Nakkas[1], Lei Hua[2], Kay-Yut Chen[3], Xianghua Wu[4], [1]University of Texas at Arlington, Arlington, TX, [2]University of Texas at Tyler, Tyler, TX, [3]University of Texas at Arlington, Mansfield, TX, [4]College of business, University of Texas At Arlington, ARLINGTON, TX, Contact: nakkas@uta.edu
This paper investigates the impact of bilateral relationships on procurement and competition incentives in a supply chain environment from a behavioral perspective. We focus on a two-retailer-two-supplier networked market where retailers negotiate supply procurement contracts with their potential suppliers. We first derive the theoretical benchmark, which is the bargaining equilibrium outcome as a function of network structure, and then conduct a laboratory experiment to confirm the results. Our experimental data suggests systematic deviations and reveal behavioral regularities on contracting behavior. We develop a new behavioral model, referred to as desperateness model, where a firm's unfavorable bargaining position inflicts additional distress to the firm and show that the behavioral model explains the experimental data well.

Sunday, 12:30 PM–1:45 PM

SC23

CC - Room 128
PSOR Best Paper Award Finalists
Award Session

Session Chair
Justin J. Boutilier, University of Wisconsin - Madison, Madison, WI

Session Chair
Mahyar Eftekhar, Arizona State University, Tempe, AZ

1 Competition and Collaboration on Fundraising for Short-term Disaster Response: The Impact on Earmarking and Performance

Arian Aflaki[1], Alfonso J. Pedraza-Martinez[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]Indiana University, Bloomington, IN
Problem definition: Most humanitarian organizations (HOs) allow donors to earmark their donations, i.e., designate their contributions to a specific purpose. Allowing earmarking may increase donations, however, it creates operational inefficiencies that undermine the impact of those donations. Extant literature has mainly studied earmarking and its operational consequences in the absence of funding competition. We examine how competition for funding impacts earmarking decisions, fundraising costs, and HO performance in short-term disaster response. We also analyze two collaborative fundraising models: (i) full collaboration, where HOs contact donors as a unit and donors cannot donate to specific HOs on the fundraiser, and (ii) partial collaboration, where HOs contact donors as a unit and donors choose among the contacting HOs. Methodology/results: We use game theory to model the interactions between multiple HOs and a market of donors and build a multinomial logit model for the donor choice problem. We find that competition for funding contributes to the prevalence of earmarked donations, increases fundraising costs, and hurts HO performance and utility. We show the two collaborative fundraising models can mitigate these issues depending on the availability of funding resources. When funding is abundant, full collaboration improves HO utility and reduces earmarking and fundraising costs. When

funding is scarce, partial collaboration reduces fundraising costs and improves performance and HO utility. When funding is intermediate, these two forms of collaboration do not necessarily benefit HOs. Managerial implications: We illustrate how funding availability drives earmarking and fundraising decisions as well as key performance metrics of different funding models during short-term disaster response. Using data from the 2010 Haiti earthquake, our numerical study indicates that partial collaboration benefits response to under-funded mega-disasters, while full collaboration suits well-funded disaster response. HOs competing for funds can use our insights to improve their response effectiveness.

2 Interpretable Models for the Automated Detection of Human Trafficking in Illicit Massage Businesses

Margaret Tobey[1], Ruoting Li[1], Osman Ozaltin[1], Maria Esther Mayorga[1], Sherrie Caltagirone[2], [1]North Carolina State University, Raleigh, NC, [2]Global Emancipation Network, Orlando, FL

Illicit massage businesses (IMBs) frequently profit illegally from the labor and sexual exploitation of victim workers. To detect human trafficking in this area, we combine data from multiple internet sources and train two interpretable prediction models, risk scores and optimal decision trees, that can identify human trafficking risk factors and asses a level of risk for each business. We focus our analysis on data from open sources in Texas and Florida including customer reviews and business data from Yelp.com, the U.S. Census, and GIS files such as truck stop, highway, and military base locations. The proposed multi-source data-based approach and interpretable models can be used by stakeholders at all levels to save time and resources, serve victim workers, and support well-informed regulatory efforts.

3 Analysis of Farm Equipment Sharing in Emerging Economies

Olufunke Adebola[1], Priyank Arora[2], Can Zhang[3], [1]Hello Tractor, Abuja, Nigeria; [2]University of South Carolina, Columbia, SC, [3]Duke University, Durham, NC

In recent years, there is a growing number of farm equipment sharing platforms in emerging economies that help connect smallholder farmers with tractor owners who are willing to fulfill farmers' requests for mechanization services. Due to the small farm sizes and low digital literacy in many rural areas of emerging economies, these platforms often rely on the so-called "booking agents" to collect demand from individual farmers and submit the aggregated demand on the platform (rather than having individual farmers submit their service requests). In this paper, we study how the presence of booking agents affects the platform's optimal pricing and wage decisions, and how various interventions (e.g., from local governments or donor agencies) that focus on enhancing the supply- and demand-side of such platforms affect the equilibrium outcomes, such as the total surplus earned by farmers. In terms of practical impact, our insights have inspired changes in Hello Tractor's practice of setting the payout ratio (wage over price) for booking agents.

4 Split Liver Transplantation: An Analytical Decision Support Model

Yanhan (Savannah) Tang[1], Alan Scheller-Wolf[1], Sridhar R. Tayur[1], Emily R. Perito[2], John P. Roberts[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of California, San Francisco, San Francisco, CA

Split liver transplantation (SLT) is a procedure that potentially saves two lives using one liver, increasing the total benefit derived from the limited number of donated livers available. SLT may also improve equity, by giving transplant candidates who are physically smaller (including children) increased access to liver transplants. However, SLT is rarely used in the US. To help quantify the benefits of increased SLT utilization and provide decision support tools, we introduce a deceased-donor liver allocation model with both efficiency and fairness objectives. We formulate our model as a multi-queue fluid system, incorporating the specifics of donor-recipient size matching and patients' dynamically changing health conditions. Leveraging a novel decomposition result, we find the exact optimal matching procedure, enabling us to benchmark the performance of different allocation policies against the theoretical optimal. Numerical results, utilizing data from UNOS, show that increased utilization of SLT can significantly increase total quality-adjusted life years, reduce patient deaths, and improve fairness among different patient groups.

5 Combating Excessive Overtime in Global Supply Chains

Chuanya Jiao[1], Anyan Qi[2], Jiayu Chen[3], [1]University of Science and Technology of China, Hefei, China; [2]The University of Texas at Dallas, Richardson, TX, [3]University of Calgary, Calgary, AB, Canada.

Workers in developing economies may be forced to work excessive overtime, which causes mental and physical issues and results in brand damage to the buyers if exposed in public. We develop a game-theoretic model of a dyadic supply chain and analyze the buyer's strategies to combat excessive overtime, including auditing and cross-training. We derive equilibrium outcomes and study the interaction of the strategies and their impact on the degree of excessive overtime and social welfare.

Sunday, 12:30 PM–1:45 PM

SC25

CC - Wabash 2

Five Starter Pieces: Quantum Information Science via Semi-definite Programs

Tutorial Session

Session Chair

Mabel Chou, National University of Singapore, SG, SG, Singapore.

1 **Five Starter Pieces: Quantum Information Science via Semi-definite Programs**

Sridhar R. Tayur[1], Vikesh Siddhu[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of Colorado, Boulder, CO

As the title indicates, this manuscript presents a brief, self-contained introduction to five fundamental problems in Quantum Information Science (QIS) that are especially well-suited to be formulated as Semi-definite Programs (SDP). We have in mind two audiences. The primary audience comprises of Operations Research (and Computer Science) graduate students who have familiarity with SDPs, but have found it daunt-ing to become even minimally conversant with pre-requisites of QIS. The second au-dience consists of Physicists (and Electrical Engineers) already knowledgeable with modeling of QIS via SDP but interested in computational tools that are applicable more generally. For both audiences, we strive for rapid access to the unfamiliar mate-rial. For the first, we provide just enough required background material (from Quan-tum Mechanics, treated via matrices, and mapping them in Dirac notation) and simul-taneously for the second audience we recreate, computationally in Jupyter notebooks, known closed-form solutions. We hope you will enjoy this little manuscript and gain understanding of the marvelous connection between SDP and QIS by self-study, or as a short seminar course. Ultimately, we hope this disciplinary outreach will fuel ad-vances in QIS through their fruitful study via SDPs.

Sunday, 12:30 PM–1:45 PM

SC27

CC - Room 138

Driving Change in Service Operations Through Flexibility and Data Analytics

General Session

Session Chair

Kenneth Moon, University of Pennsylvania, Philadelphia, PA

1 **How Customers Process Good and Bad Waiting Experiences: Identifying Compensating Experiences in Service Networks Using Machine Learning**

Peiran Xu, Kenneth Moon, University of Pennsylvania, Philadelphia, PA, Contact: peiranxu@seas.upenn.edu

Despite pervasively waiting to acquire goods and services, customers typically find waiting painful. Nonetheless, consumers are surprisingly willing to wait in long queues for popular restaurants, movie premieres, and the releases of fashion lines. Moreover, underappreciated research shows that a reasonable time spent waiting can, at times, enhance customer satisfaction. Retail destinations, including shopping centers and amusement parks, bring together numerous storefronts and attractions resulting in mixtures of positive and negative waiting experiences. Using causal analysis and machine learning (graph neural networks), we investigate the combined effects of such mixed waiting experiences on customer choices and overall satisfaction and explore their implications for retail marketplace design and event-based promotions.

2 **Battery as a Service: Flexible Electric Vehicle Battery Leasing**

Lingling Shi[1], Bin Hu[2], [1]University of Texas-Dallas, Richardson, TX, [2]University of Texas at Dallas, Richardson, TX, Contact: lxs171930@utdallas.edu

Inspired by the electric vehicle (EV) startup NIO which adopts a Battery-as-a-Service (BaaS) model with a swappable battery design and experiments with flexible battery up/downgrading, we study a flexible EV battery lease program where customers lease batteries of their chosen capacities with the option to temporarily up/downgrade to batteries of different capacities during peak periods. Adopting a game-theoretical model, we find that the manufacturer may depend on acquiring additional batteries or reallocating customers' batteries to satisfy the peak up/downgrade needs, and that flexible battery leasing can lead to win-win outcomes (increased manufacturer profit and reduced customer total cost) compared with simple battery leasing. These findings inform EV manufacturers adopting the BaaS business model and highlight the value of flexible battery leasing.

3 **Preventing Healthcare Worker Burnout Using Better Big Data**

Kenneth Moon, University of Pennsylvania, Philadelphia, PA

On-the-job stress, turnover, and burnout are significantly disrupting the staffing and productivity of healthcare workers. Across the U.S. hospital system, physician turnover and the hours lost to burnout cost an estimated $4.6B annually, or approximately $7600 per physician, whereas nursing turnover is even more endemic. In collaboration with 3 intensive-care clinics (ICUs) operating within the University of Pennsylvania hospital system, we deploy wearable biometric sensors on the ICU nursing staff to identify episodes of high-stress workflows. Specialized forms of reinforcement learning are used to train algorithms that suggest real-time interventions in staffing.

4 It Takes Two to Make It Right: How Nurses' Response to Sepsis Alerts Impacts Physicians' Process Compliance

Zahra Mobini[1], Mehmet U.S. Ayvaci[2], Ozalp Ozer[3], [1]The University of Texas at Dallas, Jindal School of Management, Richardson, TX, [2]The University of Texas at Dallas, Richardson, TX, [3]Amazon, Richardson, TX, Contact: zahra.mobini@utdallas.edu

We empirically examine how a clinical team, consisting of the two roles of nurse and physician, provides care in compliance with evidence-based standards using a sepsis alert system. In particular, we study whether and when nurses' timely response to sepsis alerts (i.e., acknowledging the alert and notifying physicians within a designated time frame) impacts physicians' compliance with sepsis care standards (i.e., performing diagnostic or treatment actions within a designated time frame). Using data from a hospital system in the US, we find that nurses' timely response to alerts has a positive spillover effect on physicians' compliance, and this effect becomes stronger as workload increases and weaker as the number of false alerts increases.

Sunday, 12:30 PM–1:45 PM

SC28

CC - Room 139

Recent Developments in Retail Operations

General Session

Session Chair

Necati Ertekin, University of Minnesota, Minneapolis, MN

1 Pricing Behavior and Fake Reviews on Online Marketplace

Ziwei Zhu[1], Saravanan Kesavan[2], Bradley R. Staats[3], [1]Cornell University, Ithaca, NY, [2]University of North Carolina-Chapel Hill, Chapel Hill, NC, [3]University of North Carolina at Chapel Hill, Chapel Hill, NC, Contact: zz575@cornell.edu

Online marketplaces have suffered from review fraud for a long time. Proliferation of fake reviews is generally recognized as a disruption to online marketplaces which undermines their operational efficiency. However, we focus on economic impact of fake reviews and provide the empirical evidence that fake review is a good signal to online marketplace. Specifically, high historical level of fake reviews is accompanied with low pricing strategy of sellers while customer utility maintains the same level or even increases. It implicitly shows that sellers make efforts to promote products at the cost of their own benefits, which is beneficial to both online marketplace and customers.

2 The Value of Last-mile Delivery

Zhikun Lu[1], Ruomeng Cui[2], Tianshu Sun[3], [1]Emory University, Atlanta, GA, [2]Emory University, Decatur, GA, [3]University of Southern California, Los Angeles, CA

We study the value of last-mile delivery in retail. This problem is not only important to online retailers, such as Amazon and Alibaba, but also to traditional businesses under digital transformation. Despite its growing importance and popularity, little empirical research has been done. To investigate this issue, we collaborate with Alibaba's logistics subsidiary, Cainiao. Cainiao has established more than one hundred thousand last-mile stations for customer pick-up. In December 2020, Cainiao launched its home delivery service. We leverage this quasi-experiment to evaluate the economic impact brought by last-mile delivery. Our difference-in-differences analysis shows that the provision of last-mile delivery significantly increases the sales and customer spending at Taobao, the Alibaba's online retail platform.

3 Communication Versus Notification in Last Mile Delivery

Natalie Epstein[1], Santiago Gallino[2], Antonio Moreno[3], [1]Harvard Business School, Cambridge, MA, [2]University of Pennsylvania, Philadelphia, PA, [3]Harvard Business School, Boston, MA

We conduct an experiment with a last mile logistics company to study the effect of changing the channel (from a notification to a communication channel) through which they tell clients their package is on its way. We study measures of the process such as failed delivery rates, duration of the delivery and customers' ratings.

Sunday, 12:30 PM–1:45 PM

SC29

CC - Room 140
MSOM/Healthcare Flash Session
Flash Session

Session Chair
Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL

Session Chair
Jun Li, Ross School of Business, University of Michigan, Ann Arbor, MI

1 How Cannabis Legalization Affects Hospital Operations

Max Yakovlev[1], Maria R. Ibanez[2], [1]Kellogg School of Management, Evanston, IL, [2]Kellogg School of Management at Northwestern University, Evanston, IL, Contact: maksim.yakovlev@kellogg.northwestern.edu

Since Colorado and Washington became the first US states to legalize recreational cannabis sales to the public in 2012, 18 states and Washington, D.C. have followed. Approximately half of Americans live in a jurisdiction with legalized recreational cannabis. In our work, we investigate the effect of RCL (recreational cannabis legalization) on hospital operational metrics.

2 Multi-channel Healthcare: Impact of Telemedicine Adoption on Clinic Patient Flow

Sokol Tushe[1], Hao Ding[2], Diwas S. KC[1], Suephy Chen[3], Howa Yeung[1], [1]Emory University, Atlanta, GA, [2]Emory University, Decatur, GA, [3]Duke University, Durham, NC

This paper studies a multi-channel healthcare system where physicians can diagnose patients and prescribe treatment remotely or in-person. We find that telemedicine adoption leads to higher patient complexity in the in-person channel, corresponding to a 20% increase in visit time and an 8.5% increase in required clinical resources. In addition, the adoption of telemedicine results in a higher throughput rate. However, we find a significant reduction in average wait time for in-person appointments (37.5%), and for medically necessary procedures (43%). We attribute the improved efficiency to early patient triage and a reduction of setup and switching costs.

3 Machine Learning Methods Applied to Cancer Treatment Planning

Jacqueline Jil Vallon[1], Wanqiao Xu[1], Neil Panjwani[1], Xi Ling[1], Sush Vij[1], Sandy Srinivas[1], John Leppert[1,2], Mark Buyyounouski[1], Mohsen Bayati[1], [1]Stanford University, Stanford, CA, [2]Veterans Affairs Palo Alto Health Care System, Palo Alto, CA, Contact: jjvallon@stanford.edu

Cancer treatment planning is complex, requiring the integration of many parts. Traditional analyses to guide cancer treatment decisions have several shortcomings: 1) Models often only incorporate covariates readily available in the EMR. However, texts such as biopsy reports include rich covariates used in clinical practice but missed in analyses because of their unstructured nature. 2) Advanced machine learning (ML) models trade off variance by injecting bias to increase estimation accuracy, potentially recommending decisions inconsistent with clinical intuition. We study these challenges by applying recent ML methods to prostate cancer treatment planning.

4 Data-driven Workforce Planning for Healthcare Organizations

Sandeep Rath[1], Kumar Rajaram[2], [1]University of North Carolina at Chapel Hill - Kenan Flagler, Chapel Hill, NC, [2]University of California-Los Angeles, Los Angeles, CA, Contact: sandeep_rath@kenan-flagler.unc.edu

Due to a multitude of demographic factors, the US healthcare system will face an acute shortage of healthcare professionals. Utilizing data-driven approaches for workforce scheduling will be one way to reduce stress on hospital systems and healthcare professionals. We will look at an application of data-driven optimization models for scheduling and planning of healthcare professionals for chronic care and operating rooms. These implementations have helped reduce healthcare costs, improve patient health outcomes, and given employees with more stable and predictable schedules.

5 The Behavioral Drivers and Operational Impact of Discretion

RJ Niewoehner[1], Bradley R. Staats[2], Diwas S. KC[3], [1]Kelley School of Business, Indiana University, Bloom, IN, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC, [3]Emory University, Atlanta, GA, Contact: rniewoeh@iu.edu

Recent operations research acknowledges that agents in our operational systems have discretion to make decisions. Modeling this behavior requires assumptions, but these assumptions may induce gaps between models and real-world observations. In the end, these decisions coalesce firm-level outputs, both for good and ill. Despite this, deliberate system design can transform problematic deviance into productive discretion. In this presentation, I detail three explorations of system design and the operational impact of human discretion.

6 **Can Hospital Advertising Benefit Emergency Patients?**

Tae Jung Yoon[1], TI Tongil Kim[2], Simon Kim[2], [1]KAIST College of Business, Seoul, Korea, Republic of; [2]University of Texas at Dallas, Richardson, TX, Contact: taejung.yoon@kaist.ac.kr

U.S. hospitals have substantially increased spending on advertising. As for emergency patients, a common belief is that advertising may not be effective for them choosing a hospital. However, using hospital discharge data and hospital television advertising data from Florida, we find that hospital advertising actually affects emergency patients' choice of hospitals and increases their travel distance to hospital. We also observe that a higher patient death rate is associated with a higher level of hospital advertising. We further discuss heterogeneous responses of patients and implications of hospital advertising to determine whether it can ultimately benefit emergency patients.

7 **A Data-driven Analytical Framework for the Opioid Prescription Epidemic**

Alireza Boloori[1], Soroush Saghafian[2], Stephen Traub[3], [1]University of Washington, Tacoma, Tacoma, WA, [2]Harvard Univeristy, Cambridge, MA, [3]Brown University, Providence, RI, Contact: aboloori@uw.edu

Opioid epidemic is attributed to the over-prescription of opioid painkillers. Medical guidelines have urged healthcare providers to lessen opioid prescriptions in their medical practices. This, however, could negatively affect those patients who suffer from acute or chronic pain symptoms. Utilizing commercial insurance claims and encounters data, we (1) analyze the trade-off between the side effects and potential benefits of using pain treatments, and (2) provide an analytical framework that helps physicians in prescribing these treatments.

8 **Conditional Approval Vs. Discount Schemes for New Medical Treatments**

Ozge Yapar[1], Stephen E. Chick[2], Noah Gans[3], [1]Indiana University, Kelley School of Business, Bloomington, IN, [2]INSEAD, Fontainebleau, France; [3]University of Pennsylvania, Philadelphia, PA, Contact: oyapar@iu.edu

Healthcare payers often make reimbursement decisions under uncertainty. A common view is that uncertainty about the health-economic value of a treatment can be mitigated either by reducing the price or by executing a conditional approval scheme (CA). Under a CA, a treatment's reimbursement is conditioned on whether data captured after the treatment has entered the market can verify its value. But the design of CAs has not received much attention. Using a game-theoretic model, we find that the price offered during a CA's period of post-market data collection can drastically affect equilibrium outcomes; and that, contrary to the common view, price and uncertainty reduction may not be substitutes.

9 **Patient Pods in the Emergency Department: A Comparison of Patient-physician Assignment Systems**

Robert J. Batt[1], Brian W. Patterson[2], [1]Wisconsin School of Business, UW-Madison, Madison, WI, [2]Wisconsin School of Business, UW-Madison, Madison, WI, Contact: bob.batt@wisc.edu

We compare the operational performance of two emergency department patient-physician assignment systems. One system is a physician-choice system in which the physician chooses what patient to serve next. The second system is a hybrid nurse-assignment-physician-choice system in which a nurse assigns the patient to an attending physician, but resident physicians may choose which patients to serve. Key measures of interest include wait time, length of stay, physician throughput, and physician multitasking level. We find evidence of physician free-riding under the physician-choice scheme.

10 **Digital Footprints: How Smartphone Location Data Can Track Health Behaviors and Other Phenomena**

Elisa Frances Long, UCLA Anderson School of Management, Los Angeles, CA

Smartphone geolocation data are increasingly used in social science to study human decision-making and behavioral phenomena. I will summarize three recent studies related to political partisanship, healthcare worker networks, and compliance with COVID social distancing orders.

11 **Should Small Online Retailers Pay for Keyword Recommendations?**

Qiuxia Chen, Bin Hu, Elena Katok, The University of Texas at Dallas, Richardson, TX, Contact: Qiuxia.Chen@utdallas.edu

Small online retailers depend heavily on keywords to generate demand. There are professional services offering paid keyword recommendations. Should all retailers pay for such recommendations? We show that they should not all pay for such recommendations because it leads to intense competition. We then show that intentionally degrading some recommended keywords may actually increase demand for recommendations and improve recommenders' profit.

Sunday, 12:30 PM–1:45 PM

SC30

CC - Room 141

Bayesian Learning under Strategic Interactions

General Session

Session Chair

Jussi Keppo, National University of Singapore, Singapore, Singapore.

Session Chair

Yanwei Jia, Columbia University, New York, NY

1 Learning to Lend Under Adverse Selection

Yifan Feng, Jussi Keppo, National University of Singapore, Singapore, Singapore.

We consider a dynamic pricing problem for a lender who repeatedly interacts with a borrower who has private information about his own default probability and strategically decides whether to accept the loan offers. We show that if the lender can commit to a simple markup policy, then asymptotically the information rent can be entirely offset by the benefit of learning. In addition, if the lender is sufficiently patient, she always lends the first loan at a low rate, which contrasts the implications of a static Akerlof-type model.

2 The Wisdom of Strategically Diverse Crowds

Yanwei Jia[1], Jussi Keppo[2], Ville Satopaa[3], [1]Columbia University, New York, NY, [2]National University of Singapore, Singapore, Singapore; [3]INSEAD, Paris, France.

In this work, we consider the wisdom of the crowd and analyze predictions that are affected endogenously by the crowd composition. In particular, the individuals are assumed to have external motives, represented by different degrees of strategic complementarity (herding) or substitutability (anti-herding). We characterize the equilibrium behavior and prove that a weakly anti-herding crowd induces the best performance and that higher uncertainty about the crowd's strategic types reduces the individuals' accuracy. In crowds with two strategy types, the simple average judgment of a homogeneous crowd is always preferred to that of a diverse crowd. As an alternative, we propose a clustering-based procedure that identifies subgroups and leverages their different strategic motives with weighted averaging.

3 Can Echo Chambers Reduce Polarization?

James Siderius[1], Mohamed Mostagir[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]University of Michigan, Ann Arbor, MI, Contact: jpsiderius@gmail.com

We build a model of how users join communities on social media. Agents enter with pre-existing beliefs and interests, and decide to join a subset of communities most aligned with them; in doing so, their future beliefs evolve with the sentiment of the community. At the center of our model is the observation that several communities that peddle misinformation and extremism are echo chambers: they mostly consist of users who share similar ideologies repeating the same information to each other. We show that aggressive policies intended to limit the harm of echo chambers (e.g., through censorship) can lead to a higher adoption of misinformation and extreme ideas. We fully characterize the set of optimal interventions in both the short term and long term. Finally, we demonstrate our main ideas empirically using data from various quarantined and banned communities on Reddit.

4 Diversified Learning from Multiple Biased Sources

Xinyuan Zhang[1], Michael Jong Kim[2], Jussi Keppo[3], [1]Sauder School of Business, University of British Columbia, Vancouver, BC, Canada; [2]University of British Columbia, Vancouver, BC, Canada; [3]National University of Singapore, Singapore, Singapore. Contact: xinyuan.zhang@sauder.ubc.ca

We consider a decision-maker (DM) who can acquire signals from multiple biased information sources to learn about a hidden state prior to making his decision. Unbiased signals are also available, but the acquisition cost is high. The DM dynamically chooses how to allocate a fixed budget across different sources to balance the trade-off between estimation error and acquisition cost. The problem is motivated by financial and healthcare applications where forecasting and decisions must be based on combining data from different biased sources. We formulate the problem as a Markov decision process and propose a Bayesian network model for the information structure. We solve the associated dynamic programming equations and characterize the optimal policy, which seeks to always diversify over different sources based on the posterior belief. We also run numerical experiments.

Sunday, 12:30 PM–1:45 PM

SC31

CC - Room 142

Platform and Marketplace Operations: Perspectives and New Directions

General Session

Session Chair
Omar Besbes, Columbia University, New York, NY

Session Chair
Yuri Fonseca, New York, NY

Session Chair
Ilan Lobel, New York University, New York, NY

1 Pricing Control and Regulation in Online Service Platforms

Gerard P. Cachon[1], Tolga Dizdarer[2], Gerry Tsoukalas[3], [1]University of Pennsylvania, Philadelphia, PA, [2]Wharton, Philadelphia, PA, [3]Boston University, Boston, MA, Contact: gerryt@bu.edu

Motivated by Uber's recent decentralized driver-pricing practice in California we investigate how a platform with large supply should set its fares when service providers are heterogeneous in costs. We use a stylized model to compare two prevalent methods in practice: platform-pricing, where the platform sets the prices for all servers, and server pricing, where prices are defined by the competitive equilibrium of server decisions. We, then, compare these methods to an optimal contract.

2 Design of Resale Platforms and the Urban-rural Income Gap in India

Ilan Morgenstern[1], Daniela Saban[1], Divya Singhvi[2], Somya Singhvi[3], [1]Stanford University, Stanford, CA, [2]New York University, New York, NY, [3]USC Marshall School of Business, Los Angeles, CA, Contact: ilanmor@stanford.edu

We collaborate with a large online marketplace in India, which is focused on reselling. In this platform, users browse for products and share information about these to their contacts attempting to sell these products, from which users generate earnings. We analyze data from this marketplace and observe significant differences in earnings for users from rural vs. urban areas. To understand the relationships between the different factors that interplay in the platform that may be driving this observation, we develop an analytical model of a resale platform. Then, we calibrate the parameters of the model using granular orders data from our collaborator and, finally, we propose interventions to improve rural users' outcomes.

3 Improving Dispute Resolution in Two-sided Platforms: The Case of Review Blackmail

Yiangos Papanastasiou, University of California Berkeley, Berkeley, CA

This paper investigates the relative merits of different dispute resolution mechanisms in two-sided platforms, in the context of disputes involving malicious reviews and blackmail.

4 Pricing and Downstream Competition in Services Marketplaces

Omar Besbes[1], Yuri Fonseca[1], Ilan Lobel[2], Fanyin Zheng[1], [1]Columbia University, New York, NY, [2]New York University, New York, NY, Contact: yfonseca23@gsb.columbia.edu

We study demand estimation and pricing policies in two-sided marketplaces that operate in two stages. In the first stage, service providers purchase leads for opportunities/customers from an assortment provided by the platform. In the second stage, customers select a provider from those who applied. A match occurs if and only if both consumers and suppliers agree. We develop a model that accounts for providers being strategic about congestion in the second phase. Based on data from a large service marketplace, we show empirically that such strategic behavior is key and ignoring it leads to overestimation of the demand elasticity. We show how one may correct for it through the structural model we propose, and validate the model with a field experiment.

Sunday, 12:30 PM–1:45 PM

SC32

CC - Room 143
Logistics and Capacity Planning
General Session

Session Chair
Manoj Vanajakumari, 1</sup

1 E-commerce Order Fulfillment with Limited Time Window

Quan Zhou, Mehmet Gumus, Sentao Miao, McGill University, Montreal, QC, Canada. Contact: quan.zhou3@mail.mcgill.ca

E-commerce companies have seen significantly higher fulfillment expenditures and worsened logistics issues, and the COVID-19 pandemic has exacerbated the situation. We study the optimal fulfillment decision in a multi-warehouse-multi-location problem with increasing marginal fulfillment costs, unlimited inventory, and multi-period fulfillment time window. We show that an optimal fulfillment strategy for the problem follows a warehouse-wise state-dependent threshold policy. Purposely delay of some fulfillment is

valuable when demands are unlikely to exceed the threshold. Most of the benefits can be gained by incorporating a short-period fulfillment window.

2 Supply Chain Planning with Hybrid Cross-docks and Uncertain Demand

Haoying Sun[1], Manoj Vanajakumari[2], Chelliah Sriskandarajah[3], [1]University of Kentucky, Lexington, KY, [2]University of North Carolina Wilmington, Wilmington, NC, [3]Texas A&M University, College Station, TX, Contact: manojuv@uncw.edu

Our research is inspired by the subcontracting problem at a major oil field services company in North America. The company's supply chain consists of suppliers bringing raw materials Free Trade Zone (FTZ). FTZ serves as the stock consolidation point for the region. The company then breaks-bulk and ship materials to various plants using subcontractors (3PLs). Subcontractors charge by the weight of the shipping unit. The goal is to minimize the total inbound and outbound transportation costs and the total inventory management costs. The demand at each plant is stochastic. We derive theoretical solutions and performs robust optimization.

3 Covid-19 and Its Impacts on Hospital Operational Performance Measures

Yu Wang[1], David Cho[2], Allison Witman[1], [1]The University of North Carolina Wilmington, Wilmington, NC, [2]California State University, Fullerton, Fullerton, CA

Using data reported by the State of California Office of Statewide Health Planning and the U.S. Department of Health & Human Services, this research first empirically investigates how performance measures such as patient average length of stay are affected by COVID-19 for over 300 hospitals in California. A stylized model is then formulated to analyze operational strategies hospitals can adopt to manage capacity when facing overwhelming demand.

4 Congestion Dissipation in Global Supply Chain from Port Disruption

Ming Hu, Chaoyu Zhang, Rotman School of Management, University of Toronto, Toronto, ON, Canada. Contact: cyu.zhang@rotman.utoronto.ca

The pandemic era has experienced a significant amount of port congestion. Such congestion at one port spreads to another, leading to shipping delays and driving up costs for shippers. We build a fluid model to study how a disruption at a port would impact the disrupted port itself in one country and its counterpart port in another country. We fully characterize the transient dynamics such as backlogs of goods and ships during the whole recovery process. Then we identify a whipsaw (whiplash) effect that one port (two ports) will (take turns to) be hit with backlogs of ships over time as container ships sequentially visit the two ports during the recovery process.

Sunday, 12:30 PM–1:45 PM

SC33

CC - Room 144

Emerging Topics in Sustainable and Socially Responsible Operations

General Session

Session Chair

Hang Ren, George Mason University, Fairfax, VA

1 Impact of Social Learning on Consumer Subsidies and Supplier Capacity for Green Technology Adoption

Hang Ren[1], Tingliang Huang[2], Georgia Perakis[3], [1]George Mason University, Fairfax, VA, [2]Carroll School of Management, Boston College, Newton, MA, [3]Massachusetts Institute of Technology, Belmont, MA, Contact: hren5@gmu.edu

To incentivize consumer adoption of green-tech products (e.g., electric vehicles and solar roofs), governments typically offer consumers subsidies through rebates and tax credits. Apart from subsidies, customers' adoption decisions are usually also influenced by the word-of-mouth information about product quality from earlier adopters. In this paper, we analyze the impact of such social learning on the government's optimal subsidy design, considering a supplier's capacity decision. We find that social learning may reduce social welfare by dis-incentivizing the supplier's capacity investment and diluting the demand base with weak-preference customers. As a result, the government may decrease (increase) the subsidy level offered to earlier (later) adopters, resulting in an increasing subsidy path.

2 Drivers and Implications of Combined Investment in Renewables and Energy Storage in the Residential Sector

Na Rea Cho[1], Youngsoo Kim[1], Karthik Murali[2], Mesut Yavuz[1], [1]University of Alabama, Tuscaloosa, AL, [2]Oregon State University, Corvallis, OR, Contact: ncho3@crimson.ua.edu

We consider a grid-connected household's problem of determining the optimal capacities of solar and energy storage technologies to minimize its electricity costs when faced with time-of-use electricity prices and sellback credits. We identify the impact of household and market characteristics, as well as electricity pricing and technology subsidy policies on the levels of investment in these two technologies. We supplement our analytical results with a case study of two U.S. cities and identify policy guidelines pertaining to the role of electricity pricing and technology subsidization on the uptake of these technologies and the ensuing implications for residential customers, the environment, and reliability of the grid.

3 From Curtailed Renewable Energy to Green Hydrogen: Infrastructure Planning for Hydrogen Fuel-cell Vehicles

Long He[1], Nan Ke[2], Wei Qi[3], Hongcai Zhang[4], [1]George Washington University, Washington, DC, [2]National University of Singapore, Singapore, Singapore; [3]McGill University, Montreal, QC, Canada; [4]University of Macau, Macau, Macao. Contact: longhe@gwu.edu

In this paper, we study how to promote hydrogen fuel-cell vehicles (HFVs) adoption by deploying HFV infrastructure and utilizing renewable sources. We formulate a planning model that integrates transportation and power grid networks. Our model jointly determines the locations and capacities of hydrogen refueling stations (HRSs) and hydrogen plants, as well as power generation, electricity transmission and grid upgrade. Applying our model to the case of Sichuan, a province in China with abundant hydropower resources and a vast amount of hydropower curtailment, we discuss how the HFV infrastructure should be deployed to reach different levels of HFV adoption target. We also develop insights into the effectiveness of promoting HFVs in reducing hydropower curtailment and the benefit of grid modeling through numerical experiments.

4 On the Complementarity Between Servicizing and Remanufacturing: Economic and Environmental Implications

Xichen Sun[1], Tharanga Rajapakshe[2], Rogelio Oliva[1], [1]Texas A&M University, College Station, TX, [2]University of Florida, Gainesville, FL, Contact: xsun@mays.tamu.edu

The recent shift in customer demand from product ownership to more economically attractive alternatives has motivated manufacturers to offer servicizing - a business strategy that sells a product's functionality as a service. Using a stylized model, this study investigates the complementarity between servicizing and remanufacturing in terms of firms' economic and environmental performance. We show that under certain conditions, adopting servicizing may contract the remanufactured product market, harm the environment, or both.

Sunday, 12:30 PM–1:45 PM

SC34

CC - Room 145
Supply Chain Practice and Empirics
Contributed Session

Session Chair
Brian Petrus, Westminster College, New Wilmington, PA

1 Redesigning Consumer Goods Supply Chains: Too Late, too Expensive?

Miguel Suarez, SKEMA Business School, Paris, France. Contact: miguel.suarez@skema.edu

One of the main lessons of the COVID-19 pandemic is the urgent need to design smarter, stronger and more diverse supply chains. Whilst there is a plethora of academic frameworks about different types of supply chain strategies, a lack of empirical approaches about how to redesign a supply chain in a structured way is evident. Especially in the case of consumer goods supply chains, choice of an optimal supply chain strategy has been the object of mainstream research: They are to be lean on the supply side, agile on the demand side and on top of everything robust, too, as disruptions often decide between financial success and bankruptcy. However and in spite of high stakes related with the right choice and timely implementation of supply chain strategy, this paper shows that consumer goods companies need too long to redesign their supply chains and points out the reasons for that.

2 The More Flexible the Better? Impacts of Manufacturing Flexibility on Supply Chain Responsiveness and Variability

Karolay Yepes Buitrago, Betzabé Rodríguez, University of Puerto RIco, Mayaguez, PR, Contact: karolay.yepes@upr.edu

Supply chain flexibility has been considered a strategic capability for industries since it allows the chain to adapt to market needs. Still, flexibility could add unwanted variability. In this regard, how flexible a manufacturer needs to be? This study seeks to answer this question using a simulation approach to compare different flexible and non-flexible scenarios at the manufacturer level and evaluate the impact on responsiveness and variability in the supply chain. Lot size variation and machine capabilities are considered drivers of flexibility. A case inspired by the pharmaceutical industry is studied. The analysis provides managerial insights to determine the needed trade-off to achieve a viable flexibilization scheme without compromising process stability.

3 Pandemic and Global Supply Chain Exploration

Brian Petrus[1], Christie Nelson[2], Benjamin Nelson[2], [1]Westminster College, New Wilmington, PA, [2]Rutgers University, Princeton, NJ, Contact: petrusba@westminster.edu

We investigated global supply chain challenges and the path to normalization. We evaluated three scenarios: (i) global outbreak of Covid-19; (ii) uneven reopening and pandemic related recovery efforts; and (iii) Russian invasion of Ukraine. We examined the impact on consumer, industrial, and commodity sectors. We performed data-driven analysis of certain key factors, such as the availability of semiconductors.

Sunday, 12:30 PM–1:45 PM

SC35

CC - Sagamore 1

Stochastic Mixed Integer Programming and Applications

General Session

Session Chair

Haoxiang Yang, The Chinese University of Hong Kong, Shenzhen, Shenzhen, China.

Session Chair

Cheng Guo, Clemson University, New York, NY

1 Incorporating Dantzig-Wolfe Decomposition into Branch-and-Cut by Cutting Planes

Rui Chen[1], Oktay Gunluk[2], Andrea Lodi[1], [1]Cornell Tech, New York, NY, [2]Cornell University, Ithaca, NY, Contact: rui.chen@cornell.edu

Dantzig-Wolfe (DW) decomposition is a well-known technique in mixed integer programming (MIP) for decomposing and convexifying constraints to obtain potentially strong dual bounds. We investigate Fenchel cuts that are derivable from DW decomposition and show that they can provide equally strong bounds as DW decomposition. These cuts in the primal space can be incorporated into a standard branch-and-cut algorithm to utilize the dual information obtained from DW decomposition. We test our approach on MIP problems where DW decomposition can efficiently provide strong dual bounds. Numerical results show that the proposed cuts are helpful for accelerating the solution of such problems under the branch-and-cut framework without the sophistication of implementing branch-and-price.

2 Stochastic Operations of Transmission Power Systems: Challenges and Benefits

Dahye Han[1], Mathieu Tanneau[1], Pascal Van Hentenryck[2], [1]Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA

The growing penetration of renewable generation and distributed energy resources has led to increased operational uncertainty for transmission system operators. In that context, the talk discusses the value of stochastic optimization in the various stages of power systems operations. From day-ahead to real-time operations, the computational challenges and practical benefits of stochastic unit commitment and economic dispatch formulations are discussed. Numerical results are presented on real-life systems in the US and France.

3 Robust Optimization with Continuous Decision Dependent Uncertainty

Haoxiang Yang[1], Hongfan Chen[2], Andy Sun[3], [1]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [2]The Chinese University of Hong Kong, Hong Kong, China; [3]MIT, Catonsville, MD, Contact: yanghaoxiang@cuhk.edu.cn

We consider a robust optimization problem with continuous decision-dependent uncertainty (RO-CDDU). RO-CDDU has two main features: an uncertainty set with linear dependence on continuous decision variables and a convex piecewise linear objective function. We prove that RO-CDDU is NP-hard in general. To address the computational challenges, we reformulate RO-CDDU to an equivalent mixed-integer nonlinear program with a decomposable structure. Such an MINLP model can be further transformed into a mixed-integer linear program by enumerating the extreme points of the uncertainty set. We propose an alternating direction algorithm and a column generation algorithm to iteratively solve the MILP formulation. We conduct numerical studies of RO-CDDU on a demand response management problem in electricity markets and demonstrate promising computational performance.

Sunday, 12:30 PM–1:45 PM

SC36

CC - Sagamore 2

Robust, Interpretable, and Fair Machine Learning

General Session

Session Chair
Phebe Vayanos, University of Southern California, Los Angeles, CA

Session Chair
sina Aghaei, USC, Los Angeles, CA

1 Strong Optimal Classification Trees

sina Aghaei, Andres Gomez, Phebe Vayanos, University of Southern California, Los Angeles, CA, Contact: saghaei@usc.edu

Decision trees are among the most popular and interpretable ML models. We consider the problem of learning optimal binary classification trees. Literature on the topic has burgeoned in recent years, motivated by the empirical suboptimality of heuristic approaches and the tremendous improvements in mixed- integer optimization (MIO) technology. Yet, existing MIO-based approaches from the literature rely on weak formulations, resulting in slow convergence and large optimality gaps. To fill this gap, we propose a flow-based MIO formulation which can accommodate side constraints to enable the design of interpretable and fair decision trees. We show that our formulation has a stronger linear optimization relaxation than existing methods.

2 Fair Optimization

Qing Ye, Weijun Xie, Virginia Tech, Blacksburg, VA, Contact: yqing1@vt.edu

This paper studies decision-making problems in presence of the group unfairness issues via an optimization lens. We introduce several fair optimization models and develop efficient algorithms to generate fair and efficient decisions. We apply the framework to a range of fair decision-making problems, including medical resource allocation and political redistricting.

3 Multistage Robust Classification with Fairness Constraints

Zhuangzhuang Jia[1], Grani Adiwena Hanasusanto[2], [1]The University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, Austin, TX, Contact: zj2869@austin.utexas.edu

In this talk, we study the multistage fair classification problem where fairness is explicitly incorporated as a constraint in the training process. We use techniques from distributionally robust optimization to enhance the out-of-sample performance. More specifically, an ambiguity set centered around the empirical distribution via Wasserstein metric is employed to model the uncertainty. We get a conservative approximation for the worst-case equal opportunity unfairness measure. We show that our approximation is equivalent to a mixed-integer optimization problem that can be solved using off-the-shelf optimization solvers. We demonstrate that our model mitigates unfairness with a negligible drop in predictive accuracy on both synthetic and real datasets.

4 Odtlearn: A Python Package for Learning Optimal Decision Trees

Patrick Vossler[1], Sina Aghaei[2], Nathan Justin[2], Nathanael Jo[2], Phebe Vayanos[2], Andres Gomez[2], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, Contact: pvossler@usc.edu

We present the ODTlearn Python package for learning optimal classification trees via mixed-integer programming. The package provides classifiers for several settings including binary classification with fairness constraints, binary classification under adversarial perturbations to data features, and personalized treatment assignment. We provide a standardized API that can directly interact with the well-established scikit-learn API, making it easy to use with existing data analysis pipelines. In addition to the high-level API, the package provides access to the fitted binary tree and includes customizable visualization methods for each classifier. The ODTlearn source code is available under a permissive open-source license.

Sunday, 12:30 PM–1:45 PM

SC37

CC - Sagamore 6
Data Driven Distributionally Robust Optimization
General Session

Session Chair
Kartikey Sharma, [1]</sup

1 Residuals-based Distributionally Robust Optimization with Covariate Information

Guzin Bayraksan[1], Rohit Kannan[2], Jim R. Luedtke[3], [1]The Ohio State University, Columbus, OH, [2]Los Alamos National Laboratory, Los Alamos, NM, [3]University of Wisconsin-Madison, Madison, WI, Contact: bayraksan.1@osu.edu

We consider data-driven approaches that integrate a machine learning prediction model within distributionally robust optimization (DRO), given limited joint observations of uncertain parameters and covariates. The approach uses residuals of the prediction/regression model to create a nominal distribution. We investigate asymptotic and finite-sample properties using Wasserstein, sample robust, and phi-divergence-based ambiguity sets within our DRO formulations, and explore cross-validation approaches for sizing these ambiguity sets. Numerical experiments validate our theoretical results, study the effectiveness of our approaches for sizing ambiguity sets, and illustrate the benefits of our DRO formulations in the limited data regime.

2 Fast Robust Classifiers for Data Streams

Kartikey Sharma, 1</sup

In this paper, we consider classification problems with streaming data that can be modeled by a time series for each class. Current methods for data streams require substantial re-computation after new observations. We develop a method that requires minimal effort to capture new information. For this, we extend the concept of Minimax Probability Machine (MPM) towards classifying data streams, and develop two algorithms: (i) The Adaptable Robust Classifier (AdRC), efficiently re-solves the MPM problem at every time step using updated moments. (ii) The Adjustable Robust Classifier (AjRC), adversarially learns the time series models and provides decision rules to adjust the classifier to new observations. Both methods are robust against the uncertainty inherent in time series. The performance of both of these methods is probed with numerical experiments.

3 Sequential Domain Adaptation by Synthesizing Distributionally Robust Experts

Bahar Taskesen, EPFL, Frankfurt am Main

Least squares estimators, when trained on a few target domain samples, may predict poorly. Supervised domain adaptation aims to improve the predictive accuracy by exploiting additional labeled training samples from a source distribution that is close to the target distribution. Given available data, we investigate novel strategies to synthesize a family of least squares estimator experts that are robust with regard to moment conditions. When these moment conditions are specified using Kullback-Leibler or Wasserstein-type divergences, we can find the robust estimators using convex optimization. We use the Bernstein online aggregation algorithm on the proposed family of robust experts to generate predictions for the sequential stream of target test samples.

4 Targeted Robustness in Minimizing Extreme Risks with Limited Data

Anand Deo, Karthyek Murthy, Singapore University of Technology and Design, Singapore, Singapore. Contact: karthyek_murthy@sutd.edu.sg

We introduce a new approach for robustifying objectives involving risk measures such as CVaR against the error introduced by "plugging-in" a model estimated from data. Differing from the conventional approach of hedging against the worst-possible element from an ambiguity set, the proposed estimator seeks to automatically cancel the bias introduced despite not knowing the nature of the error committed in the estimation step. This debiasing exercise is shown to lead to consistent decisions with exponentially fewer data samples than required by sample-average approximation. These findings add to the growing body of evidence on the effectiveness of targeted form of robustness towards tackling major challenges in "estimate, then-optimize" paradigm while optimizing under uncertainty.

Sunday, 12:30 PM–1:45 PM

SC38

CC - Sagamore 7

Theory, Algorithms, and Applications of Multistage Optimization I

General Session

Session Chair

Shixuan Zhang, Georgia Institute of Technology, Atlanta, GA

Session Chair

Andy Sun, MIT, Catonsville, MD

1 Data-driven Multistage Distributionally Robust Optimization

Rui Gao, University of Texas at Austin, Austin, TX, Contact: rui.gao@mccombs.utexas.edu

We consider multistage distributionally robust optimization with nested distance. Due to the non-convexity of the uncertainty set, the resulting multistage distributionally robust problem is notoriously difficult to solve. Despite this challenge, we develop an equivalent dynamic programming reformulation. Our contributions are three-fold: (1) Modeling-wise, the dynamic programming reformulation unifies two different formulations for distributionally robust multistage problems. (2) Computation-wise, we identify conditions under which the robust Bellman recursion can be solved via tractable convex programs. (3) Algorithm-wise, we develop a stochastic dual dynamic programming algorithm and demonstrate its superior out-of-sample performance.

2 A Long-term Generation Expansion Planning Considering Emission Quotas Under Multiple Uncertainties

Anil Kaya[1], Steffen Rebennack[2], [1]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany; [2]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany. Contact: anil.kaya@kit.edu

We introduce a long-term stochastic power generation expansion model, considering multiple uncertainties. Our aim is to minimize the total cost including investment and expected operational costs during the planning horizon. Model is defined as a two-stage stochastic mixed-integer linear program which is solved by Benders decomposition algorithm. The master problem is a deterministic problem that computes investment and retirement decisions whereas the sub-problem is a multi-stage stochastic linear optimization problem that determines operational decisions under multiple uncertainties with emission constraints. The sub-problem is solved by a stochastic dual dynamic programming. Results are coupled with an agent-based electricity market simulation (AMIRIS). We present a case study for the German power system to illustrate the efficiency of our approach.

3 Multistage Stochastic Programs with a Random Number of Stages: Applications in Hurricane Relief Logistics Planning

Murwan Siddig[1], Yongjia Song[2], [1]RWTH Aachen University, Aachen, Germany; [2]Clemson University, Clemson, SC, Contact: yongjis@clemson.edu

We consider a logistics planning problem of prepositioning relief items in preparation for an impending hurricane landfall. This problem is modeled as a multiperiod network flow problem where the objective is to minimize the logistics cost of operating the network and the penalty for unsatisfied demand. We assume that the demand for relief items can be derived from the hurricane's predicted intensity and landfall location, which evolves according to a Markov chain. We consider a multistage stochastic programming model with a random number of stages and benchmark its performance with other approximation policies such as the static and rolling-horizon two-stage stochastic programming approaches. Our numerical results provide key insight into the value of multistage stochastic programming in disaster relief logistics planning.

4 Decentralized Gossip-based Stochastic Bilevel Optimization over Communication Networks

Xuezhou Zhang, Princeton University, Princeton, NJ, Contact: zhangxz1123@gmail.com

This work studies the setting of distributed bilevel optimization over a network where agents can only communicate with neighbors, with examples from multi-task, multi-agent learning and federated learning. We propose a gossip-based distributed bilevel learning algorithm that allows networked agents to solve both the inner and outer optimization problems in a single timescale and share information via network propagation. We show that our algorithm enjoys the $\cO(\frac{1}{K \epsilon^2})$ per-agent sample complexity for general nonconvex bilevel optimization, achieving a speedup that scales linearly with the network size. The sample complexities are optimal in both ϵ and K. We evaluate our algorithm on the tasks of hyperparameter tuning and decentralized reinforcement learning, and show that our algorithm achieves superior efficiency.

Sunday, 12:30 PM–1:45 PM

SC39

CC - Room 201

Theory and Applications of Global Optimization

General Session

Session Chair

Emily Speakman, University of Colorado Denver, Denver, CO

1 New Results in the Global Minimization of Molecular Potential Energy Functions

Anatoliy Kuznetsov[1], Nikolaos Sahinidis[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: akuznetsov3@gatech.edu

In this work, we introduce novel convexification techniques for minimization problems involving the Lennard-Jones potential, a common component of molecular potential energy functions. Additionally, we present optimality-based bounds on the inter-particle distances in Lennard-Jones clusters. In order to construct these bounds, we extend a known geometric argument by incorporating upper bounds on the global minima. We present an open-source implementation of these results, and demonstrate their impact using the Lennard-Jones cluster structure prediction problem as a benchmark with the global optimization solver BARON. Finally, we discuss extensions of our results to other molecular potential energy functions.

2 Optimal Recursive McCormick Linearizations for Multilinear Programs (MLP)

Arvind Raghunathan[1], Carlos Cardonha[2], David Bergman[3], Carlos Nohra[1], [1]Mitsubishi Electric Research Laboratories, Cambridge, MA, [2]University of Connecticut, Storrs, CT, [3]University of Connecticut, Waltham, Contact: raghunathan@merl.com

We consider development of strong Linear Programming (LP) relaxations of MultiLinear Programs (MLPs) or linearization of MLP. The LP relaxations are derived using Factorable Programming techniques introduced in the 1970s and implemented in state-of-the-art global optimization solvers. In this talk, we present two fundamental innovations to this linearization approach. First, we present a method for identifying the linearization that yields the smallest size LP relaxation for a given MLP. Second, we present a method for identifying the linearization that yields the best bound for a given LP size. Our results on a collection of benchmarks indicate that our formulation can find smaller linearizations (up to 30% reduction in number of variables) and tighter relaxations (30% reduction in the root-node optimality gaps).

3 A Novel Algorithm for Constructing Tight Quadratic Underestimators for Global Optimization

William Strahl[1], Arvind Raghunathan[2], Nikolaos Sahinidis[3], Chrysanthos E. Gounaris[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Mitsubishi Electric Research Laboratories, Cambridge, MA, [3]Georgia Institute of Technology, Atlanta, GA, Contact: wstrahl@andrew.cmu.edu

Global optimization algorithms extensively utilize polyhedral outer approximations of convex relaxations to compute lower bounds. Noting recent improvements in algorithms for solving quadratically constrained quadratic programming problems, we introduce quadratic non-linearity into outer approximation methods at the prospect of computing tighter bounds. We present an algorithm to construct quadratic outer approximators for twice differentiable convex functions and non-convex difference of convex functions. Using function and optimization problem examples extracted from global optimization benchmark libraries, we demonstrate the quality of the quadratic underestimators and evaluate the root-node lower bounds they provide.

4 Using Volume to Compare Polyhedral Relaxations: What Has Been Done so Far?

Emily Speakman, University of Colorado Denver, Denver, CO, Contact: emily.speakman@ucdenver.edu

Volume has been used in the literature as a measure to compare alternative relaxations in the context of mixed-integer linear and nonlinear optimization. Here, we consider various results obtained for polyhedral relaxations and discuss techniques to extend and generalize these results. We will present ongoing work in this area and identify possible directions for further research.

Sunday, 12:30 PM–1:45 PM

SC40

CC - Room 202

Network and Graph Optimization

Contributed Session

Session Chair

Hamish Thorburn, Lancaster University, Lancaster, United Kingdom.

1 Multi-visitor Trip Planning with Activity Reservations in Crowded Destinations

Joris Slootweg, CWI, Amsterdam, Netherlands. Contact: joris.slootweg@cwi.nl

In our study we plan leisure trips in congested areas for visitors with heterogeneous preferences and with reservations for activities. We develop an algorithm that through a combination of customization and coordination can improve average user satisfaction considerably. Numerical experimentation and a case study show that our algorithm outperforms the classical First-Come-First-Served reservation policy both in terms of user happiness, and in terms of fairness among visitors. Moreover, our results show that our algorithm leads to good solutions compared to optimal for small-sized instances. Finally, the computational effort with regard to number of visitors is bounded by the capacity and the number of events, while the increase in computation time for the number of attractions is bounded by the average number of activities that fit into a trip.

2 Graph Reduction and Row Generation Schemes for Finding Maximum Independent Set

Dongwoo Kang, Hong Seo Ryoo, Korea University, Seoul, Korea, Republic of. Contact: towarmer@korea.ac.kr

An Independent set in a graph is a set of vertices that are pairwise not adjacent. The maximum independent set (henceforth, MIS) problem is an optimization problem to find the largest independent set in a graph, which is well-known to be NP-complete. For finding an MIS of a large and dense graph, we develop a graph reduction/simplification scheme that corresponds to row generation in a corresponding optimization problem based on edge information and optimality criteria. More specifically, we reduce the original graph into a weighted graph of disjoint independent sets, each of which represents a key relation with regard to maximum cardinality. This allows one to find an MIS in a graph on smaller-size, weighted graphs obtained from the original one. We demonstrated the efficacy and efficiency of our new results with benchmark and randomly generated graphs.

3 Staff Allocation in Multicommodity Processing Facilities Using Network Design Models

Hamish Thorburn, Anna-Lena Sachs, Jamie Fairbrother, John Boylan, Lancaster University, Lancaster, United Kingdom. Contact: h.thorburn@lancaster.ac.uk

Many facilities involve sequential processing of different materials. Often these materials need to pass through different work areas to be processed. Adequate staff levels in these facilities is essential, as delays upstream affect processing downstream. Furthermore, it is beneficial to shift managers to minimise staff allocated (to reduce costs) and beneficial to workers to minimise shift changes (for convenience). We use a network design model to set appropriate staff levels, and apply this model to a mail centre. We solve this model using a mixed-integer programming formulation, minimising both total staff allocated and number of changes in a shift. The two objectives are balanced by minimising a weighted linear combination of the objectives, with weights set to prioritise one objective over the other. Our results improve on those used in practice on both objectives.

Sunday, 12:30 PM–1:45 PM

SC41

CC - Room 203

The Power of Adaptivity in Learning and Decision-making

General Session

Session Chair

Rohan Ghuge, University of Michigan, Ann Arbor, MI

1 A Sharp Memory-regret Trade-off for Multi-pass Streaming Bandits

Arpit Agarwal[1], Sanjeev Khanna[2], Prathamesh Patil[2], [1]Columbia University, New York, NY, [2]University of Pennsylvania, Philadelphia, PA, Contact: arpit.agarwal@columbia.edu

The stochastic K-armed bandit problem has been studied extensively due to its wide-ranging applications such as online advertising, clinical trials etc. Motivated by applications where the number of arms can be massive, we consider a streaming setting where the arms are presented in a stream and the algorithm uses limited memory to process these arms. We establish tight upper and lower bounds on the trade-off between memory and regret when B passes over the stream are allowed, for any B≥1. Our results uncover a surprising *sharp transition phenomenon*: O(1) memory is sufficient to achieve \tilde{?}(T^{1/2+1/(2^{B+2}-2)}) regret in B passes, and increasing the memory to any quantity that is o(K) has almost no impact on further reducing this regret.

2 The Pandora's Box Problem with Sequential Inspections

Ali Aouad[1], Jingwei Ji[2], Yaron Shaposhnik[3], [1]London Business School, London, United Kingdom; [2]USC, Los Angeles, NY, [3]University of Rochester, Rochester, NY, Contact: yaron.shaposhnik@gmail.com

The Pandora's box problem is a core model in economic theory that captures an agent's (Pandora's) search for the best alternative (box). We study an important generalization of the problem where the agent can either fully open boxes for a certain fee to reveal their exact values or partially open them at a reduced cost. This introduces a new tradeoff between information acquisition and cost efficiency. We employ an array of techniques in stochastic optimization to provide a comprehensive analysis of this model and show that intuitive threshold-based policies that extend the Pandora's box optimal solution provide very effective solutions.

3 Instance-optimal PAC Algorithms for Contextual Bandits

Zhaoqi Li, University of Washington, Seattle, WA, Contact: zli9@uw.edu

In the stochastic contextual bandit setting, regret-minimizing algorithms have been extensively researched, but their instance-minimizing best-arm identification counterparts remain seldom studied. In this work, we focus on the stochastic bandit problem in the PAC setting: given a policy class, the goal of the learner is to return a policy whose expected reward is approximately that of the optimal policy with high probability. We characterize the first instance-dependent PAC sample complexity of contextual bandits, and provide matching upper and lower bounds. We show that no algorithm can be both minimax-optimal for regret minimization and instance-dependent PAC for best-arm identification. Our main result is a new instance-optimal and computationally efficient algorithm that relies on a polynomial number of calls to a cost-sensitive classification oracle.

4 Batched Dueling Bandits

Arpit Agarwal[1], Rohan Ghuge[2], Viswanath Nagarajan[2], [1]Columbia University, New York, NY, [2]University of Michigan, Ann Arbor, MI

The K-armed dueling bandit problem, where the feedback is in the form of noisy pairwise comparisons, has been widely studied. Previous works have only focused on the sequential setting where the policy adapts after every comparison. However, in many applications such as search ranking and recommendation systems, it is preferable to perform comparisons in a limited number of *parallel batches*. We study the *batched K-armed dueling bandit* problem under two standard settings: (i) existence of a Condorcet winner, and (ii) strong stochastic transitivity and stochastic triangle inequality. For both settings, we obtain algorithms with a smooth trade-off between the number of batches and regret. Our regret bounds match the best known sequential regret bounds (up to poly-logarithmic factors), using only a logarithmic number of batches.

Sunday, 12:30 PM–1:45 PM

SC42

CC - Room 204

Global Optimization and Machine Learning Flash Session

Flash Session

Session Chair

Tianshu Feng, George Mason University, Keswick, VA

1 Strategies for Non-myopic Bayesian Optimization

Darian Nwankwo, Cornell University, Ithaca, NY

Several strategies for myopic Bayesian optimization have been proposed where the immediate reward is maximized. Myopia isn't inherently bad; rather than under-weighting future consequences, we ignore them altogether. Non-myopic Bayesian optimization aims to resolve these issues by using "lookahead" algorithms that maximize a reward over a finite horizon. In this work, we provide a novel formulation for constructing non-myopic heuristics using well-tested myopic heuristics as building blocks. Our formulation creates a family of non-myopic acquisition functions that is highly parametric; the choice of "base acquisition function" and horizon creates this familial space.

2 Robust Matrix Completion with Heavy-tailed Noise

Bingyan Wang, Princeton University, NJ

We study how to estimate an underlying low-rank matrix given a set of highly incomplete entries with heavy-tailed noise. Toward this end, we adopt Huber loss which is robust against large errors when the parameter is carefully designed to balance the Huberization biases and robustness. Then, we propose an efficient nonconvex algorithm via a low-rank matrix factorization with gradient decent with robust spectral initialization. We prove that under bounded second moment condition on the error distribution, the Euclidean error of the iterates generated by the algorithm decrease geometrically fast until achieving a minimax-optimal estimation error, which has the same order as the sub-Gaussian case.

3 Random-key Optimization - Problem Independent Solvers for Combinatorial Optimization

Mauricio G. C. Resende[1], Martin Schuetz[2], Kyle Brubaker[3], Helmut Katzgraber[4], [1]Amazon.com, Inc., Bellevue, WA, [2]AWS, New York, NY, [3]AWS, San Diego, CA, [4]AWS, Seattle, WA

A random key is a randomly-generated real number in the interval (0,1]. A vector of random keys X is a vector of N random keys. A solution to a combinatorial optimization problem can be encoded as a vector of random keys. Given X, a decoder is a deterministic algorithm that takes X as input and outputs a solution to the optimization problem. As an example, consider the decoder that sorts the keys in X and outputs the indices of the sorted vector of random keys. Any solution represented as a permutation (e.g., TSP) can be recovered with this decoder. A Random-Key Optimizer (RKO), which operates in the space of the random keys and uses a decoder to evaluate solutions, is problem independent. Given an RKO one needs only to implement a decoder to apply the algorithm to a specific problem. An example of an RKO is the Random-Key GA of Bean (1994). In this talk we present other examples of RKOs.

4 Exploration of Power Demand Spatial Patterns Using Unsupervised Learning

Alfredo Oneto[1], Paolo Gabrielli[1], Giovanni Sansavini[2], Filippo Tettamanti[1], Blazhe Gjorgiev[1], [1]ETH Zurich, Zurich, Switzerland; [2]ETH Zurich, Zurich, Switzerland. Contact: aalfredo@ethz.ch

"Distribution grid data is crucial to assess the ability of the distribution grids to accept new loads and distributed sources in the light of the energy transition. However, getting reliable distribution grid data remains a challenge. Consequently, many researchers use generic data sets. Unsupervised learning has been identified as a promising approach to tackle this problem because it does not require prior knowledge of the power grids. This work proposes a novel method that identifies supply zones for power demand, which are used to derive country-wide distribution grid models using state-of-the-art routing schemes."

5 Towards Robust Cyber Vulnerability Management

Soumyadeep Hore, Ankit Shah, University of South Florida, Tampa, FL, Contact: soumyadeep@usf.edu

Vulnerability management is a critical task performed by Cyber Security Operations Centers (CSOC), which consists of vulnerability prioritization and mitigation. Researchers have explored triage methods by modeling the vulnerability selection for mitigation as a deterministic optimization problem. However, the vulnerability arrival and mitigation processes are highly stochastic due to the uncertainty in both the number and type of arrivals, as well as the time required to mitigate them. Hence, it is critical to model uncertainty in optimizing vulnerability management at a CSOC. In this talk, we present novel modeling and solution approaches for solving this problem under uncertainty.

6 Performance Enhancement Program Framework for Convex Smooth Optimization

Yunheng Jiang, Clemson University, Clemson, SC

We derived new parameters by studying the Performance Enhancement Program framework for convex smooth optimization.

7 Explaining Adverse Actions in Credit Decisions Using Shapley Decomposition

Vijayan N. Nair[1], Tianshu Feng[2,1], Linwei Hu[1], Zhanyang Zhang[1], Jie Chen[3], Agus Sudjianto[1], [1]Wells Fargo, Charlotte, NC, [2]George Mason University, Fairfax, VA, [3]Wells Fargo, San Francisco, CA, Contact: tfeng@gmu.edu

When a financial institution declines an application for credit, an adverse action (AA) occurs. The applicant is then entitled to an explanation for the negative decision. This work focuses on credit decisions based on predictive models for the probability of default and proposes a methodology for AA explanation. The problem involves identifying the important predictors responsible for the negative decision. In this work, we consider models with low-order interactions and develop an intuitive approach based on first principles. We show how the methodology generalizes to the well-known Shapely decomposition and the concept of Baseline Shapley (B-Shap). Compared with other Shapley techniques for the local explanation of machine learning outputs, B-Shap is more computationally tractable. An illustrative case study is used to demonstrate the usefulness of the method.

Sunday, 12:30 PM–1:45 PM

SC43

CC - Room 205

OPT/Integer and Discrete Optimization Flash Session

Flash Session

Session Chair

Jung Yun Bae, Michigan Technological University, Houghton, MI

1 Risk-adjustable Chance Constrained Programs with Right-hand Side Uncertainty Using Wasserstein Metric

Yiling Zhang, University of Minnesota, Minneapolis, MN, Contact: yiling@umn.edu

In this presentation, we will talk about distributionally robust chance constraints with random right-hand side (RHS) under Wasserstein ambiguity. The risk tolerance of the chance constraints, instead of being predetermined, is treated as a decision variable, and the objective trades off the risk and the cost of other variables. For discrete distributions, based on efficient points, the problem is formulated as mixed-integer programs where binary variables are used for determining optimal risk tolerance. For continuous distributions, the problem is formulated as mixed conic programs which can be enhanced by valid inequalities via utilizing submodularity. We specify the solution approaches for a demand response problem where chance constraints are used to ensure the probability of consuming renewable energy efficiently.

2 Eliminating Waste in Cadaveric Organ Allocation

Peng Shi, Junxiong Yin, University of Southern California, Los Angeles, CA, Contact: junxiong.yin@marshall.usc.edu

There is a shortage in the supply of cadaveric organs in most countries, but many successfully procured and medically tenable organs are being discarded. Many reforms have been or are currently being implemented to address the wastage problem. However, we show that waste will still be a problem as long as the allocation mechanism continues to prioritize patients by their waiting times, which incentivizes patients to reject organs of reasonable quality now to wait for better offers in the future. Through analyzing a theoretical model, we show the necessary and sufficient conditions to eliminating waste and highlight that eliminating waste may inevitably hurt certain patients' welfare.

3 A Decomposition Framework for Solving Gas Network Expansion Optimization

Yijiang Li[1], Santanu Subhas Dey[1], Nikolaos Sahinidis[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: yijiangli@gatech.edu

Gas networks are used to transport natural gas which is an important resource for both residential and industrial customers in the United States. A few types of gas network problems have been studied and the physical properties of the networks generally lead to challenging nonlinear and non-convex optimization tasks. In this paper, we propose a decomposition framework and study the expansion of gas networks. In particular, we focus on the so-called design from scratch problem and utilize a two-stage procedure that involves a convex reformulation of the original problem. We conduct extensive experiments on a benchmark network to validate the performance of our approach.

4 An Extended Formulation of the Uncapacitated Facility Location Problem and Its Polyhedra

Ishwar Murthy, Indian Institute of Management Bangalore, Bangalore, India. Contact: ishwar@iimb.ac.in

We present and extended formulation of the Single Source Uncapacitated Facility Location Problem that incorporates cardinality of the customer set assigned to facility. In this formulation, potential facility location variables as well as variables describing assignment of customers to facilities are disaggregated into n possible cardinalities. We first show that all non-trivial facets of the polytope can be described by 0-1 coefficients for variables representing assignment of customers to facilities. This greatly simplifies the identification of such facets. We next present all structures of these non-trivial facet inequalities, called p-Agent Cardinality Matching Inequalities. This then comprehensively describes the polytope.

5 Models and Algorithms for Stadium Seating Problem

Saharnaz Mehrani, Carlos Henrique Cardonha, David Bergman, University of Connecticut, Storrs, CT

We present models and algorithms for stadium-seating problems, which concern with seat-assignment of multiple small groups of people in a layout with seats aligned in consecutive rows, facing the same direction, with the goal to maximize people's utility. We present different evaluation metrics that consider different utility functions for the attendees. Under these evaluation metrics, we show the performance of our proposed optimization algorithms (exact and heuristic) on a set of randomly generated instances as well as on a real-world instance from a charity organization.

6 Faster Matchings via Learned Duals

Michael Dinitz[1], Sungjin Im[2], Thomas Lavastida[3], Benjamin Moseley[4], Sergei Vassilvitskii[5], [1]Johns Hopkins University, Baltimore, MD, [2]University of California, Merced, Florence, CA, [3]University of Texas at Dallas, Dallas, TX, [4]Carnegie Mellon University, Pittsburgh, PA, [5]Google, New York, NY

A recent line of research investigates how algorithms can be augmented with machine-learned predictions to overcome worst case bounds. This has revealed algorithmic insights into problems, with particular success in the design of online algorithms. We consider improving running times with predictions by combining the idea of machine-learned predictions with that of ``warm-starting" primal-dual algorithms for weighted bipartite matching. We identify and solve three key problems when using learned dual variables, yielding an efficient learning-augmented algorithm for weighted bipartite matching. We validate our theoretical findings through experiments on both real and synthetic data.

7 An Exact Method for the Capacitated Vehicle Routing Problem with Cross Docking

Albert Schrotenboer[1], Tom Van Woensel[2], David Lai[3], Jian Zhang[4], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Eindhoven University of Technology, Mb Eindhoven, Netherlands; [3]Eindhoven University of Technology, Amsterdam, Netherlands; [4]Eindhoven University of Technology, Eindhoven, Netherlands. Contact: a.h.schrotenboer@tue.nl

Realizing that the depot is readily available location for the temporary storage of orders in practice, this paper presents several exact methods for solving the so-called vehicle routing problem with flexible cross docking options. We explicitly allow each order to either be crossdocked or to be transported without consolidation via the crossdock.

8 A Heuristic for a Multiple Depot Heterogeneous Autonomous Vehicle Routing Problem Considering Workload Balance

Jung Yun Bae[1], Abhishek Patil[2], Myoungkuk Park[2], [1]Michigan Technological University, Houghton, MI,

[2]Michigan Technological University, Houghton, MI, Contact: bae@mtu.edu
While the heterogeneity in multi-vehicle systems is challenging due to the heavy computational load increase on the algorithms, this research aims to develop a heuristic that provides good approximate solutions within a reasonable time. Given autonomous vehicles with different (average) running velocities and load capacities, the heuristic solves that vehicles depart from distinctive depots, visit all given targets and return to the depots while considering workload balancing. The problem is a generalization of the Traveling Salesperson Problem (TSP) and NP-hard. A hierarchy heuristic is proposed based on the primal-dual technique. The algorithm relaxes capacity constraints and solves a min-max multiple depot heterogeneous TSP. The jobs that violate capacity constraints are redistributed to the available vehicles from the relaxed solution.

Sunday, 12:30 PM–1:45 PM

SC44

CC - Room 206
Networks and Game Theory
General Session

Session Chair
Sohil Shah, MIT, Madison, WI

1 Information Preferences of Individual Agents in Linear-quadratic-gaussian Network Games
Furkan Sezer[1], Ceyhun Eksin[2], [1]Texas A&M University-College Station, College Station, TX, [2]Texas A&M University, College Station, TX
We consider linear-quadratic-gaussian network games in which agents have quadratic payoffs that depend on their own and neighbors' actions, and an unknown payoff-relevant state. An information designer determines the fidelity of information revealed to the agents about the payoff state to maximize the social welfare. In this paper, we provide conditions based on the strength of the dependence of payoffs on neighbors' actions under which a rational agent is expected to benefit from optimal solution of full information disclosure. We find that all agents benefit from information disclosure for the star network structure when the game is symmetric and submodular or supermodular. We also identify that the central agent benefits more than a peripheral agent from full information disclosure unless the competition is strong and the number of peripheral agents is small enough.

2 Approximate Submodularity of Maximizing Anti-coordination in Network Games
Soham Das, Ceyhun Eksin, Texas A&M University, College Station, TX, Contact: soham.das@tamu.edu
We consider decentralized learning dynamics for agents in an anti-coordination network game. Agents' utilities playing their preferred actions decrease as more neighbors adopt it, potentially causing agents to select less desirable actions. We measure anti-coordination by the number of edges in the underlying graph that have at least one agent on either end not taking the preferred action on convergence. The MAC problem seeks to find an optimal set of agents to control so that the overall network disconnect is maximized. We show that MAC is approximately submodular in line networks, using which we motivate and derive a performance guarantee for a greedy agent selection algorithm. We further establish average submodularity of MAC for dense bipartite graphs. Finally, we show computationally the effectiveness of greedy strategies to solve MAC on general bipartite networks.

3 Optimal Information Provision for Strategic Hybrid Workers
Sohil Shah[1], Saurabh Amin[2], Patrick Jaillet[3], [1]MIT, Madison, WI, [2]MIT, Cambridge, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: sshah95@mit.edu
We study a strategic planner (SP) who signals about an uncertain infectious risk parameter. Signals affect public belief over the parameter, and hybrid workers then choose where to work. The SP seeks certain outcomes for each realization of the uncertain parameter and maximizes the probability that agents choose such an outcome for the true parameter. If the set of outcomes is invariant to the risk parameter, we derive the optimal signalling mechanism and show that it partitions the parameter domain into at most two intervals with the signals generated by interval-specific distributions. We also solve for the optimal signalling mechanism using a linear program in a situation where the SP seeks to enforce progressively more stringent in-person work capacity limits as the risk parameter increases.

4 Attraction-based Congestion Pricing Method in Monopolistic and Monopolistic Competitive Markets
Li Qinxu[1,2], Sun Zhanbo[1,2], Zhu Baichuan[1,2], [1]Southwest Jiaotong University, Chengdu, China; [2]National Engineering Laboratory of Integrated Transportation Big Data Application Technology, Chengdu, China. Contact: chacylee@my.swjtu.edu.cn
A novel attraction-based pricing (ABP) scheme is proposed to manage traffic demand and alleviate negative traffic externalities. Under ABP, the attraction sites are charged for

causing congestion, and the tolls are (partially) transferred to travelers. The Stackelberg model are used to investigate the impacts. The lower-level in both cases is a route choice model that considers attraction sites' attractiveness and generalized travel cost. In a monopoly market, the upper-level maximizes the total profit of all attraction sites. In a monopolistic competitive market, the noncooperative game among attraction sites is described using variational inequality. The proposed scheme is validated using an illustrative network. Results show that *ABP* is effective in balancing traffic demand and reducing road congestion, without affecting the profits of the attraction sites.

Sunday, 12:30 PM–1:45 PM

SC45

CC - Room 207

Disjunctive Constraints and Cutting Planes

General Session

Session Chair

Bochuan Lyu, Rice University, Houston, TX

Session Chair

Illya V. Hicks, Rice University, Houston, TX

1 Deepest Cuts for Benders Decomposition

Mojtaba Hosseini[1], John G. Turner[2], [1]Tippie College of Business, University of Iowa, Iowa City, IA, [2]University of California - Irvine, Irvine, CA

Benders Decomposition (BD), is a prevalent method for tackling challenging large-scale problems that lie at the heart of operations research. The key element in effective implementation of BD is the derivation of Benders cuts. We introduce a novel unifying Benders cut selection technique based on a geometric interpretation of cut "depth". Leveraging the duality between separation and projection, we develop a Guided Projections Algorithm for producing deepest cuts while exploiting the combinatorial structure or decomposability of problem instances. Through a generalization, we also provide systematic ways of selecting the normalization coefficients in the Minimal Infeasible Subsystems method. As a proof of concept, we demonstrate that deepest cuts often reduce both runtime and number of Benders iterations, as compared to other cut selection strategies.

2 Modeling Combinatorial Disjunctive Constraints via Junction Trees

Bochuan Lyu[1], Illya V. Hicks[1], Joey Huchette[2], [1]Rice University, Houston, TX, [2]Google Research, Mountain View, CA, Contact: bl46@rice.edu

In this work, we study the independent-branching (IB) framework of combinatorial disjunctive constraints (CDCs) and identify a class of pairwise IB-representable CDCs: combinatorial disjunctive constraints admitting junction trees. For this class of constraints, the existence of junction trees can be recognized in polynomial time. We also present a polynomial-time heuristic algorithm for the minimum biclique cover problem on the associated conflict graphs to build small and strong MIP formulations. Additionally, we apply the heuristic to find smaller MIP formulations of generalized special ordered sets with fewer variables and constraints than the existing results.

3 A Combinatorial Disjunctive Constraint Approach to Optimal Footstep Planning

Raul Garcia, Rice University, Houston, TX, Contact: rg66@rice.edu

A central modeling primitive in mathematical optimization is the disjunctive constraint: any feasible solution must satisfy at least one of some finite collection of alternatives. One approach for constructing small, ideal formulations for these is the independent branching scheme, in which the disjunctive constraint is represented in terms of a series of simple choices. In this talk we apply the independent branching scheme framework in the context of footstep planning where each footstep is assigned to one of several polyhedral obstacle-free regions in the plane. Such a formulation requires a biclique cover of an associated graph, with smaller covers resulting in a smaller problem. While the minimal biclique cover problem is NP-complete, we apply a planar separator algorithm in a divide-and-conquer manner to obtain a biclique cover in polynomial time.

Sunday, 12:30 PM–1:45 PM

SC46

CC - Room 208

Emerging Logistics Models

General Session

Session Chair

Mohammad Moshref Javadi, 1</sup

Session Chair

Seokcheon Lee, Purdue University, West Lafayette, IN

1 Performance Comparison of Hydrogen Fuel Cell Drones with Battery Drones for Truck-and-drones Last Mile Delivery System

Jayasurya Ragupathi, Purdue University, West Lafayette, IN, Contact: jragupat@purdue.edu

Hydrogen Fuel Cells are abundant and cleaner sources of energy. Hydrogen Fuel Cell Delivery Drones are much more efficient than battery drones because they have better endurance and payload capacity. This research focuses on comparing the performance of Hydrogen and Battery Delivery Drones for a truck-drone last mile delivery system. The last mile delivery system is modeled as a two-echelon vehicle routing problem with drones where multiple drones are launched from the truck to serve one or more customers. A Mixed Integer Programming model is formulated with an objective to minimize the total time of delivery of both trucks and drones for small/medium customer instances and heuristic algorithms are used to solve for large-size customer instances. A sensitivity analysis is conducted to show delivery time improvements of hydrogen drones over battery drones.

2 Nested Vehicle Routing Problem: Optimizing Drone-Truck Surveillance Operations

Fanruiqi Zeng, Georgia Institute of Technology, Atlanta, GA

We address the coordinated routing of a drone-truck pairing where the drone travels to multiple locations to perform specified observation tasks and rendezvous periodically with the truck to swap its batteries. We develop a MIQCP formulation with critical operational constraints, including drone battery capacity and synchronization of both vehicles during scheduled rendezvous. An enhancement of the MIQCP model is achieved by deriving the equivalent MILP formulation as well as leveraging lifting and Reformulation-Linearization techniques to strengthen the subtour elimination constraints of the drone. We propose an efficient neighborhood search (NS) heuristic. We envision that this framework will facilitate the planning and operations of combined drone-truck missions.

3 Crowd-based Intra-city Service Network Design

Ozgur Satici, Iman Dayarian, University of Alabama, Tuscaloosa, AL

We consider a crowd-based service network design for intra-city package delivery service in a stochastic environment. The network consists of courier company stores that can serve as sorting facilities, and inter-facility transport is performed by a set of contracted drivers and crowd-shippers that are augmented by third-party drivers employed on an as-needed basis. Taking the stochastic information for future demand and crowd-shipper availability, a two-stage stochastic model, based for minimizing the system cost on a rolling time horizon is formulated and solved using Bender's Decomposition. The first stage problem represents the allocation of the contracted drivers, then, in the second stage, available crowd-shippers and third-party drivers are integrated into the network, freeing some of the contracted drivers to be removed from the plan to decrease the cost.

4 Hybrid Truck-drone-robot Delivery Systems with Autonomous Repositioning and Docking Stations

Mohamed R. Salama[1], Sharan Srinivas[2], [1]Purdue University, West Lafayette, IN, [2]University of Missouri, Columbia, MO, Contact: salamam@purdue.edu

This research considers the problem of routing and coordinating multiple aerial drones and ground robots with a single truck for last-mile parcel delivery. Unlike previous works, a network of docking stations and autonomous repositioning of drones and robots are considered in route planning. An optimization model is formulated with the objective of minimizing the delivery completion time. Furthermore, heuristic approaches are developed to efficiently solve large instances. Different delivery settings are assessed to show the impact of autonomous repositioning and the benefit of employing a mothership vehicle (i.e., a truck that can carry drones and robots). The results demonstrate that substantial savings in delivery time can be achieved by operating the hybrid system and provide theoretical as well as practical insights on hybrid truck-drone-robot routing.

Sunday, 12:30 PM–1:45 PM

SC47

CC - Room 209

Advanced Modeling Techniques to Urban Rail Operations

General Session

Session Chair

Saeid Saidi, 1</sup

1 Estimating Rider Journey Variability Using Customer-facing WiFi Connection Data in Toronto, Canada

Willem Klumpenhouwer, Amer Shalaby, University of Toronto, Toronto, ON, Canada. Contact: willem.

klumpenhouwer@utoronto.ca
The goal of measuring public transit reliability performance is to effectively capture the entire journey experience of a rider and understand how this experience changes over time and space. Unfortunately, common measures and metrics used in practice often fall short by focusing on stop-level or vehicle-level reliability and fail to accurately reflect rider experience from origin to destination. Using data from recently introduced WiFi service in the Toronto subway system, we propose and calculate various trip-level performance measures and explore how they vary during disruptions, over the course of a day, and seasonally. These measures can help transit agencies target points of high variability within their system for improvement and to restore rider trust by demonstrating a strong understanding of rider experience.

2 The Effect of a Skip-stop Policy on The Train Frequency of a Mass Transit Line

Rodolphe Farrando[1,2], Nadir Farhi[3], Zoi Christoforou[3,4], Alain Urban[1], [1]RATP, PARIS, France; [2]Université Gustave Eiffel, Paris, France; [3]Université Gustave Eiffel, PARIS, France; [4]University of Patras, Patras, Greece. Contact: rodolphe.farrando@ratp.fr

Implementing a skip-stop policy on a metro line brings benefits to both operators and passengers. In this paper, we develop an algebraic Max-plus model that quantitatively compares train frequency on a line operated with and without a skip-stop policy. The model analytically yields three distinct phases for train frequency: free flow, capacity, and congestion. In addition, we provide and interpret analytical formulas that reveal the impact of the number of trains parity on train frequency. These formulas also allow us to calculate the gains induced by this policy. These gains come from the increase in commercial speed which, in our case, improves the capacity of the line. Finally, the gain function is piecewise linear and depends on the number of trains; we show the existence of an optimal number of trains for which the gain is maximal.

3 Integrated Agent-based Modeling for Dynamic Operations in Urban Rail Transit Systems

Bingyu Zhao[1], Yili Tang[2], [1]Vienna University of Technology, Vienna, Austria; [2]University of Regina, Regina, SK, Canada. Contact: yili.tang@uregina.ca

This study developed an agent-based simulation by integrating the data-driven optimization and passenger behavioral modeling to analyze the dynamic operations in urban rail transit systems. In the proposed simulation framework, an infrastructure environment is generated to establish the transit network characteristics including the platforms, links and transfers. Passengers' travel choices are then modelled within the network involving travel times, crowding costs and the queuing costs. Smartcard and schedule data are incorporated to evaluate the dynamic operations of the transit systems including travel patterns, in-vehicle crowdedness, operational capacity and on-platform queuing times. Results indicate the robustness, scalability and practicality of the integrated agent-based simulation to capture behavioral and operational dynamics.

Sunday, 12:30 PM–1:45 PM

SC48

CC - Room 210
Automated Intralogistics Innovations
General Session

Session Chair
Joyjit Bhowmick, Troy

1 Order Picking for Multi-entity Cooperation in Picking Warehouses

Jingwei Liu, Auburn University, Auburn, AL, Contact: jzl0196@auburn.edu

Motivated by the high flexibility of AMRs (autonomous mobile robots), we propose an order picking method for warehouses where multiple entities (pickers, transporters) with distinct tasks cooperate to fulfill orders. In our method, each picker moves to the assigned locations and picks the items from the racks. After picking an item, the picker will move to a hand-off location (could be the same as the picking location) to place the item on a transporter before picking the next item. Each transporter will take and transport multiple items to a depot to complete the order picking. A MILP model is formulated to generate routes for all entities. Also, a simulation testbed based on Simio is provided to test the performance and robustness of our method under different variabilities.

2 Congestion-aware Path Coordination Game with Markov Decision Process Dynamics

Sarah H.Q. Li, University of Washington, Seattle, WA, Contact: sarahli@uw.edu

To model competitive multi-agent stochastic path planning for heterogeneous players, we propose a novel atomic congestion game framework with Markov decision process (MDP) dynamics. Each player is equipped with a shared MDP state-action space, distinct transition dynamics, and cost functions coupled to the joint probability distribution. At the resulting Nash equilibrium, players avoid congested paths while optimally achieving individual objectives. For a subset of cost functions, finding the Nash equilibrium is equivalent to solving a potential optimization problem. We present an algorithm that extends single-agent MDP solutions to solve for the Nash equilibrium with linear complexity in the number of players. Our results are demonstrated in a warehouse setting where multiple robots autonomously deliver packages while avoiding collisions.

3 Dynamic Order Picking in a Stochastic Retail Store

Joyjit Bhowmick[1], Jennifer A. Pazour[2], Iman Dayarian[3], [1]Troy, [2]Rensselaer Polytechnic Institute, Troy, NY, [3]University of Alabama, Tuscaloosa, AL

We propose new dynamic order picking policies to synchronize collaborative robots (cobots) with stochastically arriving in-store customers and dedicated pickers to fulfill online orders from retail stores. While emerging research has considered cobots in warehouses, where both cobots and pickers are controllable, we capture in-store customers' uncertain arrivals and behaviors. We modeled the problem as a Markov Decision Process and proposed multiple heuristic approaches to govern the item assignments and routing decisions for picking resources. Experiments show the potential to offset the high requirements for human picking resources while meeting high demands and commitments for curbside pickup and home delivery services.

4 Task Assignment and Route Planning in Robotic Warehousing

Cynthia Barnhart[1], Alexandre Jacquillat[2], Riley Lenaway[3], Alexandria Schmid[4], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Sloan School of Management, Cambridge, MA, [3]MIT, Cambridge, MA, [4]MIT, Cambridge, MA, Contact: aschmid@mit.edu

We partner with a major online retailer to optimize two of the core questions in robotic warehousing: task assignment (which robot will pick up which shelf and drop it off at which station) and route planning (which robot travels through which path to avoid congestion). We develop an original integer optimization formulation using a time-space network representation of fulfillment center operations. To solve it, we propose a large-scale neighborhood search algorithm to break the problem down into smaller components, and re-optimize the solution iteratively while maintaining global feasibility. We develop machine learning models and domain-based heuristics to guide the search at each iteration. We demonstrate, via extensive computational experiments, the benefits of our model and algorithm as compared to baseline algorithms and realistic heuristics.

Sunday, 12:30 PM–1:45 PM

SC50

CC - Room 212
e-Business
Contributed Session

Session Chair
Armagan Ozbilge, McMaster University, Hamilton, ON, Canada.

2 A Model of Livestream Selling with Online Influencers

Jing Hou[1], Houcai SHEN[1], Fasheng Xu[2], [1]Nanjing University, Nanjing, China; [2]Syracuse University, Syracuse, NY

This paper develops a model of livestream selling to investigate a firm's optimal livestream adoption strategy. First, livestream selling should only be adopted when the influencer can attract a considerable number of viewers and can accurately identify the product quality, but requires low price discounts from the firm. Second, the livestream adoption always increases the firm's quality investment level but may decrease the quality-price ratio and consequently lead to lower consumer surplus and even social welfare. Third, a lower endorsement reliability or a larger bargaining power of the influencer may benefit the firm. Lastly, as more consumers become sophisticated, it always hurts the product quality and the firm's profit, and may even lower consumer surplus, leading to a "lose-lose" outcome.

3 Game-based Pedagogy in Operations Management: Impact of Playing a Simulation Game and Providing Feedback on Students' Knowledge

Hossein Rikhtehgar Berenji[1], Hossein Najmi[2], [1]Pacific University, Forest Grove, OR, [2]University of Central Oklahoma, Edmond, OK

We use Revised Bloom's Taxonomy framework to measure students' knowledge of Operations Management using Soda Pop Game. Further, we investigate the impact of providing formative feedback (general and detailed feedback) as instructional support on students' performance. Our findings extend the understanding of learning, which results from participation in simulation games and designing game-based pedagogy.

4 Perils and Merits of Cross-channel Returns

Armagan Ozbilge[1], Elkafi Hassini[2], Mahmut Parlar[2],

[1]McMaster University, Hamilton, ON, Canada; [2]McMaster University, Hamilton, ON, Canada. Contact: ozbilgea@mcmaster.ca

We study the impact of cross-channel returns on a bricks-and-clicks dual-channel retailer's overall profit, individual channel-prices, and -demand under two scenarios: (1) exogenous returns, and (2) refund-dependent returns. Our study reveals a number of interesting results, for example, when channel substitutability is high (self- and cross-channel price-sensitive parameters are close), welcoming the returns of online purchases to the B&M store is likely to drive the channel price up, despite a drop in the B&M demand due to the cannibalization effect. The retailer should mind the channel substitutability, return handling costs, and self-channel returns before collecting online returns by her physical facility as cross-channel returns may undermine the overall profit. We are also able to verify that our main findings are fairly consistent under both scenarios.

Sunday, 12:30 PM–1:45 PM

SC52

M - Lincoln

Undergraduate Operations Research Prize II

Award Session

Session Chair

Trilce Encarnacion, University of Missouri- St. Louis, Saint Louis, MO

Sample Complexity of Policy Learning for Inventory Control with Censored Demand

Xiaoyu Fan, Nanjing University, New York, NY

We study both single period and infinite horizon inventory models with offline learning under censored demand. The level of censoring in the data set impacts the learning quality of an offline algorithm. We specify sufficient conditions for the data set under which the optimal policy can be sufficiently learned. Sampling-based algorithms are proposed to circumvent downward biases caused by data censoring. We establish optimal upper bounds on the number of samples needed for the sampling-based solution to perform close to the true optimal solution under any accuracy level with high probability.

Constructing Branching Trees of Geostatistical Simulations

Juan Valencia, Universidad de Santiago de Chile, Santiago, Chile.

This paper proposes the use of multi-stage stochastic programming with recourse for optimised open-pit mine planning. The key innovations are, firstly, that a branching tree of geostatistical simulations is developed to take account of uncertainty in ore grades, and secondly, scenario reduction techniques are applied to keep the trees to a manageable size. Our example shows that different mine plans would be optimal for the downside case when the deposit turns out to be of lower grade than expected. Our approach moves toward adaptive mine planning rather than just producing a single mine plan.

The Way: "Safest" Way Out

Ilkim Bahar Güneri, Beyza Cekinel, Yagmur Lara Gorur, Kadir Can Kasan, Bilkent University, Ankara, Turkey.

In earthquake-prone cities, it is crucial to have a post-disaster plan to mitigate the effects of an earthquake and increase disaster responsiveness. This paper proposes a methodology to solve a bi-objective problem, finding the shortest and safest paths between two points in Istanbul, Fatih after an earthquake. Risk scores of arcs are found based on building attributes and earthquake-related parameters. Weighted sum scalarization is used to find Pareto optimal paths between two points in the network. This paper also presents two methods to make the methodology customizable to other places.

Sunday, 12:30 PM–1:45 PM

SC53

M - Denver

Information Diffusion, Influence, and Engagement on Social Media

General Session

Session Chair

Hanqi Wen, University of Michigan, Ann Arbor, MI

1 Charactering the Motifs of Different Rumor Topics in Weibo During a Public Health Crisis

Lifang Li[1], Ruiyao Xie[2], Haolin Wang[3], Qingpeng Zhang[4], [1]King's College Lodon, London, United Kingdom; [2]Xi'an Jiaotong University, Xi'an, China; [3]Chongqing Medical University, Chongqing, China; [4]City University of Hong Kong, HongKong, Hong Kong. Contact: lifangli2-c@my.cityu.edu.hk

The public health crisis was accompanied by an infodemic. However, rumours of different topics have some differences in nature. For example, some rumours meet people's needs for information, while some rumours cater to users' inherent cognition. Knowing the propagation process of rumours on different topics is the basis for learning the psychological needs of users and can also provide more specific strategies for the governance of rumours. This paper uses Weibo data to classify the rumours on Weibo into four types first; second, the communication network is constructed for each type of rumour and the unique Motif is analysed; third, use psychological theories to explain the rationale for the emergence of different types of motifs in the rumours. This study makes up for the lack of connections between existing rumour propagation theories and data-driven related research.

2 Disentangling SNS Privacy Paradox with the Negative Impression Management SNS-NIM Model

Guruprasad Y. Gadgil[1], Gayle Prybutok[2], Victor Prybutok[3], [1]University of Alaska Anchorage, Anchorage, AK, [2]University of North Texas, Denton, TX, [3]University of North Texas, Denton, TX, Contact: gygadgil@alaska.edu

The SNS-negative-impression-management-model is presented using the mixed approach in this (SNS-NIM) study. This model proposes new constructs for describing the relationships that impact negative impression behaviors on social media platforms. SNS selective disclosure awareness, SNS desired differential privacy awareness, and SNS stalking awareness are all antecedents of online SNS activities in this study. Factor analysis and PLS/SEM are used to analyze 399 useable samples and confirm that the SNS-NIM model creates resonant impressions in a negative mode in SNS contexts. As a result, this study explores and demonstrates how mediating behavioral links increase model complexity.

3 What Drives Engagement During a Large Connective Action on a Financial Social Media Forum - A Text Analytics Perspective

Adrija Majumdar, Shreya Pandey, Indranil Bose, Indian Institute of Management Ahmedabad, Ahmedabad, India.

In this paper, we analyze the mechanisms through which engagement is facilitated in a concerted financial online social movement. We observe the unfolding discussion on a social media forum and show how affective expressions and personal motivation frames lead to higher engagement in the connective action movement. Particularly, we study the impact of a) the personal frame of similarity in expression style b) the personal frame of negative financial sentiments, and c) the personal frame of informational relevance on the popularity of the content.

4 Dynamic Expansions of Social Followings with Lotteries and Give-aways

Hanqi Wen[1], Jingtong Zhao[2], Van-Anh Truong[3], Jie Song[4], [1]The University of Michigan, Ann Arbor, MI, [2]Renmin University of China, Beijing, China; [3]Columbia University, New York, NY, [4]Peking University, Beijing, China.

The problem of how to attract a robust following on social media is one of the most pressing for influencers. We study a practice common on popular social networking platforms of influencers' expanding their followings by running lotteries and giveaways, where a user reposts a particular blog and follows the influencer in order to join a lottery game. We are interested in how the lottery size and the seeding decisions will influence the final reward for such a campaign. We construct an information-diffusion model and show that the influenced population is first convex and then concave and increasing with the lottery size. And we also study the adaptive seeding problem by modeling it as a Markov Decision Process. We show several properties of the optimal policies. Furthermore, we provide managerial insights on both the lottery size and seeding decisions.

Sunday, 12:30 PM–1:45 PM

SC54

M - Marriott 1

Stochastic Models, Epidemiology Simulation, Deep Learning, and Robust Stability

General Session

Session Chair

Chang-Han Rhee, Northwestern University, Chicago, IL

1 Conditional Uniformity and Hawkes Processes

Andrew Daw, University of Southern California, Marshall School of Business, Los Angeles, CA

Classic results provide the distribution of a Hawkes process cluster's size through a connection to branching processes, but this is irrespective of time. Insight into the chronology of the cluster has been more elusive. Here, we employ a novel adaptation of the random time change theorem to establish an analog of the conditional uniformity property enjoyed by Poisson processes, yielding a decomposition with that is valuable both methodologically and practically.

2 Shift, Scale and Restart Smaller Models to Estimate Larger Ones: Agent-based Simulators in Epidemiology

Sandeep Juneja, Tata Institute of Fundamental Research, Mumbai, India.

In this talk we primarily focus on agent based simulators for modelling COVID-19 pandemic and dig deeper into the underlying probabilistic structure of an associated agent based simulator (ABS) to arrive at modifications that allow smaller models to give accurate statistics for larger models. We exploit the observations that in the initial disease spread phase, the starting infections behave like a branching process. Further, later once enough people have been infected, the infected population closely follows its mean field approximation. We build upon these insights to develop a shifted, scaled and restart version of the simulator that accurately evaluates the ABS's performance using a much smaller model while essentially eliminating the bias that otherwise arises from smaller models.

3 Eliminating Sharp Minima from SGD with Truncated Heavy-tailed Noise

Xingyu Wang, 1</sup

Recently, there have been discourses in machine learning literature that heavy-tailed noises in deep learning tasks enable SGDs to efficiently escape from sharp minima, which are known to lead to poor generalization. In this work, we show that by truncating the stochastic gradients in SGD under heavy-tailed noises, we can achieve a much stronger notion of the (almost) complete elimination of sharp local minima from the training trajectories of SGD. First, we establish an Eyring-Kramers type first exit time formula for truncated heavy-tailed SGD. Moreover, under appropriate structural conditions, we prove that the path-wise dynamics of truncated heavy-tailed SGD converge to a continuous-time Markov chain that never visits sharp minima. Our deep learning experiments confirm that truncated heavy-tailed SGD finds "flatter" minima with better generalization.

4 A New Approach to Robust Stability of Multiclass Queueing Networks

Feiyang Zhao[1], John Hasenbein[1], Itai Gurvich[2], [1]University of Texas-Austin, Austin, TX, [2]Northwestern University, Kellogg School of Management, Evanston,, IL, Contact: feiyang_zhao@utexas.edu

The focus of this research is on the robust stability of stochastic processing networks, under a wide class of control policies. A framework for robust stability is developed, in which the resources are given freedom to decide their own priority policy, under some general constraints. We offer a new approach for determining sufficient conditions for robust stability, which builds on, and makes connections to, suitable robust optimization problems, with the collection of priority policies as the uncertainty set. We also show how robust stability of a family of policies is inherited from the stability of some special policies, i.e., static-priority policies.

Sunday, 12:30 PM–1:45 PM

SC55

M - Marriott 2

Model Uncertainty and Distributionally Robust Optimization

General Session

Session Chair

Henry Lam, 1</sup

Session Chair

Shengyi He, Columbia University, New York City, NY

1 On the Limits of Marginal Modeling of Utilities in Consumer Choice

Yanqiu Ruan[1], Xiaobo Li[2], Karthyek Murthy[1], Karthik Natarjan[1], [1]Singapore University of Technology and Design, Singapore, Singapore; [2]National University of Singapore, Singapore, Singapore. Contact: yanqiu_ruan@mymail.sutd.edu.sg

Given data on choices made by consumers for different assortments, a key challenge is to develop tractable models that describe and predict consumer choice behavior. One such choice model is the marginal distribution model. In this paper, we develop an exact characterisation of the set of choice probabilities representable by the marginal distribution model. Allowing for alternatives to be grouped based on the marginal distribution of their utilities, we show (a) verifying consistency of choice probability data with this model is possible in polynomial time and (b) finding the closest fit reduces to solving a mixed integer convex program. Our results show that the marginal distribution model provides much better representational power as compared to multinomial logit and much better computational performance as compared to the random utility model.

2 Inf-convolution, Optimal Allocations, and Model Uncertainty for Tail Risk Measures

Fangda Liu[1], Tiantian Mao[2], Linxiao Wei[3], Ruodu Wang[1], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Science and Technology of China, Hefei, China; [3]Wuhan University of Technology, Wuhan, China. Contact: f27liu@uwaterloo.ca

We study the optimization of risk sharing for general tail risk measures. The inf-convolution of tail risk measures is shown to be a tail risk measure with an aggregated tail parameter, a phenomenon very similar to the cases of Value-at-Risk, the Expected Shortfall and the Range-Value-at-Risk. Optimal allocations are obtained in the settings of elliptical models and model uncertainty. In particular, several results are established for tail risk measures in the presence of model uncertainty, which may be of independent interest outside the framework of risk sharing. The technical conclusions are quite general without assuming any form of convexity of the tail risk measures. Our analysis generalizes in several directions the recent literature on quantile-based risk sharing.

3 Distributionally Robust Nonparametric Gaussian Regression

Xuhui Zhang, Stanford University, STANFORD, CA, Contact: xuhui.zhang@stanford.edu

We study a distributionally robust optimization formulation (i.e. a min-max game) for the problem of non-parametric Gaussian process regression. We choose the best mean-squared error predictor on an infinite-dimensional space against an adversary which chooses the worst-case model in a Wasserstein ball around an infinite-dimensional Gaussian model. The Wasserstein cost function is chosen to control features such as the amount of roughness on the sample paths that the adversary is allowed to inject. We show that the game has a well-defined value (i.e., strong duality holds in the sense that max-min = min-max) and existence of a unique Nash equilibrium which can be computed by a sequence of finite-dimensional approximations.

4 Higher-Order Expansion and Bartlett Correctability of Distributionally Robust Optimization

Shengyi He[1], Henry Lam[2], [1]Columbia University, New York City, NY, [2]Columbia University, New York, NY, Contact: sh3972@columbia.edu

: Distributionally robust optimization (DRO) is a worst-case framework for optimization under uncertainty that has gained recent popularity. In particular, DRO with an uncertainty set constructed as a divergence ball, when the ball size is suitably calibrated, has been shown to provide confidence intervals for nonparametric functionals and bears a duality with empirical likelihood (EL). In this talk, we show how refining this ball size can reduce higher-order coverage errors similar to the so-called Bartlett correction. Our correction, which applies to general von Mises functionals, is more general than the existing EL literature that only focuses on smooth function models or M-estimation. Our analysis relies on a general high-order expansion of DRO and Edgeworth expansion that also implies new insights including a higher-order self-normalizing property of DRO.

Sunday, 12:30 PM–1:45 PM

SC56

M - Marriott 3
Recent Advances in Parallel-server Systems
General Session

Session Chair
Daniela Hurtado-Lange, William and Mary, Williamsburg, VA

1 Transportation Polytope and Its Applications in Two-sided Queues

Sushil Varma, Georgia Institute of Technology, Atlanta, GA

We first analyze the transportation polytope defined as the set of all assignments that divide the fluid supply to meet the fluid demand. We establish novel results on the connectivity of the so-called support graphs and the extreme points of the transportation polytope.
Futhermore, we use the above results to analyze parallel server systems with widespread applications in manufacturing, ride-hailing, call centers, etc. Heterogeneous customers arrive in the system. Only a subset of servers can serve any given customer type. Our contribution is three-fold. We characterize asymptotic delay for a given flexibility graph, design delay-optimal sparse flexibility graphs, and improve the performance of a given system by adding one extra edge. These results serve as a guidebook for designing and improving manufacturing and production systems.

2 Heavy Traffic Queue Length Distribution Without Resource Pooling in an Input-queued Switch

Prakirt Raj Jhunjhunwala, Georgia Institute of Technology, Atlanta, GA

Input-queued switch acts as a representative of SPNs that do not satisfy the so-called complete resource pooling (CRP) condition, and consequently exhibit a multidimensional state space collapse. Except in special cases, only mean queue lengths of such non-CRP systems have been obtained in the literature. In this paper, we develop the transform method to study the steady state distribution of non-CRP systems like Input-queued switch. The key challenge is in solving an implicit functional equation involving the Laplace transform of the heavy-traffic limiting distribution. We then consider the general nxn input-queued switch that has n^2 queues. Under a conjecture on uniqueness of the solution of the functional equation, we obtain an exact joint distribution of the heavy-traffic limiting queue-lengths in terms of a non-linear transformation of 2n iid exponentials.

3 Optimal Scheduling in the Multiserver-job Model Under Heavy Traffic

Isaac Grosof, Carnegie Mellon University, Pittsburgh, PA, Contact: igrosof@cmu.edu

Multiserver-job systems, where jobs require concurrent service at many servers, occur widely in practice. To minimize mean response time, we must balance the twin objectives of prioritizing small jobs and optimizing throughput.
In this presentation, we present the ServerFilling-SRPT scheduling policy, the first policy to minimize mean response time in the multiserver-job model, in the heavy traffic limit. Our results also generalize beyond the known size setting to the unknown or partially known size setting, using the ServerFilling-Gittins scheduling policy.

Sunday, 12:30 PM–1:45 PM

SC57

M - Marriott 4

Starting Academic Career for New QSR Faculty Members 2022

Panel Session

Session Chair

Xiao Liu, AR

1 Starting Academic Career for New QSR Faculty Members 2022

Xiao Liu, University of Arkansas, Fayetteville, AR

A panel of senior QSR faculty will provide advice, tips, and best practices for having a successful academic career. The panel will have discussions on multiple academic topics including writing proposals, publishing in top journals and conferences, and building up strong connections and collaborations.

2 Panelist

Elsayed A. Elsayed, Rutgers University, East Brunswick, NJ

3 Panelist

Kaibo Liu, UW-Madison, Madison, WI

4 Panelist

Kamran Paynabar, ISyE Georgia Tech, Atlanta, GA

Sunday, 12:30 PM–1:45 PM

SC58

M - Marriott 5

Case Studies from the International Statistical Engineering Association

General Session

Session Chair

Arman Sabbaghi, Purdue University, West Lafayette, IN

1 An Introduction to Statistical Engineering

Mark Vandeven, Colgate-Palmolive, Piscataway, NJ, Contact: mark_vandeven@colpal.com

The development of the theory and application of individual statistical and analytical methods has gotten the statistics profession far. However, there is a sense that "a lot of money has been left on the table." These lost opportunities point to the need to think more deeply about how to capture major opportunities by linking and integrating methods into an overall data-based approach to scientific inquiry.
The International Statistical Engineering Association recognizes this need and has devised a unified approach to problem solving which integrates multiple methods in a holistic, integrated framework.
In this session, we will first give an overview of ISEA with emphasis on what makes ISEA distinct from other professional organizations. This overview will touch on key guiding principles and will introduce the six phases of a typical Statistical Engineering project.

2 Testing the Prediction Profiler with Disallowed Combinations - A Statistical Engineering Case Study

Ryan Lekivetz, JMP, Cary, NC, Contact: Ryan.Lekivetz@jmp.com

The prediction profiler is an interactive display that allows a user to explore the relationships between multiple factors and responses. A common use case of the profiler is for exploring the predicted model from a designed experiment. Some experiments require constraining the design region as defined by a set of disallowed combinations that the profiler should obey when presenting a predicted model. While it may not be apparent that software testing can fit within the statistical engineering framework, testing the profiler with disallowed combinations required the creation of a team from across development and testing groups and touched upon each of the fundamental principles of statistical engineering.

3 Predictive Monitoring Using Machine Learning Algorithms and a Real-life Example on Schizophrenia

Leo C. E. Huberts, University of Amsterdam, Amsterdam, Netherlands.

Predictive process monitoring aims to produce early warnings of unwanted events. We consider the use of the machine learning method extreme gradient boosting as the forecasting model in predictive monitoring. A tuning algorithm is proposed as the signaling method to produce a required false alarm rate. We demonstrate the procedure using a unique data set on mental health in the Netherlands. The goal of this application is to support healthcare workers in identifying the risk of a mental health crisis in people diagnosed with schizophrenia. The procedure we outline offers promising results and a novel approach to predictive monitoring.

4 Statistical Engineering Synergies

Dennis Leber, NIST, Gaithersburg, MD, Contact: dennis.leber@nist.gov

As a young and growing professional organization, the International Statistical Engineering Association (ISEA) is working to solidify its identity. Central to this identity is the definition of the discipline of statistical engineering that is colloquially communicated as the art and science of solving complex problems that require data and data analysis. In this talk, we briefly review several INFORMS case studies, drawing contrasts and comparisons to the ISEA case studies presented separately in this session. Through this comparison, we reinforce ISEA's mission and the definition of statistical engineering while highlighting the potential synergies between INFORMS and ISEA.

Sunday, 12:30 PM–1:45 PM

SC59

M - Marriott 6

Modeling Dynamic Network Systems from High Dimensional Data for Change Point Detection

General Session

Session Chair

Ana Maria Estrada Gomez, [1</sup]

1 Multiple Change Point Detection in Reduced Rank High Dimensional Vector Autoregressive Models

George Michailidis, U Florida, Gainesville, FL, Contact: gmichail@ufl.edu

We study the problem of detecting and locating change points in high-dimensional Vector Autoregressive (VAR) models, whose transition matrices exhibit low rank plus sparse structure. The detection is based on a two-step algorithm, wherein the first step, an exhaustive search for a candidate change point is employed for overlapping windows, and subsequently a backwards elimination procedure is used to screen out redundant candidates. The two-step strategy yields consistent estimates of the number and the locations of the change points. The effectiveness of the proposed algorithms and methodology is illustrated on both synthetic and two real data sets.

2 Estimation of High-dimensional Markov-switching VAR Models with an Approximate EM Algorithm

Xiudi Li[1], Ali Shojaie[2], Abolfazl Safikhani[3], [1]Harvard University, Boston, MA, [2]University of Washington, Seattle, WA, [3]George Mason University, Fairfax, VA

Regime shifts in high-dimensional time series arise naturally in many applications. This problem has received considerable attention in low-dimensional settings, with both Bayesian and frequentist methods developed for parameter estimation. The EM algorithm is a particularly popular strategy for parameter estimation in low-dimensional settings, although the statistical properties of the resulting estimates have not been well understood. Moreover, its extension to high-dimensional time series proved challenging. To overcome these challenges, we propose an approximate EM algorithm for Markov-switching VAR models that leads to efficient computation and facilitates the investigation of asymptotic properties of the resulting parameter estimates. We establish consistency of the proposed EM algorithm and investigate its performance in simulation studies.

3 Adaptive Sequential Change-point Detection for Hawkes Networks

Haoyun Wang[1], Yao Xie[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA

We present a new CUSUM procedure for sequential change-point detection in Hawkes networks using discrete events data. Hawkes networks have become a popular model in statistics and machine learning, primarily due to their capability in modeling irregularly observed data where the timing between events carries a lot of information. We propose an online recursive implementation of the CUSUM statistic for Hawkes processes, which is computationally and memory-efficient and can be decentralized for distributed computing. We prove theoretical properties of this new CUSUM procedure, then show the improved performance of this approach over existing methods via simulation studies and an application to population code change-detection in neuroengineering.

4 Graph Analytics-Based Vulnerability Assessment of World Trade Network

Mary E. Ogidigben[1], Dyutimoy N. Das[2], Amanda C. Jurado Guzman[3], Alfonso Mejia[3], Soundar Kumara[1], [1]Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, [3]Pennsylvania State University, University Park, PA, Contact: meo5362@psu.edu

Current disruption due to the pandemic has brought out the importance of the resilience of supply chain networks. A network representation of the world trade network allows us to extract hidden information regarding climate shocks, economic causalities, and dependencies between countries. This allows us to explore the robustness of the network to determine the supply chain reaction/resilience to shocks to better understand vulnerabilities within the global supply chain. We study multi-layered trade networks, as well as nestedness and modularity to make inferences on the resilience characteristics of the global trade networks.

Sunday, 12:30 PM–1:45 PM

SC60

M - Marriott 7

New Frontiers of Data Mining and Machine Learning in Manufacturing

General Session

Session Chair

Jia Liu, Auburn University

Session Chair

Wenmeng Tian, Mississippi State University, Mississippi State, MS

1 Imbalanced Data Classification via Generative Adversarial Network with Application to Anomaly Detection in Additive Manufacturing Process

jihoon Chung, Bo Shen, Zhenyu James Kong, Virginia Tech, Blacksburg, VA, Contact: jihoon7@vt.edu

For the quality assurance of the additive manufacturing (AM) process, classification models have been widely utilized to process anomaly detection. However, since abnormal process states rarely occur in the process, the number of training data from a normal state outweighs the number of abnormal states. It causes imbalanced training data. To overcome this training bias, it is valuable to generate effective artificial sample data for the abnormal process states to make a balanced training set. To achieve it, we propose a novel data augmentation method that is based on a generative adversarial network (GAN). Specifically, the method consists of three-player, namely, discriminator, generator, and classifier. The effectiveness of the proposed method is validated by both open-source data and real-world case studies in polymer and metal AM processes.

2 An Impulse Response Formulation for Small-sample Learning and Control of Additive Manufacturing Quality

Qiang Huang, University of Southern California, Los Angeles, CA, Contact: qiang.huang@usc.edu

Machine Learning for AM (ML4AM) is a viable strategy to enhance 3D printing performance. However, the amount of data required for model training and the lack of ability to infer AM process insights can be serious barriers for black-box learning methods. Due to the nature of low-volume fabrication of infinite product variety in AM, ML4AM also faces ``small data, big tasks” challenges to learn heterogeneous point cloud data and control the quality of new designs. To address these challenges, this work establishes an impulse response formulation of layer-wised AM processes to learn and predict printing quality.

3 Thermal History Data Anonymization for Cross-system Process-defect Modeling for Metal-based Additive Manufacturing

Durant Fullington[1], Linkan Bian[2], Wenmeng Tian[1], [1]Mississippi State University, Mississippi State, MS, [2]Mississippi State University, Mississippi State University, MS, Contact: tian@ise.msstate.edu

The research objective is to develop a secured data sharing mechanism for additive manufacturing (AM) process data that masks the printing path information while retaining quality control characteristics. A core problem in data aggregation from multiple AM users is the data privacy concern of sharing raw data, which usually contain confidential design information. The proposed adaptive design deidentification for AM (ADDAM) methodology integrates AM process knowledge with the k-anonymization method to mask the printing path information contained within the AM thermal history and synthesize a "surrogate" thermal image. A real-world case study based on the directed energy deposition (DED) process is used to validate the proposed method.

4 Allocating Robot/cobots to Production Systems Considering Both Productivity and Ergonomic Strain

Congfang Huang[1], Shiyu Zhou[2], [1]UW Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI, Contact: chuang286@wisc.edu

The job allocation between human and robot resources can improve the performance of an assembly serial system in both productivity and ergonomics. Most of the recent research on job allocation in assembly systems focus on the job decomposition of an individual job or consider the productivity performance and the ergonomic factors separately. In this work, we formulate a well-defined human-robot collaborative assembly system and propose an optimization model for the job allocation problem between human, independent, and collaborative robots at the system task level. The objective function of our optimization model is unified integrated metrics of productive and ergonomic performance. Several simulated cases are designed based on the real-world scenarios and some rules and strategies are concluded from the optimization results.

Sunday, 12:30 PM–1:45 PM

SC61

M - Marriott 8

Resource Adequacy and Resilience in Market Modeling

General Session

Session Chair

Yinong Sun, Johns Hopkins University, Lakewood, CO

1 Insights into Methodologies and Operational Details of Resource Adequacy Assessment

Yinong Sun[1,2], Bethany Frew[2], Sourabh Dalvi[2], Surya Dhulipala[2], [1]Johns Hopkins University, Lakewood, CO, [2]National Renewable Energy Laboratory, Golden, CO, Contact: ysun104@jhu.edu

In this study, we systematically explore how operational details impact resource adequacy (RA) assessments. The RA modeling dimensions include: the objective function and level of operational detail in the underlying model formulation; the quantity (look-ahead) and quality (accuracy) of data that is available for making operational decisions within models; and the physical configuration of PV with battery storage hybrid resources, whose charging cycles introduce complexity for how such resources can contribute to RA. We apply a spectrum of probabilistic RA tools and production cost modeling tools to a realistic test system based loosely on a future ERCOT system dominated by solar PV resources. Our results suggest that multi-stage probabilistic assessments may provide a more robust evaluation of RA by capturing a wider range of operational and system interactions.

2 The Impact of Wholesale Market Design on Long-run Resource Investment and Reliability

Jonghwan Kwon[1], Todd Levin[1], Audun Botterud[2], Zhi Zhou[3], [1]Argonne National Laboratory, LEMONT, IL, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Argonne National Laboratory, Argonne, IL, Contact: kwonj@anl.gov

Increasing penetrations of low or zero marginal cost generation may lead to declining wholesale energy prices and a corresponding decline in revenues for generators. As a result, resources may increasingly rely on revenues from other services, such as reserves or capacity, to ensure revenue sufficiency. This talk will discuss the impact of wholesale market designs on resource investment and system reliability. We will first introduce a market-based resource adequacy assessment framework that can analyze the system generation portfolio that results in a competitive market environment. The modeling framework is based on Stackelberg leader-follower games and is formulated as a bi-level optimization problem, which is then transformed into a mathematical program with equilibrium constraints. A case study of the ERCOT-like system will be discussed.

3 Extreme Events and Resource Adequacy for a Decarbonized Future

Aidan Tuohy[1], Jo Ann Rañola[2], [1]Electric Power Research Institute, Chicago, IL, [2]Electric Power Research Institute, Austin, TX

As the resource mix of the electric system changes to meet decarbonization targets, and with extreme weather such as widespread heat and cold events having particular impact in recent years, there is a need to revisit methods for resource adequacy. In an ongoing project, these issues are being examined in terms of new metrics and criteria to ensure adequacy, updated models and improvements in the software tools. A particular focus is on ensuring energy reliability and resilience towards extreme events, with methods under development to better identify the scenarios that must be included. Case studies examining these issues will be presented here, showing how stress testing can be incorporated into the broader picture of adequacy studies.

4 Resource Value Streams in an Adequacy-Aware Planning Framework

Gord Stephen, University of Washington, Seattle, WA

Traditional power system planning optimizations rely on planning reserve margin constraints and exogenously-specified resource capacity credits in order to enforce system adequacy requirements. While the shadow prices of such constraints can provide a rough approximation of capacity market price signals, the exogenous nature of the capacity accreditation process prevents a more detailed first-principles understanding of the economic value of a resource's adequacy contribution. This presentation introduces a novel adequacy construct for power system planning models and explores the deeper economic insights it can provide for understanding the fundamental value streams provided by resources with varying operational characteristics.

Sunday, 12:30 PM–1:45 PM

SC62

M - Marriott 9

Optimizing Power Grid Resilience to Extreme Weather Events

General Session

Session Chair

Erhan Kutanoglu, University of Texas-Austin, Austin, TX

1 Budget Allocation for Power Grid Resilience: Hardening, Pre-event Preparation or Load Loss

Ashutosh Shukla, Erhan Kutanoglu, John Hasenbein, University of Texas-Austin, Austin, TX, Contact: ashutosh.shukla@utexas.edu

We present and analyze a three-stage stochastic optimization model that integrates outputs from a hydrological flooding model with an optimal power flow model for grid resilience decisions against storm-surge-induced flooding. The model coordinates the decisions made in multiple stages of the resilience management cycle and recommends an optimal allocation of the overall resilience investment budget across mitigation and preparedness measures. The model trades off such investments with the total value of load loss incurred due to the out-of-service components of the grid. We also present a case study for the Texas Gulf Coast region to demonstrate how the proposed model is used to address different kinds of grid resilience questions.

2 A Performance-constrained Stochastic Optimal Power Flow Model for Flood Resilience Planning

Brent Austgen[1], John Hasenbein[2], Erhan Kutanoglu[2], [1]The University of Texas at Austin, Austin, TX, [2]University of Texas-Austin, Austin, TX

We present a stochastic power flow model for informing flood mitigation decisions prior to an imminent hurricane. The model's objective is to minimize the number of mitigation resources required to satisfy a set of post-disaster grid performance constraints. We compare and contrast a few classes of performance constraints including deterministic, chance, and conditional value-at-risk constraints. Finally, we apply the model to a synthetic but representative grid of Texas subjected to realistic flooding scenarios based on Hurricane Harvey and discuss the results.

3 Equitable Optimization of Power Grid Resiliency

Baris Bilir, Erhan Kutanoglu, John J. Hasenbein, The University of Texas at Austin, Austin, TX

Extreme weather events result in devastating damages in the U.S. These low probability high impact events can cause widespread power outages and cost billions of dollars to society. Scientists predict that such events will be more frequent and more intense, and last longer with climate change. Therefore, resiliency of the power grid to extreme weather events is of increasing importance. In addition, there is evidence that underprivileged communities experience power outages more frequently and for longer periods of time than others. Hence, integrating equity into decisions regarding improving power grid resiliency is critical. In this study, we consider equitable resilience investment decisions and quantify its benefits with computational experiments using the synthetic Texas grid as a case study.

4 Capacity Expansion of Power Grid to Enhance the Resilience Against Extreme Weather

Berk Sahin[1], John Hasenbein[2], Erhan Kutanoglu[2], [1]University of Texas-Austin, Austin, TX, [2]University of Texas-Austin, Austin, TX, Contact: berk.sahin@utexas.edu

Grid operators should continuously expand the capacities of grid components to satisfy the growing demand. Due to the demand constraints and budget, it is not possible to make expansion investments simultaneously. A capacity expansion investment plan is needed to make reasonably ordered investment decisions. We propose a two-stage stochastic programming model to prioritize the capacity expansion decisions of the power grid considering resilience against extreme weather events. We consider expanding the capacities of power grid components such as generators, lines, substations, and switches. The model aims to minimize the load shed considering the extreme weather scenarios. We present numerical results on a synthetic version of the Texas grid considering the scenarios generated using historical extreme weather events.

Sunday, 12:30 PM–1:45 PM

SC63

M - Marriott 10
ENRE/MIF: Energy Equity Flash Session
Flash Session

Session Chair
Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA

Session Chair
Destenie S. Nock, Carnegie Mellon University, Pittsburgh, PA

1 Optimizing Collaborative Energy Storage Systems and Its Equity Outcomes
Ogechi Nwadiaru, University of Massachusetts, Massachusetts, MA
To support the delivery of an equitable and just transition it is imperative to study models of ownership that can promote adoption in a sustainable way. The aim of the study is to assess the benefits for co-operatively owned and operated storage systems. We hypothesize that there will be savings. The hypothesis is built on the flexibility offered by storage as a demand response asset, which can be used by residents in price-based demand response programs and equally provides consumers with increased autonomy and reduced cost.

2 Energy Resources' Effect on Energy Poverty
Erick C. Jones, University of Texas at Arlington, Arlington, TX, Contact: erick.jones@uta.edu
Energy is treated as an unlimited resource with no caps on demand and supply expected to keep up with whatever demand as increasing price encourages more expensive production. While on a macro scale this is largely accurate, rising energy prices illustrate an inefficient use of energy resources that disproportionately impacts the most vulnerable households. Certain energy resources are better at certain uses than others and rationing demand of more valuable energy resources for higher value uses can decrease energy costs disproportionately benefiting the most vulnerable.

3 Infrastructure Decision Preferences and the Influence of Social Justice Education
Charles Van-Hein Sackey[1], Destenie S. Nock[2], Christine Cao[1], Alexander Davis[1], Daniel Armanios[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Oxford University, London, United Kingdom. Contact: cvanhein@andrew.cmu.edu
The research question we explore in this paper is how does educating stakeholders in the energy sector about social justice change their preferences for equality and decision-making process in planning electricity systems. We use the maximize energy access (MEA) benefit-maximization model to generate maps of electricity system plans. Each map generated is based on a given value of equality. We then use these maps in a discrete choice experiment, in which participants' preferences for equality are estimated based on their choice of maps. Our work contributes to the literature by quantitatively determining the impact of education on equality preferences in an electricity system planning model.

4 Low-carbon Energy Transitions: A Systematic Approach to Quantifying Equity and Sustainability Trade-offs
Teagan Goforth[1], Destenie S. Nock[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: tgoforth@andrew.cmu.edu
Energy transitions require rapid changes to a nation's electricity generation mix, yet there is vast uncertainty about how these pathways will affect the nation's energy equity and sustainability goals. We develop a framework for analyzing the trade-offs between cost, sustainability, and equity under different decarbonization pathways. We accomplish this by coupling a least cost energy optimization model with a multi-criteria decision analysis model. Our initial results show that communities with high Black and high poverty populations are more likely to experience higher concentrations of pollutants until a mandate requires full deployment of renewable or low-carbon technologies.

5 Phasing Out Coal Power Plants Based on Cumulative Air Pollution Impact and Equity Objectives in Net Zero Energy System Transitions
Erin Mayfield, Dartmouth College, Hanover, NH
Transitioning to a net zero economy entails rapidly retiring coal capacity, a major source of both greenhouse gases and air pollution. To evaluate the coal phase-out, we optimize

for alternative climate policy goals as well as air pollution objectives related to the distribution of impacts on the basis of demographic, economic, and political factors. Phase-out strategies associated with policy objectives to minimize cumulative mortalities across the population are generally consistent with objectives to minimize impacts on vulnerable subpopulations, but differ from those that target specific environmental justice communities.

6 Impact of Building Climate Adaptation on Energy Burden Using a Coupled Weather-building Energy Model

Luis Ortiz, George Mason University, Fairfax, VA

As summers temperatures rise, so will the need for air conditioning as well as the economic burden associated with its use. Here, we estimate this burden, and strategies to reduce it, using a coupled weather-building energy model driven by present and end of century climate data and up-to-date urban morphology, with New York City as a case study. Results show that under a full adoption scenario, building adaptation strategies benefit low-income households the most, lowering energy burdens by up to 20% in the highest burden areas. p { line-height: 115%; margin-bottom: 0.1in; background: transparent }

7 Modeling for a Just and Reasonable Energy Future: Examining Pathways for Considering Social Equity in Power System in Distribution System Planning

Jasmine McAdams, University of California Berkeley, Berkeley, CA, Contact: jmcadams@berkeley.edu

Social equity has recently emerged as a key priority for decision-makers as they consider policies and investments to support a low-carbon energy future. Public utility commissions, in particular, have been mandated in a growing number of states to consider equity in their regulation of investor-owned utilities, thus having significant influence on aspects such as affordability, reliability and resilience of energy services and the modernization of the distribution grid. This presentation will explore how such considerations can be incorporated into distribution system planning.

8 An Equitable Transition to Clean Heating for Us Cold Climates

Parth Vaishnav, Claire J. McKenna, Shagun S. Parekh, University of Michigan, Ann Arbor, MI, Contact: parthtv@umich.edu

Electrifying residential space heating is a key decarbonization strategy, but it may raise energy bills for existing homes in cold regions. We gather data on household behavior and physical housing characteristics from 50 households, half of which have incomes below the regional median, and around 40% of which are energy-insecure, in Southeast Michigan. We integrate these data with physics-based energy models to estimate energy use and heating bills, and validate these models against empirically-observed energy use. We then test a suite of envelope upgrades along with air source heat pumps and expect to identify a package of strategies that reduce the bills for each home under dynamic utility pricing scenarios. We present building upgrade cost estimates. We juxtapose these data with data on income and housing values to assess the environmental justice implications.

Sunday, 12:30 PM–1:45 PM

SC64

M - Indiana A

Responsible, Ethical, and Socially Aware Operations II

General Session

Session Chair

Rad Niazadeh, Chicago Booth School of Business, Stanford, CA

Session Chair

Vahideh Manshadi, Yale University

1 Individual Fairness in Prophet Inequalities

Makis Arsenis[1], Robert Kleinberg[2], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, Contact: marsenis@cs.cornell.edu

Standard stopping rules for prophet inequality problems might treat individual candidates unfairly in a number of different ways. In this work we identify two types of individual fairness that might be desirable and give precise definitions. We call them identity-independent fairness (IIF) and time-independent fairness (TIF). We give polynomial-time algorithms for finding the optimal IIF/TIF stopping rules for a given instance with discrete support and we manage to recover a prophet inequality with factor 1/2 when the decision maker is required to satisfy both IIF and TIF while the prophet is unconstrained. We also consider a setting in which the decision maker doesn't know the value distributions but has access to a bounded number of independent samples from each and we provide constant-competitive, IIF/TIF algorithms.

2 Fair and Diverse Allocation of Scarce Resources

Hadis Anahideh, 1</sup

Due to disparities in socioeconomic stability and access to health care across different population subgroups in the US, certain low-income and minority groups are particularly more vulnerable to COVID-19. To provide sufficient vaccine and medical resources to all residents and effectively stop the further spreading of the pandemic, the average medical resources per capita of a community should be independent of the demographic features but only conditional on the exposure rate to the disease. To this end, we design a fairness-aware allocation framework for scarce resources that considers a trade-off between Geographical Diversity and Social Group Fairness as the guiding principles for prevention-centered strategies. We propose a tuning approach to identify an optimal range for the trade-off and investigate the price of fairness using observational data.

3 Optimality of Online Algorithms in the Presence of Fairness

Mohammad Reza Aminian[1], Rad Niazadeh[1], Vahideh Manshadi[2], [1]The University of Chicago, Chicago, IL, [2]Yale University, New Haven, CT, Contact: Mr.aminian1999@gmail.com

There has been a descent research on optimal online algorithms and their comparison with their offline benchmark. However, these proposed algorithms only try to maximize the utility and have no concern about the fairness of their output. Consequently, they are highly susceptibe to make bad use of the biased data, thereby hurting a sensitive group in an unfair fashion just to avoid some costly risks. In our work, we add some fairness restrictrictions to these problems and then try to find the optimal online and offline algorithms. We have considered the regular as well as the noisy version of Pandora's Box problem with two different notions of fairness and provide the optimal online algorithm for each of which. Additinally, we considered the noisy version of the Prophet Inequality problem, and found the optimal offline as well as a variety of online approximation algorithms.

4 An Improved Approximation Algorithm for Maximin Shares

Jugal Garg[1], Setareh Taki[2], [1]UNIV OF ILLINOIS AT URBANA CHAMPAIGN, Urbana, IL, [2]University of Illinois at Urbana-Champaign, Urbana, IL, Contact: setareh.taki@gmail.com

Fair division is a fundamental problem in various multi-agent settings, where the goal is to divide a set of resources among agents in a *fair* manner. We study the case where m indivisible items need to be divided among n agents with additive valuations using the fairness notion of *maximin share* (MMS). While it is known that such an allocation need not exist, Ghodsi et al. 2021 showed the existence of a 3/4-MMS allocation and a PTAS to find a (3/4-⍰)-MMS allocation for an ⍰ > 0. In this presentation, we develop a new approach that gives simple proof for showing the existence of a 3/4-MMS allocation. Furthermore, we extend our result in two directions: First, we get a strongly polynomial-time algorithm to find a 3/4-MMS allocation. Second, we show that a (3/4+1/12n)-MMS allocation always exists, improving the best previous factor.

Sunday, 12:30 PM–1:45 PM

SC65

M - Indiana B

Smallholder Agricultural Supply Chains

General Session

Session Chair

Can Zhang, Duke University, Durham, NC

1 Optimizing Quality Supervision to Improve Artisans' Productivity

Bhavya Singhvi[1], Divya Singhvi[2], Somya Singhvi[3], Xinyu Zhang[4], [1]Indian Institute of Management Udaipur, Udaipur, India; [2]New York University, Drayton, SC, [3]USC Marshall School of Business, Los Angeles, CA, [4]New York University, New York, NY, Contact: xz1151@stern.nyu.edu

This work is in close collaboration with a social enterprise that works with thousands of women artisans from low-income households in India to manufacture rugs. In order to ensure timely completion of rugs without defects, the enterprise assigns quality supervisors to visit women artisans at regular frequency. In this work, we work with the enterprise to formulate the problem of supervisor assignment and routing with an objective to maximize women artisans' productivity. We show that this problem is computationally hard, and as a result, we develop a novel algorithm that produces a scheme of supervisor assignment and routing with good analytical guarantees. Finally, we show on actual data that the proposed algorithms significantly improve productivity.

2 Two-sided Benefits of Price Transparency in Smallholder Supply Chains

Yuan Shi[1], Joann de Zegher[2], Irene Yuan Lo[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Sloan, Cambridge, MA, [3]Stanford University, Stanford, CA, Contact: yuansh@mit.edu

This paper studies the impact of price transparency on price and welfare in smallholder supply chains and identifies conditions and driving forces for creating two-sided benefits to both buyers and suppliers. With a new Hotelling model of price search, we find that a moderate increase in price transparency can lead to strong Pareto improvement in both competitive and collusive equilibria for buyers and suppliers under demand asymmetry and costly supply uncertainty. We further establish that the impact of transparency on supply uncertainty is a key determinant of welfare: the welfare benefits can only be fully realized if transparency is created without increasing supply uncertainty. Our analyses reveal important nuances about the interplay between transparency, pricing and supply uncertainty, bringing managerial insights for information platform designers.

3 Operational Challenges for EMS Platforms in Developing Countries

Pieter van den Berg[1], Andre Du Pin Calmon[2], Andreas Kilian Gernert[3], Stef Lemmens[4], Gonzalo Romero[5], [1]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands; [2]Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, [3]Kühne Logistics University, Hamburg, Germany; [4]Rotterdam School of Management, Rotterdam, Netherlands; [5]Rotman, University of Toronto, Toronto, ON, Canada. Contact: s.lemmens@rsm.nl

Many developing countries lack the health-emergency infrastructure of the developed world. In this context, our industry partner Flare (operating in Nairobi, Kenya) coordinates existing ambulance providers by operating a platform. Flare aggregates the available ambulance capacity and demand for emergency services. Since ambulance platforms in developing countries make use of independent ambulance providers, the ambulance fleet can only be partially relocated. We study the operational challenges for such platforms as they often lack the knowledge about all ambulances' future availability and their location at a tactical level and typically do not fully control these ambulances.

4 Index-based Yield Protection for Smallholder Farmers

Kehan Lu, Can Zhang, Jing-Sheng Jeannette Song, Duke University, Durham, NC, Contact: kehan.lu@duke.edu

Government subsidies are common in the agricultural sector to protect farmers from unexpected losses due to low prices or low crop yields. However, implementing indemnity-based yield protection schemes that subsidize farmers when the yield level is low is challenging in emerging economies due to small farm sizes and high costs of yield assessment. To overcome this challenge, an innovative index-based approach has emerged in recent years, under which farmers receive a payment when a predetermined index (e.g., rainfall level) predicts a low yield level. This paper explores the design and value of such a government-issued index-based yield protection policy.

Sunday, 12:30 PM–1:45 PM

SC66

M - Indiana C

Forestry Applications for OR

General Session

Session Chair

Erin Belval, USDA, Fort Collins, CO

1 Balancing Wildlife Habitat Protection and Wildfire Hazard Mitigation with a Critical Nodes Detection Approach

Denys Yemshanov[1], Denyse Dawe[2], Amanda Bakalarzcyk[1], Ning Liu[1], Yan Boulanger[3], Jonathan Boucher[3], Alexandre Beauchemin[4], Dominique Arseneault[5], Marc-André Parisien[2], [1]Natural Resources Canada, Sault Ste. Marie, ON, Canada; [2]Natural Resources Canada, Edmonton, AB, Canada; [3]Natural Resources Canada, Quebec, QC, Canada; [4]Hydro-Quebec, Montreal, QC, Canada; [5]Université du Québec à Rimouski, Rimouski, QC, Canada. Contact: denys.yemshanov@canada.ca

We propose a bi-objective network model for a protection of human infrastructure from wildfires via fuel treatments and maintaining a critical wildlife corridor to improve viability of a threatened wildlife populations. The model combines a Critical Node Detection (CND) problem with a habitat connectivity problem that allocates a minimum-resistance corridor between isolated wildlife refuges. Our results offer optimal solutions to concurrently lessen the threat of wildfires to critical human infrastructure while meeting wildlife conservation management goals. We apply the approach to investigate the protection of the proposed high-voltage power line within the range of a boreal woodland caribou in northern Québec, Canada.

2 Fuel Break Prioritization Using Simulated Fire Events

Yu Wei[1], Erin Belval[2], Matthew Thompson[3], Dave Calkin[4], [1]Colorado State University, Fort Collins, CO, [2]USDA, Fort Collins, CO, [3]U.S. Forest Service, Fort Collins, CO, [4]USDA Forest Service, Missoula, MT, Contact: yu.wei@colostate.edu

Establishing, maintaining and improving fuelbreaks could help fire managers to improve fire suppression effectiveness. Prioritizing fuelbreak management needs to consider the likelihood of future fire activities and how those established fuelbreaks may interact with fire and influencing fire spreads. A two-stage MIP model is developed to use the spatially explicit footprints of a large number of simulated fires to inform the first-stage fuelbreak management decisions. Our presentation introduces the general modeling concepts, the MIP model, the input data requirements and the data processing steps to populate the model. We also present a case study in Southern California that uses this MIP model to support their fuelbreak management.

3 *Igen* a Rule Based System to Link Forest Reality to Mathematical Programming

Silvana Nobre[1], Marc Eric McDill[2], Luiz Carlos E Rodriguez[3], Luis Diaz-Balteiro[1], [1]Universidad Politecnica de Madrid, Madrid, Spain; [2]Pennsylvania State University, University Park, PA, [3]University of Sao Paulo, Piracicaba, SP, Brazil. Contact: silvana.rnobre@gmail.com

Forest managers have used mathematical programming modeling techniques since the early 60s. No matter how diverse the forest is, foresters still need to optimize strategic goals, setting possible management alternatives subject to complex constraints. Generating management alternatives consumes most of the time to formulate the models. This work presents iGen, an Artificial Intelligence approach to develop a flexible rule-based builder to generate forest management alternatives. An Inference Engine applies user-defined rules to a particular forest reality and generates the alternatives in a graph structure. The graph is an easy-to-read stable structure to provide a complete source for the forest models to address each specific forest.

Sunday, 12:30 PM–1:45 PM

SC67

M - Indiana D

New Frontiers in Revenue Management

General Session

Session Chair

Omar Besbes, Columbia University, New York, NY

Session Chair

Santiago Balseiro, Columbia University, Armonk, NY

1 Column Randomized Linear Programs: Performance Guarantees and Applications

Velibor Misic, Yi-Chun Chen, UCLA Anderson School of Management, Los Angeles, CA, Contact: velibor.misic@anderson.ucla.edu

Many important problems, in revenue management and other areas, give rise to large scale linear programs (LPs), where the number of columns n far exceeds the number of constraints m. In this talk, we propose the column randomization method, which involves randomly sampling a set of columns according to a user-specified randomization scheme and then solving the sampled problem. Our main contribution is a high probability bound on the optimality gap attained by this column randomization method that holds for general LPs and relies only on elementary arguments (LP sensitivity analysis and McDiarmid's inequality). Through numerical experiments with the cutting stock problem and the ranking-based choice estimation problem, we show that column randomization can attain a fixed positive optimality gap in significantly less time than classical column generation.

2 Designing Service Menus for Bipartite Queueing Systems with Strategic Users

Rene A. Caldentey[1], Lisa Hillas[2], Varun Gupta[1], [1]The University of Chicago, Chicago, IL, [2]University of Chicago, Chicago, IL, Contact: lhillas@chicagobooth.edu

We consider a multi-class multi-server queueing system, in which customers of different types have heterogenous preferences over the many servers available. A service provider designs a menu of service classes that balances maximizing the customers' average service reward and minimizing customers' average waiting time. Customers act as rational self-interested utility maximizing agents when choosing which service class to join. We study the problem of designing an optimal service menu under heavy traffic conditions.

3 Joint Product Design and Assortment Optimization

Mengxin Wang[1], Paat Rusmevichientong[2], Heng Zhang[3], Zuo-Jun Max Shen[4], [1]University of California-Berkeley, Albany, CA, [2]USC Marshall School of Business, Los Angeles, CA, [3]Arizona State University, Tempe, AZ, [4]University of California Berkeley, Berkeley, CA, Contact: mengxin_wang@berkeley.edu

We study the integration of strategic and tactical decisions by examining a setting in which the strategic decision is to choose product designs and the tactical decision is the dynamic assortment optimization. Our formulation has many applications, including optimizing products' return eligibility and determining discounts. We develop an approximation framework for jointly optimizing these decisions and create metrics that measure the individual effectiveness of strategic and tactical decisions. Numerical experiments based on data from a major U.S. retailer show that our method is over 95% effective, representing 10% improvements over methods that fail to integrate strategic and tactical decisions. The experiments also show the prominent role of the strategic design, which explains 85% of the total variation in observed effectiveness across different methods.

4 On the Robustness of Second-price Auctions in Prior-independent Mechanism Design

Jerry Anunrojwong, Santiago Balseiro, Omar Besbes, Columbia University, New York, NY, Contact: jerryanunroj@gmail.com

The seller wants to sell an item to n buyers such that the buyers' valuation distribution is from a given class (i.i.d., mixtures of i.i.d., affiliated and exchangeable, exchangeable, and all distributions) and the seller minimizes worst-case regret. We derive in quasi closed form the minimax values and the associated optimal mechanism. In particular, we show that the first three classes admit the same minimax regret value, decreasing in n, while the last two have the same minimax regret equal to that of the case n = 1. Across all settings, the optimal mechanisms are all second-price auctions with random reserve, which shows its robustness in prior-independent mechanism design. En route to our results, we develop a principled methodology to determine the form of the optimal mechanism and worst-case distribution via first-order conditions that is of independent interest.

Sunday, 12:30 PM–1:45 PM

SC68

M - Indiana E

New directions in Revenue Management and Pricing

General Session

Session Chair

Elaheh Fata, ON, Canada.

1 Use Neural Networks to Guide Data-driven Operational Decisions

Ningyuan Chen[1], Saman Lagzi[2], Joseph Milner[3], [1]University of Toronto, Mississauga, ON, Canada; [2]Wilfrid Laurier University, Waterloo, ON, Canada; [3]University of Toronto, Toronto, ON, Canada. Contact: saman.lagzi@rotman.utoronto.ca

We use Neural Networks as approximation algorithms to address complex problems. Given sample data that includes observations of decision variables, covariates and the objective function value, we train a neural network, where the input of the neural network is the covariates and decision variables, and its output is the predicted value for the objective function. Then, for a given set of covariates, the decision variable is chosen so the predicted value of the neural network is optimal. We characterize the performance of our methodology in terms of the generalization bound of the Neural Network and show strong performance on both the Newsvendor problem and the assortment pricing problem.

2 Selling and Renting Mechatronics (Digitally Controlled Physical Goods)

Xianfeng Meng, Guang Li, Anton Ovchinnikov, Queen's University, Smith School of Business, Kingston, ON, Canada. Contact: 16xm4@queensu.ca

Firms that sell digital goods routinely utilize free-premium-upgrade business models for product differentiation. When downloading an app, one can try a free version first, then pay to unlock permanent premium functionality or rent additional temporary functionality. Recent technological advances allow physical goods firms to do the same: they can create products with identical hardware that are digitally controlled to allow for similar differentiation. This paper presents a stylized model to explore when physical goods firms should adopt such digitally-enabled product differentiation instead of the traditional product line design with high- and low-end products.

3 Assortment Optimization Under a Multi-item Choice Model

Milad Mirzaee[1], Guang Li[2], Elaheh Fata[2], [1]Queen's University, Kingston, ON, Canada; [2]Queen's University, Kingston, ON, Canada.

We propose a multi-stage choice model under which a customer can purchase multiple products and multiple units of each product in a single shopping incidence. We characterize the structure of the optimal solutions for the assortment optimization problem under various constraints, including cardinality, capacity, and maximum basket size constraints. We prove the problem become NP-hard when it is under the capacity constraint or the maximum basket size constraint . We also consider the price optimization problem under this model and propose efficient algorithms to find the optimal prices.

4 Price and Quantity Promotions for Clearance Sales

Arvind Sainathan[1], Fang Liu[2], [1]NEOMA Business School, Reims, France; [2]University of Chinese Academy of Sciences, Beijing, China. Contact: arvind.sainathan@neoma-bs.fr

We consider a retailer who does clearance pricing to sell off the excess inventory of a certain product. In this context, we compare Buy-One-Get-One (BOGO) and Buy-Two-Get-One (BTGO) policies with traditional price discounts. Specifically, we develop models to examine how customers' discount factors for buying additional units and the amount of inventory affect which promotion policy performs the best.

Sunday, 12:30 PM–1:45 PM

SC69

M - Indiana F

Fairness in Operations

General Session

Session Chair

Vahideh Manshadi, Yale University, New Haven, CT

1 **Presenter**

Siddhartha Banerjee, Cornell University, Ithaca, NY

2 **Equity Promotion in Online Resource Allocation**

Will Ma[1], Karthik Sankararaman[2], Aravind Srinivasan[3], Pan Xu[4], [1]Columbia University, Cambridge, MA, [2]Meta AI, Menlo Park, CA, [3]University of Maryland, College Park, MD, [4]New Jersey Institute of Technology, Newark, NJ, Contact: pxu@njit.edu

We consider two models for real-time equitable resource allocation problems motivated from applications such as COVID-19 medical supply allocation and food donation problems. The first is called external equity promotion where agents arrive sequentially and have heterogeneous demands, where the demand is drawn from a prior distribution known ahead of time. The goal is to allocate a fair share of resources proportional to the agent's demand. The second is called internal equity promotion, where arriving agents have uniform demands but are heterogeneous in internal traits such as demographics. In particular, each requester can be identified as belonging to one or several groups. An allocation of resources is regarded as equitable when every group of requesters can receive a fair share proportional to the percentage of that group in the whole population.

3 **Designing Online Platforms to Incentivize Outcomes**

Rim Hariss[1], Shreyas Sekar[2], [1]McGill University, Montreal, QC, Canada; [2]University of Toronto, Toronto, ON, Canada.

Recently, there has been a growing concern that the adopted policies by online platform can exacerbate the biases present in the data and lead to outcomes that favour specific groups of popular users. This can affect the long-term health of the marketplace by endangering users' trust in the platform and lead to lopsided growth.This work tackles the problem of designing data-driven policies for online platforms that lead to diverse/fair outcomes. We focus on one lever used by the platform: pricing/revenue sharing. We adopt a two-pronged approach: 1) Use publicly available data from platforms such as Spotify to quantify how current policies lead to undesirable outcomes that only benefit some users; 2) Design policies for revenue sharing that benefit a broad spectrum of users operating on the platform.

Sunday, 12:30 PM–1:45 PM

SC70

M - Indiana G

The Future of COIN-OR

Panel Session

Session Chair

Matthew J. Saltzman, Clemson University, Clemson, SC

1 **The Future of COIN-OR**

Matthew J. Saltzman, Clemson University, Clemson, SC

The COIN-OR initiative is 22 years old, and the foundation that manages the publication of COIN-OR software is 18. Until a few years ago, the COIN-OR Fountation's mission has been to provide infrastructure for the developer and user communities contributing projects. We have also supported a number of key projects with build systems, packaging for various operating systems, and other tools. In recent years we have moved projects to GitHub to take advantage of contribution and testing infrastructure, giving us the opportunity to redirect our focus to new initiatives. The Foundation is looking to the community to help us plan how to best support the OR community with open-source software and tools and how to find the support (financial and personnel) to accomplish those objectives. Join the discussion here.

2 **Panelist**

Kevin C. Furman, ExxonMobil, Houston, TX

3 **Panelist**
Ted K. Ralphs, Lehigh University, Bethlehem, PA

4 **Panelist**
William E. Hart, Sandia National Laboratories, Berlin, MA

5 **Panelist**
Steven P. Dirkse, GAMS Development Corporation, Fairfax, VA

Sunday, 12:30 PM–1:45 PM

SC72

M - California
Social Media Analytics: Methods, Tools and Platforms
General Session

Session Chair
Tung Cu, Northeastern Illinois University, Chicago, IL

1 **Predicting Poverty Using Socio-Economic Indicators - The Case of Shelby County**
Srikar Velichety, University of Memphis, Cordova, TN
We develop a model to predict poverty in Shelby County and similar United States Metropolitan areas using traditional data sources such as the federal, state, and local agencies and big-data sources such as Google Earth Satellite Images, school catchment area maps to develop features for predicting poverty rates. Finally, we quantify how the location of a census tract predicts its poverty using social network analysis. In doing so, we not only provide ways for researchers to use a combination of deep learning and social network analysis techniques to formulate relevant measures but also provide an overarching framework for policy makers to use multiple sources of data and make decisions that fight poverty effectively. Our work has major implications for researchers using deep learning and social network analysis for policy and decision making.

2 **Analyzing Sparse Consumer Data for Strategic Planning**
Amy Lynn Magnus, Quantum Autonomy LLC, Yellow Springs, OH
We analyze sparse consumer data that are collected via social media to inform strategic planning in retail. We demonstrate how actionable information may be pulled from corpi of less than 5000 words. By ranking responses according to the apparent level of effort demonstrated by respondents, we separate concepts that are easy to convey from those that are difficult. Next, we group concepts with respect to consumer interaction: interactions with tangible elements, cognitive abstractions, social organization, or regulatory behaviors. In this way, we extract overall trends in retail consumer experiences and how consumers problem solve within these experiences. We pay particular attention to transitional concepts that is, those concepts that lie between what consumers grasp easily and what they find difficult to resolve but worthy of effort.

3 **#ad - Analyzing the Differential Impact of Social Media Influencers Ad-disclosure on Consumer Engagement**
Sae Hoon Chang, Ceren Kolsarici, Queen's University, Kingston, ON, Canada. Contact: 13shc3@queensu.ca
We investigate the impact of ad disclosure by influencer type on consumer engagement in social networks. Using deep-learning-based NLP methods and difference-in-difference analysis, we examine how Instagram post characteristics by micro vs. celebrity influencers in ad-disclosure/non-disclosure environments influence re-posts, likes, and comments of platform users. The results suggest ad disclosure leads to generally lower (higher) engagement for micro (celebrity) influencers.

Sunday, 12:30 PM–1:45 PM

SC73

M - Colorado
ENBIS Invited Session
Panel Session

Session Chair
Kamran Paynabar, ISyE Georgia Tech, Atlanta, GA

1 **Panelist**
Marco Grasso, Politecnico Di Milano, Milan, Italy.

2 **Panelist**
Christian Capezza, University of Naples Federico II, Napoli, Italy.

3 **Panelist**
Bianca Maria Colosimo, Politecnico di Milano, Milan, Italy.

Sunday, 12:30 PM–1:45 PM

SC74

M - Florida
Stochastic Control and Machine Learning
General Session

Session Chair
Xianhua Peng, Peking University HSBC Business School, New York, NY

Session Chair
Xuedong He, The Chinese University of Hong Kong, Shatin, Hong Kong.

1 **Dependence Learning of Asynchronous Sequences - A Co-evolving Neural ODE Approach**
Yijun LI[1], Leung Cheuk Hang[1], Chaoqun Wang[1], Yiyan Huang[1], Qi Wu[1], Dongdong Wang[2], Zhixiang Huang[2], [1]City University of Hong Kong, Kowloon Tong, Hong Kong; [2]JD Digits, Beijing, China. Contact: yijunli5-c@my.cityu.edu.hk
A challenge of using GRUODE to model multivariate sequences which are both serially and cross-sectionally dependent is that if the components are not in sync, asynchrony would confuse the training process. This is because the architecture of GRUODE makes no distinctions between those representing the path-dependencies in the marginal dynamics and those representing the path-dependencies in the copula dynamics. Targeting asynchrony, we design a new architecture that seamlessly integrates continuous-time ODE solvers with a set of memory-aware GRU blocks. It learns memory profiles separately and addresses the issue of the asynchronous arrival of randomly occurring events cleanly. Numerical results confirm that this new architecture is effective and notably superior compared with a variety of state-of-the-art baseline models on simulated and real-world datasets.

2 **NEEDS TITLE**
Haoyang Cao, École Polytechnique, Palaiseau, France. Contact: haoyang.cao@polytechnique.edu
Inverse reinforcement learning attempts to reconstruct the reward function in a Markov decision problem, using observations of agent actions. It has been observed that the problem is ill-posed, and the reward function isn't identifiable, even with perfect information about optimal behavior. We provide a resolution to this non-identifiability for problems with entropy regularization. For a given environment, we fully characterize the reward functions leading to a given policy and demonstrate that, given demonstrations of actions for the same reward under two distinct discount factors, or under sufficiently different environments, the unobserved reward can be recovered up to a constant. We also give general necessary and sufficient conditions for reconstruction of time-homogeneous rewards on finite horizons, and for state-only rewards.

3 **Menuless and Preference-free Screening Contracts for Fund Managers**
Steven Kou[1], Xuedong He[2], Sang Hu[3], [1]Boston University, Boston, MA, [2]The Chinese University of Hong Kong, Shatin, Hong Kong; [3]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China. Contact: kou@bu.edu
We propose a family of incentive contracts that can attract some fund managers who are favored by investors and deter any manager who is unfavored by some investors. The contract problem has hidden types, hidden actions, hidden knowledge of preferences, and opportunity cost. In contrast to standard screening contracts, our contracts neither depend explicitly on the utilities of the managers and investors nor have a menu of choices. The contracts have two crucial components: (i) a first-loss deposit to be used to offset some of the principal's losses and (ii) a liquidation boundary. A case study is also given.

Sunday, 12:30 PM–1:45 PM

SC75

M - Illinois
Cryptocurrency, Microloans, Social Trading, and NFT
General Session

Session Chair
Runshan Fu, Carnegie Mellon University, PA

1 **1+1>2? Infomation, Humans, and Machines**
Tian Lu[1], Yingjie Zhang[2], [1]Arizona State University, Phoenix, AZ, [2]Peking University, Beijing, China. Contact: lutiansteven@gmail.com
Inspired by the information processing literature, we introduce information volume and identify its roles in determining collaboration performance. We conduct a two-stage field experiment. First, we show that humans, especially experienced ones, might resist alternative information sources but make decisions via a traditional process with small information volumes. Second, machines perform better on larger information scales and better than humans but would unintentionally incur decision biases. Third, in the human-machine collaboration mode, the

presence of machine interpretations could reduce humans' potential resistance to machines' recommendations. More importantly, the co-existence of large-scale information and machine interpretations can invoke humans' systematic rethinking, which in turn, shrinks biases and increases prediction accuracy.

2 The Merton Model Re-visited: Design of Optimal Incentives for Traders in Copy Trading

Kai Sun[1], Mingwen Yang[2], Vijay S. Mookerjee[3], [1]University of Texas at Dallas, Richardson, TX, [2]University of Washington, Seattle, WA, [3]University of Texas- Dallas, Richardson, TX

Copy trading allows retail investors (followers) to automatically copy the trades of experts (traders) in real time after paying following fees to the platform. To help mitigate the potential principle-agency problem, we propose a model that compensates the trader in a way that his trading behavior will not be altered.

3 Impact of Resale Royalty on Sale Prices and Market Liquidity in the NFT Marketplace

Murat M. Tunc[1], Thomas van den Heuvel[1], Hasan Cavusoglu[2], Zhiqiang Eric Zheng[3], [1]Tilburg University, Tilburg, Netherlands; [2]University of British Columbia, Vancouver, BC, Canada; [3]University of Texas-Dallas, Richardson, TX, Contact: m.m.tunc@tilburguniversity.edu

Non-fungible token (NFT) marketplaces facilitate users to mint and trade digital assets. To protect creators, many NFT platforms adopt resale royalty which pays back the creator a certain percentage of future resale amount. The adoption of resale royalty is seemingly beneficial for token creators. However, it may have unintended consequences on the sale prices and liquidity of the underlying NFT. In this paper, we investigate the impact of resale royalty on average sale prices both on the primary market and the secondary market. We find that a higher resale royalty rate leads to a significant decrease in the average primary sale price, however the average secondary sale price significantly increases. Moreover, we find that resale royalty has a negative influence on the liquidity of NFT marketplace, specifically success rate of a sale listing and the duration to sale.

Sunday, 12:30 PM–1:45 PM

SC76

M - Michigan

Operations Management and Marketing Flash Session II

Flash Session

Session Chair

Dennis Z. Yu, Clarkson University, Potsdam, NY

1 Integrated Showroom Locating, Inventory Management, and Pricing

Dincer Konur, Texas State University, San Marcos, TX, Contact: d_k141@txstate.edu

Showrooms are used in practice by many online only brand-name companies for customer engagement. In this paper, we analyze integrated showroom locating, inventory management, and pricing problem. Complexity of the problem is presented. Several properties for the optimum solution are characterized and a solution approach is discussed.

2 Controlling Inventories in Omni / Multi - Channel Distribution Systems with Variable Customer Order-sizes

Peter Berling[1,2,3], Johan Marklund[4], Lina Johansson[5], [1]Norwegian university of science and technology, Trondheim, Norway; [2]Linnaeus University, Växjö, Sweden; [3]Lund University, Lund, Sweden; [4]Lund University, Lund, Sweden; [5]Lund University, Lund, Sweden. Contact: lars.p.berling@ntnu.no

The fast growth of e-commerce and omni/multi-channel retailing brings new challenges for efficient inventory management. One such challenge concerns service differentiation across channels when upstream central warehouses satisfy both direct customer demand and replenishment orders from downstream retailers. Motivated by industry collaboration we address this issue by developing a combined stock method and computationally efficient heuristics designed to deal with real systems characterized by highly variable customer order-sizes and fill rate constraints. A numerical study, including real data, shows that the heuristics provides near optimal solutions and significant opportunities to reduce total inventory costs.

3 The use of Purchase Limits During Shortages

Jihwan Moon[1], Steven Mark Shugan[2], [1]UNSW, Sydney, Australia; [2]University of Florida, Gainesville, FL, Contact: steven.shugan@warrington.ufl.edu

Pandemics, natural disasters, strikes, piracy, and other events can unexpectedly disrupt supply or spike demand, creating shortages. Unlike ordinary stock-outs, shortages involve the entire supply chain. One tool for managing shortages is purchase limits which restrict the quantity each shopper can purchase of the scarce product possibly increasing availability to others. Although altruistic stores might use purchase limits for egalitarian goals (e.g., reducing hoarding, waste, panic buying, arbitrage, and unfair distribution), we find that profit-maximizing stores can use purchase limits to increase profits during shortages. Our findings suggest that stores' price-and-limit strategies depend on shortage severity, store size, competition, and seasonality. Interestingly, purchase limits can improve both store profits and consumer surplus.

4 Product Line and Capacity Decisions for the Real Estate Industry Under Willingness-to-pay Uncertainty

Muge Yayla Kullu[1], Jennifer K. Ryan[2], Jayashankar M. Swaminathan[3], [1]University of Central Florida, Orlando, FL, [2]University of Nebraska–Lincoln, Lincoln, NE, [3]University of North Carolina Chapel Hill, Chapel Hill, NC, Contact: muge@ucf.edu

A residential construction firm's product mix and land investment decisions are highly complex due to the need for long-term planning. We study these decisions using a 3-stage capacity-constrained stochastic optimization model with a heterogeneous consumer base under willingness-to-pay distribution uncertainty. Among others, we find that the land investment increases with uncertainty. We also discuss the impact of competition and housing affordability regulations and find non-intuitive results.

5 End-of-life Product Collection Strategy and Remanufacturing Technology Portfolio Planning

Ying Cao[1], Kai Meng[2], Guang Li[3], Richard Peng[4], Xianghui (Richard) Peng[5], [1]Penn State Erie The Behrend College, Erie, PA, [2]Massachusetts Institute of Technology, Nanjing, China; [3]Queen's University, Kingston, ON, Canada; [4]CAMBRIDGE, MA, [5]Penn State Erie The Behrend College, Fairview, PA, Contact: yxc673@psu.edu

End-of-Life (EOL) product collection rate is an important input in the closed-loop supply chain, which impacts the remanufacturing technology portfolio selection for a remanufacturer who is exposed to various technology alternatives. And, the remanufacturer's technology portfolio decision in return influences his preference for EOL product collection. In this research, we study remanufacturer's joint decision of EOL product collection pricing and remanufacturing technology portfolio planning in order to maximize the expected profit. We derive the properties of optimal pricing strategy and technology portfolio structure. In addition, we conduct numerical study and develop managerial insights for remanufacturing industry.

6 To Clean or to Compensate - How to Manage Data Inaccuracy in Inventory Decisions

Michael Becker-Peth[1], Kai Hoberg[2], [1]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands; [2]Kühne Logistics University gGmbH, Hamburg, Germany. Contact: m.beckerpeth@rsm.nl

The quality of any operational decision depends on the quality of the input data. However, data used for supply chain decision making is often inaccurate. In our study we focus on inventory management decisions that are subject to inaccurate inventory data. Due to shrinkage and loss, the available physical inventory can be lower than recorded system inventory. To handle this inaccuracy decision makers can decide to invest into cleaning data before placing order decisions. Alternatively, decision makers can deliberately decide to not clean the data, but to account for the inaccuracy by compensating the actual order decision. Depending on cleaning cost and the efficiency loss due to compensation, decision makers have an incentive to either clean or compensate. We present a set of hypotheses on the cleaning-compensation trade-off and test these hypothesis in a lab experiment.

7 Characterizing Human-Automated Vehicle Interactions: An Investigation into Car-following Behavior

Yanlin Zhang, Alireza Talebpour, Yalda Rahmati, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: yanlinz4@illinois.edu

Automated vehicles are expected to influence human drivers' behavior. Accordingly, capturing such changes is critical for planning purposes. Focusing on the car-following behavior, a key question is whether existing car-following models can replicate such changes in human behavior. Using a dataset collected from the car-following behavior of human drivers when following automated vehicles, this presentation offers a robust methodology based on the concept of dynamic time warping to capture the critical parameters that can best substantiate the behavioral changes in human drivers. The findings suggest that some common car-following models cannot capture the changes in human behavior in response to automated vehicles and imply that a stochastic extension to car-following models is needed when analyzing and simulating a mixed-autonomy traffic flow environment.

8 Order Quantity or Total Consumption? How Consumers Mode of Payment Affect Gasoline Retailer's Profitability

Nathan C. Craig[1], Ananth Raman[2], Ehsan Valavi[3], [1]Ohio State University, Columbus, OH, [2]Harvard University, Boston, MA, [3]Harvard Business School, Boston, MA

Gasoline is believed to be an inelastic commodity. Yet, its high price volatility raises questions about how consumers react to its price variation. In this research, we curated a dataset from a large gasoline retailer to study the effect of consumers' mode of payment on their order quantity.

9 An Online Platform's Pricing and Sourcing Decisions with Vendor Managed Inventory

Dennis Yu, Clarkson University, Potsdam, NY, Contact: dyu@clarkson.edu

We study an online platform's optimal pricing and sourcing decisions when the platform can purchase from a manufacturer who also provides VMI option to the platform while having its own OEM direct channel. We consider two competing distribution channels including the platform's online selling channel and the manufacturer's direct channel by using the platform's online retailing services. Both the platform and the manufacturer need to determine the retail prices to compete for the market demand with customers who have a diversified preference in retail channels. We take the platform's perspective to investigate the platform and the manufacturer's optimal pricing decisions under two different scenarios with a cooperative dual-channel competition framework.

Sunday, 12:30 PM–1:45 PM

SC77

M - Texas
BOM Flash Session
Flash Session

Session Chair
Jason (Xianghua) Wu, University of Houston, Houston, TX

1 Bounded Rationality in Capacitated and Multi-variate Sourcing Decisions

Thomas B. Cassidey[1], Nickolas K. Freeman[2], Sharif Melouk[2], [1]The University of Alabama, Tuscaloosa, AL, [2]The University of Alabama, Tuscaloosa, AL, Contact: tcassidey@crimson.ua.edu

We study the decision making behavior of concurrent sourcing firms subject to all-or-nothing outsource supply disruptions. The sourcing decision maker must balance capacity constraints, demand risk, supply uncertainty, and costs to determine component production and order amounts under the supplier delivery and disruption scenarios. We show that diversification and order volume error is predicted by bounded rationality. We perform a laboratory experiment to test the effect of differing production capacity constraints on decision behavior. Although the ability to concurrently source is a sunk cost and supply disruption is mitigated by contingent planning, we find strong evidence for diversification error, both when sole and dual sourcing are optimal, accompanied by evidence of bounded rationality.

2 Building a Bidirectional Supply Chain for Farm to Rural Grocery to Wholesale

Karen L. Donohue, University of Minnesota, Minneapolis, MN

This talk highlights results from a multi-year USDA sponsored project developing a new model for small and medium-sized crop producers to access wholesale markets in the Midwest. The proposed Farm to Rural Grocery to Wholesale (F2G2W) model leverages an existing network of rural grocery stores and their wholesale suppliers to "backhaul" locally grown produce on emptied wholesale trucks for redistribution through wholesale markets. The project aims to increase the viability, competitiveness, and sustainability of rural produce supply chains. In piloting the model, a special focus is placed on how to align objectives and counter-act potential behavioral detractors across diverse stakeholders.

3 Voluntary Disclosure, Endogenous Matching and Bargaining: Theory and Experiments

Kyle Hyndman[1], Andrew M. Davis[2], [1]University of Texas at Dallas, Richardson, TX, [2]Cornell University, Ithaca, NY

We study bargaining with private information in which the privately informed player may voluntarily and truthfully disclose their private information. We do this both when there is and is not a potential matching benefit to disclosure, whereby a disclosing player may be matched with a better partner than a non-disclosing player. We generate theoretical predictions and then test these predictions in two laboratory studies. A key insight is that disclosure may actually be driven by the demands of uninformed players, particularly those strong enough, or attractive enough, to be able to insist upon it as a requirement for doing business.

4 The Market Value of Sustainability Disclosure: A Cross-cultural Study

Tim Kraft[1], Douglas Thomas[2], Yanchong (Karen) Zheng[3], [1]NC State - Poole College of Management, Raleigh, NC, [2]University of Virginia, Charlottesville, VA, [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: thomasd@darden.virginia.edu

Partnering with Goodio, a Finland-based craft chocolate producer, we explore how consumers react to story-based and fact-based messaging regarding supply chain (internal) and community development (external) initiatives. We test the effects of transparency in Goodio's two largest markets - the US and Finland. We find that consumers in both markets prefer messaging on internal intiatives over external initiatives. However, Finnish consumers prefer story-based messaging, while US consumers prefer fact-based messaging. To further the latter result, we test the effects of cultural differences between the two subject pools.

5 Exclusive or Not an Experimental Analysis of Parallel Innovation Contest

Ramazan Kizilyildirim[1], Gizem Korpeoglu[2], Ersin Korpeoglu[3], Mirko Kremer[4], [1]UCL, London, United Kingdom; [2]Eindhoven University of Technology, Eindhoven, Netherlands; [3]University College London, London, United Kingdom; [4]Frankfurt School of Finance and Management gGmbh, Frankfurt Am Main, Germany. Contact: ramazan.kizilyildirim.19@ucl.ac.uk

We study parallel innovation contests. The quality of a solver's solution in a contest can be improved by exerting effort, yet it is also subject to an output uncertainty. Theory shows that organizers should discourage solvers from participating in multiple contests under low output uncertainty to benefit from solvers focusing their efforts into a single "exclusive" contest rather than splitting them across multiple "non-exclusive" contests. In a controlled laboratory experiment, we find that non-exclusive contests are attractive for organizers even at low output uncertainty levels. We link this to behavioral drivers that lead to a smaller average and a larger variance of solvers' effort.

6 Ups and Downs: How to Shape Spectators' Sentiment

Hongqiao Chen[1], Ming Hu[2], Jingchen Liu[3], Yaniv Ravid[4], [1]Nanjing University, Nan Jing Shi, China; [2]University of Toronto, Minneapolis, MN, [3]Nanjing University Business School, Nanjing, China; [4]University of Toronto, Toronto, ON, Canada. Contact: y.ravid@rotman.utoronto.ca

Under the application of prospect theory, this paper considers a decision maker who wishes to maximize an audience's experienced utility under three different settings. First, we investigate the problem of simultaneous vs. sequential release of content such as songs or TV episodes, where the decision maker may not know a priori the audience's valuation of each item. Second, we study the problem of releasing a piece of good vs. bad news, where the decision maker may preempt the release with other pieces of their choice. Lastly, we consider the problem of sequencing experiences of known valuations, such as in a concert, and provide guidelines on the decisions which give the most pleasant experiences.

7 Censorship Bias and Self-inflicted Stockouts in Grocery Retail Replenishment

Bengu Ozdemir, Antti Tenhiala, IE Business School, Madrid, Spain. Contact: bengu.ozdemir@student.ie.edu

In the retail industry, store managers are typically empowered to adjust the proposals of automatic store replenishment (ASR) systems to incorporate their private knowledge. Apart from occasionally improving ordering decisions with human insights and information that is not available to the algorithms of the ASR system, we show that the store managers are suspect to biases. We examine the prevalence and performance implications of censorship bias, which explains a paradox where retailers order less after a stockout. Accounting for the endogeneity of ordering decisions, we show that censorship bias is equally prevalent and detrimental as the well-known anchoring bias of ordering behavior.

9 Who Should Bear the Risk? A Theoretical and Behavioral Investigation of After-sales Service Contracts

Rob Basten[1], Ozge Tuncel[2], Michael Becker-Peth[3], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Maastricht University, Eindhoven, Netherlands; [3]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands.

Using the right after-sales service contract is key to achieve high equipment availability. Resource-based contracts fail to motivate suppliers to provide reliable products as they are paid for their after-sales services. Performance-based contracts shift much of the downtime risk to the supplier, but then customers might reduce care efforts. We propose the full-care contract (FCC) to achieve both high reliability and care. We analytically find that only the FCC can achieve full chain efficiency. We conduct a lab study with decision makers as suppliers. It confirms that the FCC achieves highest total profits. We further observe that effort levels set by suppliers are above normative predictions.

Sunday, 12:30 PM–1:45 PM

SC78

M - Utah

Economics of AI and Online Marketplaces

General Session

Session Chair

Zhaohui Jiang, Tepper School of Business, Carnegie Mellon University, Sewickley, PA

1 **Aggregating Privacy-Sensitive Forecasters**
Marat Salikhov[1], Ruslan Momot[2], [1]New Economic School, Moscow, Russian Federation; [2]Kellogg School of Management, Northwestern University, Ann Arbor, MI, Contact: msalikhov@nes.ru
Organizations often make forecasts by eliciting inputs from their internal experts and then aggregating these inputs for decision-making. Experts are generally interested in providing quality forecasts, however, in some cases their incentives may be distorted by fears for their privacy. Allowing experts to have "plausible deniability" about their forecasts may improve both the participation rates and forecast quality. We propose introducing such deniability by adding noise to all publicly made forecasts. Adding noise has two effects on forecasting performance: a negative effect - noisy forecasts are less efficient to aggregate, and a positive effect - the experts have weaker incentives to bias their forecasts. We construct an analytical model that describes the optimal level of noise and analyze its implications for forecast aggregation.

2 **Can Crowdsourcing Cure Misinformation? The Impact of Twitter's Birdwatch Program on Content Generation**
Sameer Borwankar, Jinyang Zheng, Karthik Kannan, Purdue University, West Lafayette, IN, Contact: sborwank@purdue.edu
All content-sharing sites, including social media platforms, face the creation and spread of misinformation, which leads to wrong beliefs, a hyper-partisan atmosphere, and public harm. Experts have suggested leveraging the "wisdom of crowds" to identify misinformation. However, the implication of such crowdsourcing programs on their participants is not carefully studied in the field. We take the first step and leverage the quasi-field experiment of Twitter's Birdwatch program to investigate the causal effect of participating in the crowdsourcing program on the subsequent activities of the participants. The results show negative impact on the quantity of the generated content and some positive impact on the quality of the content.

3 **Growth Versus Competition in Emerging Digital Marketplaces: Evidence from Amazon Prime's Effect on Competitors**
Kevin Zhu[1], Zhe Zhang[2], Xiaofeng Liu[3], [1]University of California-San Diego, La Jolla, CA, [2]University of California-San Diego, San Diego, CA, [3]UC San Diego, La Jolla, CA, Contact: kxzhu@ucsd.edu
It is important to understand the impacts of a dominant player's growth on its competitors in an emerging digital market. Amazon has been a dominant flagship retailer in online markets. As Amazon Prime membership is a discrete moment when adopters significantly increase their Amazon usage, we analyze the impacts of Prime adoption on adopters' non-Amazon spending. The results show that Prime adoption has a positive spillover on adopters' non-Amazon spending. More specifically, the positive spillover is more salient for novice adopters, but not significant for experienced adopters. We propose and validate a potential mechanism: the positive spillover is from increased comfort gained through the increased Amazon usage, and also rule out other possible explanations. The results highlight the potential value of dominant player's growth in market expansion.

Sunday, 12:30 PM–1:45 PM

SC79

JWM - Room 201
Decision Making in Innovation Settings
General Session

Session Chair
Param Pal Singh Chhabra, University of Alberta, Edmonton, AB, Canada.

1 **It'S Time to Break Up: Dynamics Surrounding Young-established Firm Alliance Duration**
Navid Asgari[1], Annapoornima Subramanian[2], Moren Levesque[3], Pek-Hooi Soh[4], [1]Fordham University, New York, NY, [2]National University of Singapore, Singapore, Singapore; [3]York University, Toronto, ON, Canada; [4]Simon Fraser University, Toronto, BC, Canada. Contact: mlevesque@schulich.yorku.ca
While young firms often benefit from their relationships with established firms, these relationships can be risky. We adopt the young firm's perspective and dynamically weighs the tradeoffs between risks of continuing and discontinuing a relationship with an established firm, thereby deciding its alliance duration. We first develop an analytical model to understand how the alliance duration (time between alliance formation and termination) between the young and established firms is affected by each firm's alliance portfolio size, the young firm's IP portfolio size, and the number of technologies underlying the alliance that were affected by a technological discontinuity. We then test the resulting hypotheses on a large sample of alliances between biotechnology and pharmaceutical firms during the 1986-2000 period, which straddles a technological discontinuity.

2 **Causal Gradient Boosting**

Amandeep Singh, Wharton Business School, philadelphia, PA

Recent advances in the literature have demonstrated that standard supervised learning algorithms are ill-suited for problems with endogenous explanatory variables. In this paper, we propose an alternative algorithm called boostIV that builds on the traditional gradient boosting algorithm and corrects for the endogeneity bias. We demonstrate that our estimator is consistent under mild conditions. We carry out extensive Monte Carlo simulations to demonstrate the finite sample performance of our algorithm compared to other recently developed methods. We show that boostIV is at worst on par with the existing methods and on average significantly outperforms them.

3 **Issues and Models in Autonomous Vehicle Operations**

Amin Abbasi Pooya[1], Nagarajan Sethuraman[2], Suman Mallik[2], [1]University of Kansas, Lawrence, KS, [2]University of Kansas, Lawrence, KS, Contact: a.abbasipooya@ku.edu

The presentation is based on an ongoing research on modeling operations management issues in the autonomous vehicle market. We use game theoretical models to capture the market dynamics, characterize the equilibrium, and analyze its properties of it. Our results provide insights for autonomous vehicle manufacturers to optimize their operations.

4 **Choosing to Compete: The Role of Group Size, Prize Type, and Participant Heterogeneity on Contest Entry**

Jeeva Somasundaram[1], Konstantinos Stouras[2], [1]IE Business School, Madrid, Spain; [2]UCD, Dublin, Ireland. Contact: konstantinos.stouras@ucd.ie

This experiment compares the performance of three key contest designs: the number of potential entrants, whether to split the winning prize among entrants or not, and the heterogeneity among entrants. We find that participation is maximized when the contest has higher potential entrants, offers a winner-takes-all prize and entrants appear ex-ante homogeneous. This contest design performs the best by mitigating the effects of competition by providing the greatest possible returns on entry and by limiting the degree to which heterogeneity discourages weaker entrants. These findings could inform the design of competitive markets with entry such as on-demand services with endogenous supply, ideation contests, and campaigns to support a philanthropic cause or a marketing promotion which mainly seek to attract entrants into the pursuit of a common objective.

Sunday, 12:30 PM–1:45 PM

SC80

JWM - Room 202

2022 MCDM Junior Researcher Best Paper Award

Award Session

Session Chair

Roman Slowinski, Poznan University of Technology, Poznan

1 **Network Models for Multiobjective Discrete Optimization**

David Bergman[1], Merve Bodur[2], Carlos Henrique Cardonha[1], Andre Augusto Cire[3], [1]University of Connecticut, Storrs, CT, [2]University of Toronto, Toronto, ON, Canada; [3]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada. Contact: bodur@mie.utoronto.ca

We propose a novel framework for solving multiobjective discrete optimization problems with an arbitrary number of objectives. Our framework formulates these problems as network models, in that enumerating the Pareto frontier amounts to solving a multicriteria shortest path problem in an auxiliary network. We design tools and techniques for exploiting the network model in order to accelerate the identification of the frontier. We show that the proposed framework yields orders-of-magnitude performance improvements over existing state-of-the-art algorithms on four problem classes containing both linear and nonlinear objective functions.

2 **Multicriteria Decision Support for the Evaluation of Electricity Supply Resilience: Exploration of Interacting Criteria**

Eleftherios Siskos, Peter Burgherr, Paul Scherrer Institute, Villigen, Switzerland. Contact: eleftherios.siskos@psi.ch

The increasing risk of extended electricity supply disruptions and severe electricity price fluctuations are stressing the need for an evaluation of electricity supply resilience. Towards this direction, this paper proposes a multicriteria decision support framework to assess resilience at a country level, on the basis of three major dimensions: Resist, Restabilize, Recover. In total, 35 European countries are ranked according to their performance on 17 indicators, through a synergy of MCDA methods, techniques and communication protocols. The assessment framework has been extended to incorporate the Choquet Integral, as an importance index, in order to accommodate potentially interacting pairs of criteria and negate their arbitrary effects on the final ranking.

3 **Incorporating Uncovered Structuralpatterns in Value Functions Construction**
Mohammad Ghaderi[1], Milosz Kadzinski[2], [1]Pompeu Fabra University (UPF), Barcelona, Spain; [2]Poznan University of Technology, Poznan, Poland.
A common approach in decision analysis and choice modeling is to infer a preference model in the form of a value function from the holistic choice examples. This paper introduces an analytical framework for estimating individuals' preferences through uncovering structural patterns that regulate general shapes of value functions. We suggest a simple characterization of structural patterns and investigate the impact of incorporating information on such patterns on the predictive validity and estimation accuracy of preferences through an exhaustive simulation study and analysis of real decision makers' preferences. We found that accounting for the structural patterns at the population level considerably improves the predictive performance of the constructed value functions at the individual level. This finding is confirmed across a wide range of settings with different levels of heterogeneity among the individuals and various complexity levels in their true preferences. We found, however, that improvement in the predictive performance is more significant when the choice examples come from a larger number of individuals, and when a smaller amount of preference information is available. The proposed model is developed based on a convex optimization problem with linear constraints, thus being computationally efficient and applicable to datasets of realistic size.

4 **Bound Set Based Branch and Bound Algorithms for Multi-objective Integer Linear Programming Problems**
Sune Lauth Lauth Gadegaard, Aarhus University, Skanderborg, Denmark.
This talk takes its outset in the paper "*Bi-objective Branch-and-Cut Algorithms Based on LP Relaxation and Bound Sets*". The concept of bound-set-based branch-and-bound algorithms will be introduced and we show how branching can be performed in both decision and objective space. The algorithm discussed computes, for each branching node, a lower-bound set and compares it with an upper-bound set. We outline approaches for fathoming branching nodes, and we propose an updating scheme for the lower-bound sets that prevents us from solving the bi-objective linear programming relaxation of each branching node. To strengthen the lower-bound sets, we propose a bi-objective cutting-plane algorithm that adjusts the weights of the objective functions such that different parts of the feasible set are strengthened by cutting planes. In addition, we discuss a recent generic branch-and-bound algorithm for solving multi-objective integer linear programming problems. In the recent literature, competitive frameworks have been proposed for bi-objective 0-1 problems, and many of these frameworks rely on the use of the linear relaxation to obtain lower bound sets. When increasing the number of objective functions, however, the polyhedral structure of the linear relaxation becomes more complex, and consequently requires more computational effort to obtain. Here, a speed-up technique is proposed to make these computations feasible. This is done by warm-starting a Benson's like algorithm. Finally, branching in the objective space is extended to higher dimensions and some computational results are presented.

UNREGISTERED Award Presenter
Jiapeng Liu, Xi'an Jiaotong University, Xi'an, China.

Sunday, 12:30 PM–1:45 PM

SC81

JWM - Room 203
Supply Chain Science
Joint Session

Session Chair
Margaret Pierson, Wayfair, Seattle, WA

1 **Trailer Rebalancing at Convoy**
Yashar Khayati, Convoy, Seattle, WA, Contact: yashar.khayati@convoy.com
Semi-truck Trailers are Bigger than Scooters Supply chains are intrinsically imbalanced in terms of empty trailer needs. A mixed-integer programming (MIP) model, TRIP (Trailer Rebalancing Integer Programming), is developed at Convoy which is responsible for repositioning all the empty trailers based on real-time information. The objective of the model is to get the right amount of trailers, to the right places, at the right time to service shipper customers considering all various business constraints.

2 **Demand Shaping Via Exposure Mechanisms**
Emre Ertan, Wayfair
Wayfair has an opportunity to align supplier and Wayfair incentives using exposure as a mechanism. By nudging customers towards products that have better unit economics, we can reduce supply chain costs and incentivize suppliers to do the same. There are many challenges in implementing this strategy and we'll share our early work and learnings from taking on this question.

3 **Optimization of Pharmacy Prescription Fill Process Using Machine Learning**
Taras Gorishnyy, CVS Health, Woonsocket, RI
CVS Retail Pharmacy fills over 1.5 billion prescriptions each year. Each fill involves multiple steps which often requires interactions between a pharmacists, prescribers, payors and customers. Optimizing efficiency and effectiveness of the dispensing process in critical to ensure positive customer and colleague experience.
In this talk we will discuss how CVS Health uses machine learning to optimize its prescription fill process. We will review application areas for analytics, describe design and performance of data science models and discuss complexity of implementing real time technology at scale.

4 **Multi-Echelon Temperature-Constrained Supply Chain Management at Amazon**
Gizem Cavuslar, Amazon.com, Seattle, WA
Fresh, Amazon's grocery business, operates on a multi-echelon temperature constrained supply chain. Fast delivery and easy customer access are key to the customer satisfaction. Therefore, the end nodes of the supply chain, online and offline, should be close to the major population areas. Unfortunately, this limits the size of the stores and storage facilities, causing a year-round capacity constrained nodes. On top of that, having considerably high number of new stores with less than one year of operation and trickling effects of the pandemic are resulting in non-stationary demand and supply processes. We, the scientists at Amazon Fresh, utilize a combination of Machine Learning, Operations Research, and Reinforcement Learning approaches to model and solve this non-stationary, multi-echelon, multi-period, and perishable inventory optimization problem. In this talk, we will provide an overview of the problem space and go over modeling approaches developed by the Grocery Inventory Science team.

Sunday, 12:30 PM–1:45 PM

SC82

JWM - Room 204
Writing Strategies for Junior Faculty
Panel Session

Session Chair
Clara Novoa, Texas State University, San Marcos, TX

1 **Writing Strategies for Junior Faculty**
Clara Novoa, Texas State University, San Marcos, TX, Contact: cn17@txstate.edu
This panel is an excellent opportunity to hear from faculty with vast experience in academic writing. The discussion will center on strategies for effectively writing papers and proposals, considering single authorship and collaborative environments. The tips provided and the answers to questions from other faculty in the audience will broaden junior faculty perspectives on academic writing.

2 **Panelist**
Nazanin Morshedlou, Mississippi State University

3 **Panelist**
Laura A. Albert, University of Wisconsin-Madison, Madison, WI, Contact: laura@engr.wisc.edu

4 **Panelist**
Alexandra M. Newman, Colorado School of Mines, Golden, CO

5 **Panelist**
James J. Cochran, The University of Alabama, Tuscaloosa, AL

Sunday, 12:30 PM–1:45 PM

SC84

JWM - Room 206
Dynamic Data Driven Application Systems
General Session

Session Chair
Jie Xu, George Mason University, Fairfax, VA

1 **Machine Learning based Simulation for Fault Detection in Microgrids**
Joshua Darville, Nurcin Celik, University of Miami, Miami, FL
Fault detection (FD) is crucial for a functioning microgrid (MG) but is particularly challenging since faults can stay undetected indefinitely. Hence, there is a need for real-time, accurate FD in the early phase of MG operations to mitigate small initial deviations from nominal conditions. To address this need, we propose an FD framework for MG operational planning. Our proposed framework is synthesized from i) a dataset generated by introducing faults into an MG with PV cells, ii) processing the dataset to train various machine learning (ML) models for FD, iii) benchmarking the resulting FD models using classification metrics, and iv) applying an appropriate

fault mitigation strategy. Although noisy measurements were present during the experiment due to variations in ambient temperature and solar irradiance, our proposed FD model is shown to be both computationally efficient with an average training time of 1.76 seconds and accurate with a weighted F-score of 0.96.

2 Resource Allocation Subject to Stochastic Failures: Application to Snow Plowing Operations in Utah

Yinhu Wang[1], Ye Chen[2], Ilya Ryzhov[3], Xiaoyue Liu[1], Nikola Markovic[1], [1]University of Utah, Salt Lake City, UT, [2]Virginia Commonwealth University, Richmond, VA, [3]University of Maryland, Baltimore, MD

We consider a two-stage planning problem where a fleet of snow plow trucks is first divided among a set of independent regions and then each region designs routes for efficient snow removal. However, snow plow trucks are subject to failures, which gives rise to a stochastic variant of the problem. In a risk-neutral setting, we allocate trucks such that the expected maximum turnaround time across all the regions is minimized and devise a custom branch-and-bound algorithm to solve the non-linear non-convex problem optimally. In a risk-averse setting, we allocate trucks to minimize the maximum turnaround time that can be sustained with a user-specified probability. The chance-constrained program is solved optimally with a custom solution algorithm. The benefits of the proposed methods are demonstrated through implementation in northern Utah.

3 Dynamic Data-driven Approach for Secure and Resilient Energy System Cyberinfrastructure

Kevin Jin[1], Yanfeng Qu[2], Gong Chen[2], [1]University of Arkansas, Fayetteville, AR, [2]Illinois Institute of Technology, Chicago, IL, Contact: dongjin@uark.edu

We apply the dynamic data-driven applications systems (DDDAS) paradigm to enhance cyber security and resilience of energy systems. We use software-defined networking (SDN) to monitor and control the cyberinfrastructure and explore security applications that consider both the cyber and physical characteristics of the grid to detect and mitigate attacks, such as the emerging MadIoT attack, a variant of Internet of Things (IoT) botnet attacks, allow an adversary to disrupt the power grid's normal operation by manipulating the total power demand using compromised IoT devices of high wattage. We take a decentralized approach to selectively deploy the learning-based detection engine on switches for fast detection. We also utilize the global visibility and direct network control offered by SDN to design algorithms to mitigate the attack traffic and self-heal the network.

4 Multimodal Fusion of Satellite and Radar to Predict Future Weather Events

Grace Metzgar[1], Nathan Gaw[2], [1]Air Force Institute of Technology, Wright-Patterson AFB, OH, [2]Air Force Institute of Technology, Wright-Patterson AFB, OH, Contact: Grace.Metzgar@afit.edu

The uncertainty of Earth's weather greatly impacts the lives of the general public inciting the application of machine learning in meteorology. However, the complexity of weather data increases the difficulty of creating models that can accurately recognize and forecast weather patterns. To address these shortcomings, we employ the Storm EVent ImagRy (SEVIR) dataset which was created to aid in the inefficiencies of developing these complex models by combing spatial and temporal weather data from multiple sensing modalities. We hypothesis that utilizing such data in machine learning techniques will allow for greater accuracy and reliability in predicting certain weather patterns.

Sunday, 12:30 PM–1:45 PM

SC85

JWM - Room 207

Publishing in INFORMS Transactions on Education

General Session

Session Chair

Stefan Creemers, IESEG, Aarschot, Belgium.

1 Editor-in-Chief

Stefan Creemers, IESEG, Aarschot, Belgium.

We discuss which types of papers (regular papers, case studies, classroom games, puzzles) are currently published in ITE. Furthermore, we interact with the audience on how ITE should proceed in order to become the flagship journal in OR/MS/analytics education.

2 Recent Author ITE

Steven Shechter, University of British Columbia, Vancouver, BC, Canada.

3 Recent Author ITE

Dries Goossens, Ghent University, Gent, Belgium.

4 Area Editor in Classroom Games

Jeroen Belien, KU Leuven, Brussel, Belgium.

Sunday, 12:30 PM–1:45 PM

SC86

JWM - Room 208

AAS Best Student Presentation Competition 1/3

Award Session

Session Chair

Keji Wei, Sabre, Grapevine, TX

1 Award Presenter

Amir Hossein Moadab, WSU Carson College of Business, Pullman, WA

AbstractThe fast and cost-efficient delivery of goods ordered online is logistically a challenging problem. Many firms are looking for ways to cut delivery times and costs by exploring opportunities to take advantage of drone technology. Deploying drones as a promising technology is more efficient from both environmental and economic perspectives in last-mile delivery. This paper considers a last-mile delivery system in which a set of drones are operated in coordination with public transportation system to deliver a set of orders to customer locations. A mathematical model based on Vehicle routing Problem (VRP) is extended to solve this problem. A real-world case inspired by Bremen 2025 transportation paradigm is also developed to validate the developed mathematical formulation. Results show that the sequence of visiting customers and public transport stations highly impacts the remaining charge and efficiency of drone tour planning. Also, using public transport vehicles, which enables drones to charge their battery or to approach customers, can reduce the number of drones required for satisfying the demands in a service area. The results show that there are high potentials to save energy for drone-enabled last-mile delivery by using the public transportation network. Problem Description and Mathematical FormulationFor this article, more than 60 research and paper written in the context of last-mile delivery and using emerging technologies, have been surveyed. Because of limitation in number of abstract pages, only nine of these references have been mentioned [1]-[9]. This section describes the main assumptions of the defined problem and presents the associated mathematical model. The objective function of the problem aims at minimizing the total required energy for the last-mile delivery of customer orders. Hence, the following key decisions must be optimized. (i) assignment of customer locations to depots, (ii) assignment of customers' packages to drones, (iii) sequence of visiting customer locations and public transport stations, and (iv) assignment of flying drones to pre-existing public transport routes, if required. In this problem, not only do drones use public transportation for charging purposes, but also, they may use them for traveling between locations without further consuming energy. Drones can only be mounted on public transport at the first (public station 1) and middle stations for charging operations, either from a warehouse node or customer node. Drones are not allowed to hop on public transport at the last station (station |B|) due to the relatively long suspension of public transport operation until its resumption. So, drones can only leave station |B| to travel toward a warehouse or customer node and are not allowed to enter the last station. Also, drones are not allowed to leave the first station toward a warehouse or customer node because the station is the start point, and the public transport has not yet resumed its operation, which as a result, the drone battery did not receive energy. After assuming additional operational assumptions, a mixed-integer linear programming has been developed based on four sets including set of drones, customers, warehouses, and public transportation vehicles. Besides, an objective function has been considered in terms of total energy consumption minimization subject to three sets of constraints including (A) route feasibility and synchronization, (B) capacity and weight tracking, and (C) energy tracking and charging policy. The developed model is validated and implemented using a real-world scenario inspired based on the actual input parameters of nodes in Bremen, Germany. To further analyze the impact of input parameters, the paper has conducted an experimental study changing the problem size in terms of the number of warehouses and customers, the warehouse locations (near to service area/far from service area), and the available number of drones at each warehouse. Finally, discussion and managerial insight were investigated based on the benefits of the proposed drone delivery system based on the public transportation network from three points of view: e-commerce companies and LSPs, customers, and the environment. References: As attached in the file sent. (Word limitation)

2 Competing on Emission Charges

Nicole Adler[1], Gianmarco Andreana[2], Gerben De Jong[1], [1]Hebrew University of Jerusalem, Jerusalem, Israel; [2]University of Bergamo, Bergamo, Italy.

Motivation

The aviation industry currently produces 2.5% of global carbon dioxide (CO_2) emissions, and this is expected to triple by 2050 if air transport continues to grow according to current trends [3,5]. In the absence of a global government, decision-makers at the local, national and supra-national levels (e.g. the European Union and ICAO) have mandated various environmental policies in an attempt to control aviation emissions [4]. However, the extent and the efficiency of these environmental measures diverge significantly across countries and regions.

Research problem

Given the existing asymmetry of environmental policies, we investigate the impacts of emission reduction schemes on competitive aviation markets. Consequently, we seek to identify a set of environmental policies that may lead to efficient social welfare allocations. We focus on the possibility of developing a cooperative and unique equilibrium strategy for all regulators, in an attempt to overcome the environmental free-riding problem [6].

Methodology

We define our game-theoretic model as a two-stage Nash game. The set of players composing the first stage is characterized by multiple local and regional regulators in addition to supra-national decision-makers. Each regulatory body maximizes the social welfare of the area under its control by setting the level of environmental taxation applied, including charges on passengers and airline taxes per ton of CO_2 produced. In the second stage, airlines compete through profit maximizing, best response functions that set airfares and service frequencies, hence market shares per city pair [1-2].

To respond to changes in the climate policies, airlines may choose to (i) sell off less efficient aircraft and possibly replace them with newer technologies, (ii) utilize higher emission aircraft less, (iii) reallocate higher emission aircraft to routes with lower environmental taxes and/or (iv) reduce frequencies on regulated routes. These decisions will impact the capacity offered per city pair.

The game is solved iteratively by developing a grid-search algorithm in the first stage and an interior point penalization algorithm [8] in the second stage. We search for the Subgame Perfect Nash Equilibrium (SPNE) of the game in which no regulator nor airline would choose to deviate from the equilibria outcome [7].

Expected results

The main result of this research is an equilibrium outcome for airlines and regulatory bodies that ensures ongoing connectivity whilst minimizing the environmental impact of aviation. To be specific, we find the equilibrium in airfares, service frequency, fleet composition and aircraft allocation for the airlines. We also search for the efficient set of environmental charges that maximizes the social welfare of passengers, airlines and governments belonging to a regulator's jurisdiction. Finally, we test whether an awareness of the potential policy levers being set by each regulator, at the airport, country, regional and global scale, leads to more efficient and coordinated decisions.

Contribution

The contribution of this paper is threefold. First, we develop a game-theoretic framework that assesses the impact of environmental policies on the aviation industry a-priori, taking into account both airline and regulator competition. Second, we propose a heuristic framework to solve two-stage games by addressing the double dynamics resulting from the nature of the consecutive stages of implementation. Third, the proposed framework will provide a decision support tool and guidance to national and supra-national policymakers when defining new mechanisms to achieve environmental goals in the most efficient manner possible.

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3 Award Presenter

Bazyli Szymanski, Massachusetts Institute of Technology, Cambridge, MA, Contact: bazyli@mit.edu

Most existing RM systems are built assuming monopoly, and academic work that models competition tends to seek game-theoretic equilibria given extensive knowledge and strong assumptions. In contrast, we propose a simple *competitor adjustment* approach, where airline's willingness-to-pay (WTP) estimates used for fare quotation are altered exclusively based on current competitor fare.

The adjustment is tested in the emerging context of continuous pricing, where airlines are not restricted to a small set of price points. We quantify the competitive impacts of the adjustment through simulations and discuss whether it could help pave the way to adoption of new WTP-based optimizers for continuous pricing.

4 A Market-based and Policy-based Competitor-aware Conditional Forecasting Method

Tim Yuxuan Lu, Massachusetts Institute of Technology,

Cambridge, MA, Contact: lutim@mit.edu
The proliferation of OTA, implementation of the NDC, and removal of fare class restrictions promote price transparency and amplify price competition. Forecasting demand based on observations and predictions of competitors' offerings can benefit airlines significantly. We propose a market-based and policy-based competitor-aware conditional forecaster, which predicts competitors' policies based on historical policy observations and then explicitly constructs forecasts based on actual and predicted competitors' policies. With the proposed forecaster, forecast accuracy can be improved, and fare class forecasts can be dynamically adjusted according to competitors' offerings. The concept, methodology, process, and preliminary results are shared.

Sunday, 12:30 PM–1:45 PM

SC87

JWM - Room 209

Air Traffic Management and Flight Delay

General Session

Session Chair

Ke Liu, 1</sup

1 Air Corridor Metrics Development: A Case Study Based on Traffic Within 150 Miles of Edwards Air Force Base

Xuan Jiang, UCB
Currently, the aviation metrics are mostly developed by simulation and optimization which is redundant and bulky (see Bauer et al. 2021). Our work aims on ending this trend and propose different ways of aviation metrics based on different stakeholders' interests while building an air corridor. We proposed our way of describing the corridor as a cube based on the vertical and lateral distance threshold FAA regulated. We used aircraft time, the number of aircraft within the cube within a certain period, and certain location slices of the corridor. We gave methods for choosing the best corridors from several corridors, and we proposed an innovative way to choose the best route for a given origination and destination. We demonstrate the methodology with a case study based on the data of air traffic within 150 miles of Edwards Airforce Base and the method is transferrable to other cases.

2 Benefits of Shifting Passenger Traffic from Air to Rail: A Case Study of California High-speed Rail

Kaijing Ding[1], Lu Dai[1], Mark M. Hansen[2], [1]University of California, Berkeley, Berkeley, CA, [2]University of California-Berkeley, Berkeley, CA
This study provides a method to quantify the benefit of shifting passenger traffic from air to high-speed rail from the perspective of flight delay cost reduction. We first estimate the number of flight reductions for airport pairs based on the HSR ridership forecast and then apply Lasso models to estimate the impact of the reduced queuing delay of SFO, LAX and SAN on the arrival delay of national Core 29 airports. Finally, we monetize these delay reductions and ultimately arrive at delay cost savings of $71-123 million in 2029 and $370-618 million in 2033.

3 Excess Delay from GDP: Measurement and Causal Analysis

Ke Liu[1], Mark M. Hansen[2], [1]University of California, Berkeley Berkeley, CA, Berkeley, CA, [2]University of California-Berkeley, Berkeley, CA, Contact: liuke126@berkeley.edu
GDPs have been widely used to resolve excessive demand-capacity imbalances at arrival airports by shifting foreseen airborne delay to pre-departure ground delay. While offering clear safety and efficiency benefits, GDPs may also create additional delay as a result of imperfect execution and uncertainty in predicting arrival airport capacity. This paper presents a methodology for measuring excess delay resulting from individual GDPs, and investigates factors that influence excess delay using regularized regression models. We measured excess delay for 1210 GDPs from 33 airports in 2019. On a per-restricted flight basis, the mean excess delay is 30 min with std of 20 min. In our regression analysis, the factors affecting excess delay include time variations during gate out and taxi out for flights subject to GDP, program rate setting and revisions, and GDP time duration.

4 Sensing and Learning in Aircraft Network Routing

Xiyitao Zhu[1], Jing Gao[2], Ankur Mani[3], Lavanya Marla[4], [1]University of Illinois Urbana-Champaign, Champaign, IL, [2]University of Minnesota, Minneapolis, MN, [3]University of Minnesota - Twin Cities, Minneapolis, MN, [4]University of Illinois at Urbana-Champaign, Urbana, IL, Contact: xiyitao2@illinois.edu
In the US National Aviation System (NAS), aircraft rely on weather information for routing decisions. We propose that using en-route aircraft as sensors to collect updated weather information at the right place and right time maintains high-quality weather information that benefits the NAS. Motivated by the spatial and temporal correlations in weather, we propose a novel modeling framework for routing

decisions on (airspace) networks with non-stationary Gaussian bandits, temporal information diffusion, and in particular, with combinatorial path structures. We find time and fuel savings of the order of 5% across multiple O-Ds in the NAS. Our framework is also applicable to intra-city aircraft and unmanned aircraft such as UAVs and drones.

Sunday, 12:30 PM–1:45 PM

SC98

CC - Exhibit Hall E

Minority Issues Forum (MIF) Student Poster Session

Poster Session

Session Chair

Shannon Harris, [1</sup]

Session Chair

Ruben Proano, Rochester Institute of Technology, Rochester, NY

01 Association Between Advanced Image Ordered in the Emergency Department and Subsequent Imaging for Abdominal Pain Patients

Valerie Odeh-Couvertier, University of Wisconsin, Madison, WI, Contact: odehcouverti@wisc.edu

Abdominal pain is associated with high rates of emergency department (ED) imaging utilization and revisits. A better understanding is needed on when the decision to image is justified. We evaluated associations between ED imaging on subsequent outpatient imaging and revisits among abdominal pain patients discharged from the ED. Imaging in the ED was associated with lower imaging utilization and revisit to an ED after discharge, suggesting that ED imaging may replace downstream imaging.

02 Incorporating Ventilation and Heat in Short-term Underground Mine Production Scheduling

John Ayaburi, Colorado School of Mines, Golden, CO

The accumulation of heat in underground mines not only disrupts the schedule but also affects the health and safety of mine workers. We develop a large-scale, short-term production scheduling model that minimizes deviation between i) medium- and short-term schedules and ii) production goals. Constraints include precedence, resource consumption and heat limits. We correspondingly present novel techniques to improve model tractability. The model produces a consistent schedule while ensuring the safety of the work environment.

03 Active Learning for Non-parametric Choice Models

Fransisca Susan[1], Negin Golrezaei[2], Ehsan Emamjomeh-Zadeh[3], David Kempe[4], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Lexington, MA, [3]Meta Platforms, Inc., Seattle, WA, [4]University of Southern California, Los Angeles, CA, Contact: fsusan@mit.edu

We study the problem of actively learning a non-parametric choice model based on consumers' decisions. We show that such choice models may not be identifiable, then introduce a directed acyclic graph (DAG) representation of the choice model that captures as much information about the choice model as could information-theoretically be identified. We design an efficient active-learning algorithm to estimate the DAG representation of the non-parametric choice model, which runs in polynomial time when the set of frequent rankings is drawn uniformly at random. We show that our algorithm performs better empirically compared to the existing non-active learning algorithms.

04 Capturing Carbon but Not Its Co-pollutants: Carbon Capture, Electricity and the Challenge of Just Decarbonization

Paola Furlanetto, University of Massachussets, Boston

Carbon Capture (CC) for use or sequestration is an interesting technology for decarbonization. While its cost- and carbon-effectiveness are under debate, current technologies remove CO_2 not co-pollutants. CO_2 affects the entire planet, but co-pollutants are harmful for those directly exposed with particular consequences for people of color and low-income. This work combines power systems modeling, integrated assessment modeling, and socioeconomic data to evaluate the role of CC distributional equity considering technological uncertainties and policy design.

05 Vote-by-mail Modeling to Track Equity Concerns

Carmen Haseltine, University of Wisconsin- Madison, Madison, WI, Contact: haseltine@wisc.edu

Cyber-physical system security planning requires identifying vulnerabilities as well as selecting and deploying security mitigations to manage risk across multiple agents in resource-constrained environments. We study these issues through a case study of vote-by-mail election systems. We introduce a new Markov chain model, real-world data set, and case study analysis.

06 Data Analysis Tool to Predict Defects in Additive Manufacturing

Amrutha Amarnath, Taylor N. White, North Carolina State University, Raleigh, NC, Contact: aamarna5@ncsu.edu

The complex nature of Additive Manufacturing processes prevents in situ monitoring for defects. Due to extreme temperatures, cameras are not feasible options, x-rays are not suitable for all materials, and CT scanning is exorbitantly expensive and does not offer real time feedback. The objective of this research is to develop a data analysis tool to predict defects in additive manufacturing processes in real time, that maintains accuracy of defect recognition while cutting down on cost.

07 Predictive Factors for Number of Stages in Mohs Micrographic Surgery

Coralys M. Colon-Morales, University of Florida, Gainesville, FL

Mohs Micrographic Surgery is an iterative outpatient surgery for the treatment of skin cancer. At each iteration, a layer of skin tissue is examined for the presence of cancer cells, and this continues until a cancer-free layer is identified. This reentrance aspect, which occurs when a patient requires another iteration, can potentially add hours to the procedure, leading to long patient waiting times and clinic overtime. Therefore, this work applies stochastic programming to provide optimal surgical schedules.

08 Developing Heat Constraints for Underground Mining Production Scheduling

Aaron Swift, Colorado School of Mines, Golden, CO

Battery electric vehicles are becoming more common in mining applications. One benefit of battery electric vehicles (BEVs) in an underground mining setting is the absence of diesel emissions. However, BEVs still generate heat, which can lead to unsafe working conditions. This research compares the heat produced by BEVs relative to diesel vehicles in executing mining activities. The results inform heat constraints in a production scheduling optimization model.

09 Fair Assortment Planning

Qinyi Chen[1], Negin Golrezaei[2], Fransisca Susan[1], Edy Baskoro[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Lexington, MA, [3]Institut Teknologi Bandung, Bandung, Indonesia. Contact: qinyic@mit.edu

Many platforms tend to feature items with the highest popularities when making assortment planning decisions. This, however, can lead to too little visibility for the rest of the items. Motivated by that, we introduce and study a fair assortment planning problem, which requires any two items with similar merits to be offered similar visibility. We propose a framework to find near-optimal solutions to this problem, using the Ellipsoid method and a separation oracle to its dual. We then develop two approximate separation oracles, which result in a polynomial-time 1/2-approx. algorithm and an FPTAS. We conclude with a case study on the MovieLens dataset, demonstrating the efficacy of our algorithms.

10 Optimizing Collaborative Energy Storage Systems and Its Equity Outcomes

Ogechi Nwadiaru, University of Massachusetts, Massachusetts, MA

The study aims to assess the benefit of co-operatively owned and operated storage systems. We model storage decisions under various pricing schemes, ownership systems, and consumer behavior. We hypothesize that there will be value delivered, including savings. The hypothesis is built on the flexibility offered by storage as a demand response asset deployed by residents in price-based demand response programs. Equally, it provides consumers with increased reliability, autonomy, and reduced cost.

11 Food Bank Responsiveness During Natural Disasters

Faith O. Idoko[1], Chrysafis Vogiatzis[2], Lauren Berrings Davis[3], [1]North Carolina A&T University, Greebnsboro, NC, [2]University of Illinois at Urbana-Champaign, Urbana-Champaign, IL, [3]North Carolina A&T State University, Greensboro, NC, Contact: faithidoko13@gmail.com

The unpredictable nature of natural disasters leads to disruptions in supply chains. A typical aftermath of such effect is the disruption of food supply as evidenced in the role of food banks. An increase in the number of food insecure people at such times fosters a surge in demand to the food banks. Prepositioning relief items to mitigate the effect of disasters is a viable approach. In this work, we incorporate this concept while considering nonfood items, perishable, and nonperishable food as well as the road and foodbank networks post disaster. Options for self-accessible food lockers for both frozen and dry food items are also considered.

12 Importance of Covid-19 Specific Antibody Testing During Vaccine Allocation

Akane Fujimoto Wakabayashi[1], Pinar Keskinocak[1], Inci Yildirim[2], [1]Georgia Institute of Technology, Atlanta, GA,

[2]Yale University, New Haven, CT, Contact: afujimoto@gatech.edu

A compartmental model was developed to analyze the value of using antibody testing to identify individuals who have previously acquired COVID infections to prioritize the vaccination of fully susceptible individuals. The model simulates the disease spread, diagnosis and isolation of infected individuals, and testing and vaccine allocation. The use of antibody testing as part of a COVID-19 vaccine distribution plan might be effective and substantially reduces the infection attack rate and deaths.

13 Data Science Models for the Prediction of Adverse Maternal Outcomes

Meghan Meredith[1], Lauren N. Steimle[1], Sheree Boulet[2], Kait Stanhope[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Emory University, Atlanta, GA

Racial/ethnic minority and rural populations are disproportionately affected by comorbid conditions and preventable adverse maternal outcomes. We present risk prediction models for adverse maternal outcomes that incorporate interactions between comorbid conditions. We leverage machine learning methods and consider clinical, lifestyle, and demographic information as potential risk factors to better understand their associations with adverse maternal outcomes.

Sunday, 12:30 PM–1:45 PM

SC99

CC - Exhibit Hall D

Sunday Poster Session

Poster Session

Session Chair

Changhyun Kwon, University of South Florida, Tampa, FL

Session Chair

Jun Zhuang, University at Buffalo, Buffalo, NY

01 Identifying Hotspots for Mental Health Treatment

Junyuan Quan, Anthony Bonifonte, Denison University, Granville, OH, Contact: quan_d1@denison.edu

This research attempts to estimate the unmet mental health services demand at a census tract level and identify new mental health facility locations to maximize the number of SMI patients who can receive treatment. We estimate the unmet demand in each census tract and build an optimization model to identify hotspots in need of additional treatment capacity. We find that among the total of 765,304 SMI patients in Ohio, 469,549 (61.4%) perceived an unmet need for mental health services. The model suggests 10 new potential mental health facilities can serve up to 418228 new patients, about 89.1% of the total SMI patients with unmet mental health services demand in Ohio.

02 Testing Race Differences In Risk of Gestational Diabetes Mellitus Associated with Household Food Insecurity (using NHANES 2007-2018)

Carolina Gonzalez-Canas[1], Qinglan Ding[2], Vicki L. Simpson[2], Zachary Hass[3], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN, [3]Purdue University, West Lafayette, IN, Contact: gonza490@purdue.edu

We used a weighted logistic regression model to estimate the impact of household food insecurity on Gestational Diabetes Mellitus risk from the National Health and Nutrition Examination Survey (NHANES) from 2007-2018 after controlling for several theoretical and health-related risk factors like age, obstetric history, family history of diabetes, and BMI. Analyses were stratified by race/ethnicity to provide insight into how gestational diabetes risk differs by subpopulation. Results indicated that family history of diabetes is a risk factor across all races while household food insecurity is a significant risk factor for only the Hispanic subpopulation.

03 The Implications of State Aggregation for Markov Decision Process Models with Medical Applications

Madeleine Pollack[1], Lauren N. Steimle[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: mpollack9@gatech.edu

Markov decision processes (MDPs) are mathematical models of sequential decision-making under uncertainty that have found applications in chronic disease treatment. Modelers often characterize patient health by aggregating measures of disease severity into discrete health states, and transition probabilities describe the Markov process over those states. However, there are no clear guidelines as to how to construct a state space: having too many states leads to inaccurate transition probability estimates but having too few states leads to imprecision in the model. In this work, we consider how the size of the state space impacts lifetime estimates and treatment recommendations from MDPs.

04 Identification of Risk Factors Associated with Baby Low Birthweight and Health

Disparities in Prenatal Care: A Machine Learning Approach

Yang Ren, Dezhi Wu, Yan Tong, University of South Carolina, Columbia, SC

Low birthweight (LBW) is the second-leading cause of neonatal death in the U.S. after congenital malformations. The LBW babies have a higher risk of short- and long-term adverse health effects than the babies with normal birth weight. Based on 255,647 birth records from 2015 to 2021 in a large U.S. hospital system, we used six machine learning classification models to predict LBW and associated prenatal risks and health disparities between the different mom groups based on the moms' demographic and social determinants. This study provides important implications to prenatal care services and public health policymakers.

05 A Random Forest Assessment to Measure Clinical Pathway Concordance with Breast Cancer Patients' Survival

Ping Lin, Milton Soto-Ferrari, Indiana State University, Terre Haute, IN, Contact: plin4@sycamores.indstate.edu

This research aims to assess the attributes that influence the clinical pathways of breast cancer patients and their relationship with survival. The evaluation focuses on a sample of 119.000 patients collected by the SEER program from 2010 to 2015 in the US. We developed a random forest framework to measure the level of concordance for clinical pathways. We calculated the proposed model's accuracy performance to estimate the pathway concordance valuation. Our study determined that multiple factors, encompassing surgery type, age, and cancer stage, as part of the first course of treatment combined with tumor grade and behavior have a significant positive association with patients' survival.

06 Effectiveness of Social Distancing Under Partial Compliance of Individuals

Hyelim Shin, Kyeonghyeon Park, Huijae Kim, Taesik Lee, KAIST, Daejeon, Korea, Republic of. Contact: hyelim.shin@kaist.ac.kr

Assuming individual agents' social distancing decisions are driven by utility maximization, we calculate a Nash equilibrium in a community under a social distancing policy. Numerical experiments suggest that an excessively strict social distancing policy leads to non-compliance and that an appropriate level of penalty should be imposed for such violations.

07 Construction and Evaluation of Stroke Care Network in Rural Area

Po-Yi Lee[1], Yu-Ching Lee[2], [1]National Tsing Hua University, Chiayi city, Taiwan; [2]National Tsing Hua University, Hsinchu, Taiwan. Contact: benson0042@gmail.com

Recombinant tissue plasminogen activator (rt-PA) has been proved for effectively treating patients with ischemic stroke, increasing the chance of recovering. Stroke care network connects the nearby hospitals (spoke) together with the hospitals capable of providing rt-PA (hub). The aim of our study is to construct a stroke care network in rural areas of Taiwan, Pingtung county and evaluate network performance based on 2 criteria, coverage rate and total expected time. The results indicate that the current layout of the hospitals in Pingtung county covered most of the population, and will help members treating patients with rt-PA more cautiously and reducing inspection time and personnel cost.

08 A Mixed-integer Linear Programming Model for a Stochastic Elective Surgery Scheduling Problem

Nicklas Klein, University of Bern, Bern, Switzerland. Contact: nicklas.klein@unibe.ch

We consider the problem of scheduling elective surgeries in operation blocks over a fixed time horizon. The schedule has to accommodate emergency surgeries that arrive at random and must be performed on the day of their arrival. The goal is to assign a start time and a block to the elective surgeries to minimize the total cost for the block assignments plus the expected cost of delaying or canceling surgeries plus the expected cost of operating room idle- and overtime. We propose a two-stage mixed-integer linear programming model that is based on sample average approximation and analyze the impact of various parameters on the computational performance.

09 Optimization of the Hospital Selection Strategy and the Distribution of Endovascular Thrombectomy Resources

Chun-Han Wang, Yu-Ching Lee, National Tsing Hua University, Hsinchu City, Taiwan. Contact: ga2006124742@gmail.com

Nowadays, emergency medical technicians decide to send a suspected stroke patient to a primary stroke center (PSC) or to an endovascular thrombectomy (EVT)-capable hospital, based on the Cincinnati Prehospital Stroke Scale. However, if an acute ischemic stroke patient with large vessel occlusion is first sent to a PSC, and then needs to be transferred to an EVT-capable hospital, the time to get definitive treatment is significantly increased. To solve this problem, we build optimization models for the redistribution and centralization of EVT resources for stroke patients, which enables therapeutic medical teams to increase their experience and skills efficiently within a short period of time.

10 A Vehicle Routing Problem for Massive Covid-19 Testing in Antofagasta, Chile

Hernan Caceres[1], Javiera Auad[1], Andrea Fernández[2], Blanca Peñaloza[2], María Soledad Zuzulich[2], [1]Universidad Catolica del Norte, Antofagasta, Chile; [2]Pontificia Universidad Católica, Santiago, Chile. Contact: hcaceres@ucn.cl

The COVID-19 pandemic has demanded massive and recurrent testing due to the high number of cases that have been found in the last two years. Mass testing requires significant resource management to develop, which is why a useful tool to manage them is optimization. A project was developed in Antofagasta, Chile, to help small businesses to have more control over positive cases in their establishments. A medical team would visit them regularly to have greater control and provide them with more security. To do that efficiently, a vehicle routing problem with multiple time windows was developed to optimize the time of visit routes and medical equipment necessary to carry out the testing.

11 Does New Knowledge of Disease or Screening Matter in the Cancer Screening Education? Evidence from a Randomized Controlled Trial

Xiaodong Wang[1], Yongjian Zhu[2], Yini Gao[3], Zhichao Zheng[3], [1]Singapore Management University, Singapore, Singapore; [2]University of Science and Technology of China, Hefei, China; [3]Singapore Management University, Singapore, Singapore. Contact: xdwang.2020@pbs.smu.edu.sg

Colorectal cancer (CRC) is reported as the most/second most frequent incidence of cancer for males/females in Singapore. Although deadly, it's 5-year relative survival rate is 90% if detected in the early/localized stage. Given the low initial screening rate in Singapore, this study empirically examined the effectiveness of health education on self-reported screening intention for CRC via a randomized controlled trial (RCT). We found education effect exists and new knowledge of screening rather than that of disease matters. Different subgroups of age, gender, baseline knowledge, and subjective belief are moderators, providing practical implications for the future health education.

12 Logistics for Diagnostic Testing: An Adaptive Decision-support Framework

Hannah Bakker[1], Fabian Dunke[1], Viktor Bindewald[2], Stefan Nickel[3], [1]Karlsruhe Institute of Technology, Karlsruhe, Germany; [2]Universität Siegen, Siegen, Germany; [3]Karlsruhe Insitute of Technology, Karlsruhe, Germany. Contact: hannah.bakker@kit.edu

Diagnostic testing is a fundamental component of effective outbreak containment during a pandemic. When health care providers are privately owned, the assignments of samples from test facilities to laboratories are determined by individual stakeholders. While may effectively match supply and demand during normal times, dispersed outbreaks as encountered during the COVID-19 pandemic, lead to imbalanced requests for diagnostic capacity. Local backlogs build up rapidly leading to increased waiting times for test results. We present a rolling horizon framework that supports a coordinating authority in matching supply and demand in an otherwise decentrally operating system.

13 Analyzing the Effect of Social Connections on Opioid Overdose Deaths

Kushagra Tiwari[1], M.Amin Rahimian[1], Mary G Krauland[2], Mark S Roberts[1], Jeanine M Buchanich[3], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, [3]University of Pittsburgh, Pittsburgh, PA, Contact: kut20@pitt.edu

During the past two decades, the Opioid Epidemic has been a major cause of concern in the US. There has been an increasing recognition that its etiology is rooted in part in the social contexts that mediate substance use and access. We analyze the significance of effect size of Meta's Social Connectedness Index (SCI) on Opioid Overdose Deaths (OOD) in ZIP codes by controlling for physical proximity. We lay the groundwork to depict the use of SCI for creating proxies for Social Network and further find its application in planning and developing intervention strategies against Opioid Epidemic.

14 Using Data Analytics for Telehealth Utilization: A Case Study in Arkansas

Aysenur Betul Cengil[1], Sandra D. Eksioglu[1], Burak Eksioglu[1], Hari Eswaran[2], Corey J. Hayes[3], Cari A. Bogulski[3], [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas for Medical Sciences, Little Rock, AR, [3]University of Arkansas for Medical Sciences, Fayetteville, AR

Telehealth may allow clinics to service more patients without increasing the healthcare workforce. We use data analytics techniques to understand which patients utilize telehealth. We build a random forest regression model to identify the important factors in telehealth utilization. We analyze how telehealth services impact waiting time and appointment length.

15 Identifying Prenatal Alcohol Exposures and Its Determinants on Twitter

Dezhi Wu[1], YANG REN[2], Yuqi Wu[1], Peiyin Hung[3], Shan

Qiao[3], Phyllis Raynor[3], Xiaoming Li[3], Jiajia Zhang[3], Constance Guille[4], Kacey Eichelberger[5], [1]University of South Carolina, Columbia, SC, [2]UNIVERSITY OF SOUTH CAROLINA, WEST COLUMBIA, SC, [3]University of South Carolina, Columbia, SC, [4]Medical University of South Carolina, Columbia, SC, [5]University of South Carolina, School of Medicine Greenville |Prisma Health Upstate, Columbia, SC

Alcohol consumption during pregnancy is a prevalent health concern, causing fetal alcohol spectrum disorders (FASDs) and risks for miscarriage, stillbirth, and other adverse events. This study collected over six million tweets related to perinatal substance use disorder on Twitter. After segmenting perinatal alcohol use tweets, we used topic modeling, sentiment analysis, text mining, and machine learning techniques to identify determinants of FASD-related adverse events. Study implications are informative to alcohol health services and public health policies related to prenatal alcohol exposure, alcohol drug abuse, addiction, and prenatal and postpartum care.

16 Blockchain-based Data Transparency in Pharmaceutical Supply Chain

Alejandro E. Chicas, Afrooz Moatari-Kazerouni, Amin Keramati, Widener University, Chester, PA, Contact: amoatarikazerouni@widener.edu

The unpredictability of clinical trial processes increases the cost for developing pharmaceutical drugs across the supply chain. Data is subject to both intentional and accidental tampering, threatening the correct representation of a clinical trial analysis. The use of blockchain technology allows storing time stamped transaction records, making it near impossible to steal or alter clinical trials data. This study explores how blockchain supports clinical data management throughout the pharmaceutical supply chain. Such intelligent supply chain allows patients to have control over their medical data and researchers to meet reporting requirements.

17 Managing Covid-19 Pandemic: Lessons from an Indian City

Ravichandran Narasimhan, Indian Institute of Management-Ahmadabad, Ahmedabad, India. Contact: nravi@iima.ac.in

In a large city in India the Covid -19 epidemic was effectively controlled by a combination of Centralized resources, decentralized planning and a purposeful leadership. The frontline workers were motivated to be effective. The treatment plan optimized utilization of scared resources. Resource constraints on manpower, infrastructure ,medical facilities were resolved by innovation. A modular structure and a comprehensive information dash board was an enabler. The sample collection to patient treatment was seamlessly managed. The consequence of all these is an admirable reduction in the spread of the infection. This work documents this practical application.

18 Multi-secant Extensions of BFGS

Mokhwa Lee, Yifan Sun, Stony Brook University, Stony Brook, NY, Contact: mokhwa.lee.726@gmail.com

When dealing with a large-scale optimization problem, classical second-order methods are no longer practical. Therefore, Quasi-Newton methods are introduced because they are more efficient. This project focuses on multi-secant extensions of the BFGS method, to improve its Hessian approximation properties by applying a perturbation strategy to construct an almost-secant positive-definite Hessian estimate matrix to guarantee the descent direction. This strategy has a low computational cost, involving only rank-2 updates with variable and gradient successive differences. We also explored several ways of accepting and rejecting older updates according to several nondegeneracy metrics.

19 Improving Temporal Graph Network Messaging

Celeste Groux, McGill University, Montreal, QC, Canada. Contact: celeste.groux@mail.mcgill.ca

The Temporal Graph Network algorithm introduced by Rossi et al. was found to efficiently outperform multiple recent algorithms for the task of link prediction in networks that change over time. In this algorithm, each change is introduced as input to a message function whose output is then used to update the affected node’s memory. Improvements to the message function are explored, particularly to share messages to a node’s neighbourhood so as to take into account neighbourhood changes when making predictions. Results for the proposed variants show very small inconsistent improvements for both networks tested.

20 Taxi Routing Optimization

Tinghan Ye[1], David B. Shmoys[2], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, Contact: ty357@cornell.edu

A taxi routing problem can be solved via bipartite matching, where a maximum matching corresponds to the minimum number of taxis needed to cover all trips. We demonstrate this problem on an NYC dataset and prove a min-max theorem: the maximum number of pairwise incompatible trips equals the minimum number of taxis needed.

21 Tractability of Optimizing over Multi-constrained Knapsack Sets Using Multi-module Capacitated Lot-sizing Problem

Kartik Kulkarni, Virginia Tech, Blacksburg, VA, Contact: kartikrf@vt.edu

We address the existence of polynomial time algorithms for optimizing a linear function over certain structured mixed-integer sets. These sets arise as substructures in several problems related to production planning, facility location, and capacitated network design. These sets have nT number of integer variables where T is the number of constraints, and n is the number of integer variables in each constraint. We address these open questions by establishing the equivalence between optimizing over these sets and generalizations of constant capacitated lot-sizing problems.

22 Metaheuristics vs. Exact Solvers: Finding Optimal Solutions to the Minimum Sum Coloring Problem

Yu Du, University of Colorado Denver, Denver, CO, Contact: duyu197@gmail.com

The minimum sum coloring problem (MSCP) is a well-known NP-hard problem. Exact methods(like Gurobi) and metaheuristic solvers have greatly improved in recent years enabling optimal solutions to be found to a growing set of MSCP problems. We introduce several alternative models for MSCP and provide a computational study using a standard set of test problems from the literature that compares the general-purpose exact solver from Gurobi to the leading metaheuristic solver NGQ™. Our results show that a constrained version of binary quadratic model (QUBO-Plus) using NGQ™ provides the best performance for finding optimal solutions to these important problems

23 Optimum Space Utilization in Block Stacking Storages System: Temporary Warehousing Case Study

Amir Hossein Sadeghi, Amirreza Sahebifakhrabad, North Carolina State University, Raleigh, NC, Contact: asadegh3@ncsu.edu

Stock Keeping Unit (SKU) loading and unloading are fundamental to logistics management systems in temporary warehouses, such as production lines, and ports. The present study is a simulation-based model to measure warehousing KPIs(key performance indicators) in temporary warehouses' administrative decisions during the two phases of the warehouse's transportation and space operations. This research provides a simple, yet comprehensive simulation approach, which can be used in all temporary warehousing problems.

24 Scalable Learn-to-optimize Frameworks for Networks

Babak Aslani[1], Shima Mohebbi[2], [1]George Mason University, Fairfax, VA, [2]George Mason University, Fairfax, VA, Contact: baslani@gmu.edu

Network optimization methods have become popular for addressing combinatorial optimization problems in various network applications. Most problems are defined as Mixed Integer Programming (MIP) models, which become *NP-hard* for large-scale problems. To overcome this challenge, leveraging the information during the search process to embed machine learning methods in optimization algorithms has emerged as a promising research area. Hence, this work seeks to develop scalable Learn-To-Optimize frameworks for deterministic and stochastic formulations concerning large-scale networks.

25 A Fast Modified Hungarian Algorithm to Solve Optimal Transport

Yiling Xie[1], Yiling Luo[2], Xiaoming Huo[3], [1]ISyE Georgia Tech, ATLANTA, GA, [2]ISyE Georgia Tech, Atlanta, GA, [3]ISyE Georgia Tech, Marietta, GA, Contact: yxie350@gatech.edu

We propose a modified Hungarian algorithm to exactly solve a special type of the optimal transport (OT) problem. For an OT problem between marginals with m and n atoms (m ≥ n), the computational complexity of the proposed algorithm is O(m^2n), while other algorithms, like the Hungarian algorithm, have the best possible order of O(m^3). We also show that computing the empirical Wasserstein distance in the independence test requires solving this special type of OT problem, where we have m=n^2. After adopting our modified Hungarian algorithm, the computational complexity is O(n^5), while the order of the classic Hungarian algorithm is n^6). Numerical experiments validate our theoretical analysis.

26 Sparse Optimization and Distributed Control for Large-scale Autonomy

Yang Zheng, University of California San Diego, San Diego, CA, Contact: zhengy@eng.ucsd.edu

This poster focuses on distributed control and scalable optimization techniques to ensure the efficient and reliable operation of large-scale autonomous systems. In particular, I will present a new technique that allows us to recover convexity for a class of distributed control problems, and show how to exploit sparsity structures to design scalable algorithms for solving large-scale convex optimization problems (especially semidefinite optimization). By exploiting the properties of chordal graphs and sparse positive semidefinite matrices, I will introduce a decomposition method that can scale sparse semidefinite optimization to large-scale instances, achieving massive scalability.

27 When to Relocate Vehicles of a Variable Size Fleet to Maximize Coverage

Gianfranco Cossani, Hernan Caceres, Universidad Catolica del Norte, Antofagasta, Chile. Contact: gianfranco.cossani@ce.ucn.cl

Vehicles relocation is a joint research topic in operations research. In this work, we will analyze the need to re-optimize the deployment points for a fleet of first response vehicles when one or more of them are unavailable while attending an emergency. This new optimization could include moving vehicles short distances or impractically short periods. We present an algorithm using DEA and heuristics to determine areas where we should not move the ambulances even if the new optimization result recommends it.

28 Mathematical Modeling for Containers with Dangerous Goods in the Multi-port Master Bay Planning Problem

Kiros Kebedow, Hawassa University-Ethiopia, Hawassa, Ethiopia. Contact: kirosmaths@gmail.com

In this talk, we extend existing models for Master Bay Planning by handling containers holding dangerous goods, so-called IMO containers. Incompatible IMO containers must be separated from each other on board a vessel according to specific rules. These rules affect both Master Bay Planning and Slot Planning,
which are the two planning problems normally handled in container stowage planning. To the best of our knowledge, this is the first time handling of
IMO containers is included in Master Bay Planning. We present results from computational tests showing that our model can be solved to optimality, or near optimality, in a reasonable time for realistically sized instances.

29 Patterns Matter: Evaluating Effects of Spatial Patterns for the Vehicle Routing Problem

Melissa Tilashalski, Virginia Polytechnic Institute and State University, Blacksburg, VA, Contact: mtilashalski@vt.edu

This research focuses on how spatial patterns of customer locations affect vehicle routing problem heuristic solutions. Both standard and industry are characterized to demonstrate differences in customer locations. The performance of the heuristics is evaluated and the findings demonstrate that spatial patterns influence the quality of heuristic solutions.

30 Dual-objective Optimization Methodology for Order Picking Process

Seungwon Park, Kyungmin Kim, Myongji University, Yongin-si, Korea, Republic of. Contact: benny0215@naver.com

Growing e-commerce market has enforced distribution companies to provide faster and more accurate delivery services. Order picking process is the most time-consuming and labor-intensive of the logistics processes carried out at the distribution center. In this paper, we consider the problem of distributors who want to change order picking sequence to minimize the total order picking time as well as workspace capacity simultaneously. We propose MINLP(Mixed Integer Non-Linear Programming), MILP(Mixed Integer Linear Programming), and NSGA-II(Non-dominated Sorting Genetic Algorithm-II) models. Through numerical experiments, we compare and verify their performances.

31 A Storage Assignment Heuristic for Order Picking Problem in the Mixed Shelves Warehouses

Takashi Irohara, Sophia University, Chiyoda-Ku, Japan.

In this research, a new model for a storage assignment problem is considered in the mixed shelves warehouses where multiple storage positions per one stock keeping unit can be available. For this model, mathematical optimization formulation and the heuristic approaches are proposed to solve the storage assignment problem for order picking. Effectiveness of the proposed methodologies are validated by conducting numerical experiments.

32 Algorithms Using Local Features to Predict Epidemics:

Yeganeh Alimohammadi[1], Christian Borgs[1], Amin Saberi[2], [1]Stanford University, Stanford, CA, [2]Stanford University, San Francisco, CA, Contact: yeganeh@stanford.edu

We study a simple model of epidemics: each node infects its neighbors independently with a probability p. In this setting, we ask: what information is needed for general networks to predict the size of an outbreak? Is it possible to make predictions by accessing small subgraphs?
We answer the question in the affirmative for large-set expanders with Benjamini-Schramm limits. We show that there is an algorithm that gives a (1−⍰) approximation of the probability and the size of an outbreak by sampling a constant-size neighborhood of a constant number of nodes chosen uniformly at random. We also present corollaries for the preferential attachment and study generalizations with household structure.

33 Distributionally Risk-receptive and Risk-averse Network Interdiction Problems with General Ambiguity Sets

Sumin Kang[1], Manish Bansal[2], [1]Virginia Polytechnic Institute and State University, Blacksburg, VA, [2]Virginia Tech., Blacksburg, VA, Contact: suminkang@vt.edu

We introduce generalizations of stochastic network interdiction problem with distributional ambiguity: a distributionally risk-averse (or robust) network interdiction problem (DRA-NIP) and a distributionally risk-receptive network interdiction problem (DRR-NIP) where a leader maximizes a follower's minimal expected objective value for either the worst-case or the best-case, respectively, probability distribution belonging to a given set of distributions (referred to as ambiguity set). We present solution approaches for DRA-NIP and DRR-NIP with a general ambiguity set and conditions for which these approaches are finitely convergent.

34 Online Learning for Traffic Routing Under Unknown Preferences

Devansh Jalota[1], Karthik Gopalakrishnan[1], Navid Azizan[2], Ramesh Johari[1], Marco Pavone[1], [1]Stanford University, Stanford, CA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: djalota@stanford.edu

The efficacy of road tolling schemes, designed to cope with efficiency losses due to selfish user routing, often relies on complete information on users' trip attributes, such as their values-of-time. Since these user attributes are typically unknown to a central planner, we propose an online learning approach to set tolls to drive users with different values of time to a system-efficient traffic pattern. Our algorithm adjusts tolls based on observed aggregate flows without relying on user attributes, thus preserving privacy. We establish the efficacy of our approach through performance bounds and demonstrate its superior performance relative to benchmarks on a traffic network.

35 On the Convergence of Stochastic Extragradient for Bilinear Games Using Restarted Iteration Averaging

Chris Junchi Li, UC Berkeley, Berkeley, CA, Contact: junchi.li.duke@gmail.com

I will present an analysis of the same-sample Stochastic ExtraGradient (SEG) method with constant step size, and also variations of the method that yield favorable convergence for stochastic bilinear minimax optimization problem. In sharp contrasts with the basic SEG method whose last iterate only contracts to a fixed neighborhood of the Nash equilibrium, SEG augmented with iteration averaging provably converges to the Nash equilibrium under the same standard settings, and such a rate is further improved by incorporating a scheduled restarting procedure. I will also discuss the generalization of this idea to achieve lower bounds for a class of convex-concave minimax optimization problems.

36 Improving Safety Stock Calculations in Semiconductor Supply Chain

Aparna Komarla, Solidigm (formerly Intel), Folsom, CA, Contact: aparnax.sk.komarla@intel.com

Traditionally, safety stock calculations in a SSD (Solid State Drive) semiconductor supply chain are performed with historical data of the SSD's true or forecasted demand. In particular, these calculations model demand at any given time using a normal distribution. Here, I introduce a new model for safety stock calculation that utilizes not just the demand data of the SSD in question, but also the historical data of past SSDs that have completed their life cycle. Additionally, this model leverages kernel density estimation, a non-parametric probability distribution to model SSD demand, instead of a normal distribution which is shown to have limitations with capturing the true behavior of demand.

37 Design of Urban Logistics Networks to Support Home Delivery with Driverless Vehicles

Ekin Yalvac[1], Michael G. Kay[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC, Contact: eyalvac@ncsu.edu

An urban logistics network model for home delivery is proposed in this presentation. Our model uses only five parameters and location information. On top of Delaunay triangulation and Dijkstra's algorithm, we used lesser-known methods like aggregate distance and proximity factor are used. The algorithm finds the most optimal warehouse locations by minimizing the distance a unit of load travels. We tried our algorithm for different-sized cities and for a range of parameters to check its validity for different circumstances. Our results indicate that the algorithm provides an optimal result for almost all types of parameter-city sets when we tried our algorithm for different circumstances.

38 Revisiting Supply Chain Flows: A Road Map Through Paradox Theory

Muhammad Hasan Ashraf, University of Rhode Island, United States, RI, Contact: mashraf@uri.edu

While there have been numerous supply chain flows (SCF) papers published in last few years, they appear to mostly address four most acknowledged flows i.e*., material, service, information* and *financial*. However, COVID-19 posed new threats to supply chains, triggering interactions among SCF that may possibly have caused certain insufficiently researched flows to become more influential in managing operations. We recommend that time is ripe for supply chain scholars to broaden their horizon, and consider flows that have been understudied or overlooked in the literature. We aim to conduct a multi-method qualitative study, involving researchers and professionals from various industry sectors.

39 The Effects of Competition Between Fair Trade Organizations

Daehun Chung, Seung Jae Park, Yonsei University, Seoul, Korea, Republic of. Contact: hooney@yonsei.ac.kr

In this study, we explore the effects of competition on fair trade operations. Specifically, as abenchmark, we explore a model with one fair trade organization (FTO), i.e., the monopoly FTO. We thenconsider two competing FTOs, i.e., the duopoly FTOs. We show that the benefit to farmers per unit ofproduct sold is greater with the monopoly FTO, but the aggregate benefit to farmers is greater with theduopoly FTOs due to higher consumer demand. We also show that utilizing blockchain technologyfurther benefits farmers and alleviates the effects of competition because consumers directly connectwith farmers through the blockchain.

40 The High Cost of Low-cost Food Supply in U.S.

Chen Zhou, ISyE Georgia Tech, Atlanta, GA, Contact: cz3@gatech.edu

The cost of foods in US is lower than the other developed counties. This is a great achievement by many sectors in the food supply chain. However, US has the shortest Healthy Life Expectancy, according to the World Health Organization (WHO) countries and highest healthcare costs among all the developed countries. The over consumption of low cost, strong flavored, always available and heavily processed food is one of the major contributors. This research is to analyze the processed and fresh food supply chain and find the direct costs and indirect costs associated with the low-cost processed food.

41 Reman-FMEA: A New Tool to Sustain Remanufacturability

Mehnuma Tabassum[1], Gul Kremer[2], [1]Iowa State University, Ames, IA, [2]University of Dayton, Dayton, OH

This work develops a new tool (Reman-FMEA: Remanufacturing Failure Modes and Effects Analysis) that regards crucial elements of product and process FMEA and brings a newer systematic approach for ranking failure modes (FM) for remanufactured products. Expert opinion on frequency, severity, and prevention of the FM is collected through Z-numbers instead of the standard risk priority number to capture the subjective uncertainty. We employ a Z-number based VIKOR technique to prioritize the FM. Also, we suggest design and process changes and evaluate their technical, economic, and environmental feasibility. The value gain from Reman-FMEA is demonstrated through an engine cylinder head case study.

42 Adaptive Sample Robust Optimization for Bidding of a Virtual Power Plant in a Day-ahead Electricity Market

Seokwoo Kim, Dong Gu Choi, Pohang University of Science and Technology (POSTECH), Pohang, Korea, Republic of. Contact: seokwookim@postech.ac.kr

In this study, we try to solve the optimal bidding problem for a virtual power plant (VPP) in a day-ahead electricity market. In the problem, supply uncertainty should be taken into account for two distributed resources, PV (photovoltaics) and DR (Demand Response). At the same time, decision-making should be suitable for the incentive-based market structure. After modeling this as an Adaptive Sample Robust Optimization (ASRO) problem, this study established an effective bidding algorithm by applying the duality-based reformulation and decomposition method.

43 An Inexact Variance-reduced Method for Stochastic Quasi-variational Inequality Problems with an Application in Healthcare

Zeinab Alizadeh[1], Brianna Otero[2], Afrooz Jalilzadeh[2], [1]The University of Arizona, Tucson, AZ, [2]The University of Arizona, Tucson, AZ, Contact: zalizadeh@email.arizona.edu

This paper is focused on a stochastic quasi-variational inequality (SQVI) problem with a continuous and strongly-monotone mapping over a closed and convex set where the projection onto the constraint set may not be easy to compute. We present an inexact variance reduced stochastic scheme to solve SQVI problems and analyzed its convergence rate and oracle complexity. A linear rate of convergence is obtained by progressively increasing sample size and approximating the projection operator. Moreover, we show how a competition among blood donation organizations can be modeled as an SQVI and we provide some preliminary simulation results to validate our findings.

44 Sinkhorn Distributionally Robust Optimization

Jie Wang, Georgia Institute of Technology, Atlanta, GA, Contact: jwang3163@gatech.edu

We study distributionally robust optimization with Sinkhorn distance -- a variant of Wasserstein distance based on entropic regularization. We derive convex programming dual reformulations when the nominal distribution is an empirical distribution and a general distribution, respectively. Compared with Wasserstein DRO, it is computationally tractable for a larger class of loss functions, and its worst-case distribution is more reasonable. To solve the dual reformulation, we propose an efficient batch gradient descent with a bisection search algorithm. Finally, we provide various numerical examples using both synthetic and real data to demonstrate its competitive performance.

45 Strongly Monotonic Efficiency Measures in Data Envelopment Analysis

Yu Zhao[1], Kazuyuki Sekitani[2], [1]Tokyo University of Science, Tokyo, Japan; [2]Seikei University, Tokyo, Japan. Contact: yu.zhao@rs.tus.ac.jp

This study investigates the monotonicity issue of efficiency measures for data envelopment analysis (DEA) models with nonlinear objective functions. We propose a class of DEA models, including variants of the Russell graph measure, BRWZ measure, slack-based measure, and geometric distance function. The proposed DEA models provide monotonic maximum efficiency measures and can be solved by linear programming. We show that the maximum efficiency measure can be explicitly expressed as a decreasing function of the least Manhattan distance. We further show that the maximum efficiency measure satisfies strong monotonicity by adding certain consistent weighting restrictions to the DEA models.

46 When Do Models Make Money? A Path from Return Predictability to Profitability

Ruixun Zhang, Yufan Chen, Lan Wu, Peking University, Beijing, China. Contact: zhangruixun@pku.edu.cn

In the context of a single-asset market, we propose an analytical framework to link the profitability of a model-driven investment strategy to the predictability of the underlying model. Our framework accounts for trading costs, applies to general return-forecast models with arbitrary precision--recall curves, and yields an explicit solution to strategy profit as a function of model performance metrics. We demonstrate the applicability of our model with tick-level data that accounts for the bid-ask spread and actual liquidity in the limit order book. Empirical results show that the model-implied analytical profitability aligns with estimates of profitability from a simulation engine.

47 Supply Chain Finance Tools and Their Impact on Operations Management in Africa: The Case of Moroccan Firms

Jamal Elbaz[1], Jean Noel Beka Be Nguema[2], [1]Ibn Zohr University, Agadir, Morocco; [2]Rabat Business School UIR, Rabat, Morocco. Contact: j.elbaz@uiz.ac.ma

The purpose of this research is to investigate how Supply Chain Finance (SCF) tools are employed in the context of Moroccan firms. Based on several interviews with Moroccan executives, the authors identfiy the drivers of SCF applications categorized as internal (e.g. top management involvement and technical infrastructure) and external (institutional factors, collaboration with partners and quality of financial services providers) drivers. The authors alsoo examine the outcomes of SCF on firms' performance. Based on the results, a conceptual model linking SCF drivers and the outcomes of SCF tools is proposed by the authors.

48 Automated Rebate Computation Modelling

Alexander Billups[1], Shubhi Asthana[2], Nitin Ramchandani[1], Pawan Chowdhary[1], [1]IBM Research, San Jose, CA, [2]IBM Research, SAN JOSE, CA, Contact: abb5975@psu.edu

Suppliers offer different types of rebates to customers, in order to sign multiple contracts with customers. Typically in financial services sector, there is no uniform rebate structure followed when offering these rebates. Suppliers may alter rebate terms, payment terms that provision how customers would be invoiced, for multiple contracts each week . In order to streamline the process, we propose the Automated Rebate Computation Model. Our model performs smart selection of contract and invoice features in order to automate rebate computation and validate the rebates signed with the invoice billed.

49 Optimization of Travel Subscription Use

Jiang Jiang[1], Chris K. Anderson[2], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, Contact: jj438@cornell.edu

Travel subscription provides limited guidance to consumers when they make travel plans. The value of the subscription is difficult to evaluate. This study demonstrates that the service providers can assist consumers to maximize total nights of stay by adding functions like sort by cost per night. Three ways of making travel plans are compared: (1) random selection; (2) the heuristics, where listings with lower cost get higher priority; and (3) Integer Linear Programming. Using synthetic data and real listings from one subscription platform, we showed that on average, the heuristics can increase the total nights by 26% of the optimal solution compared to the random selection.

50 Revenue Management Under a Price Alert Mechanism

Nanxi Zhang, University of British Columbia, Vancouver, BC, Canada. Contact: sufenanxizhang@163.sufe.edu.cn

Many online platforms adopt a price alert mechanism to facilitate customers tracking the price changes. This mechanism allows customers to register their valuation to the system when they find the price is larger than the valuation on their arrival period. In this paper, we study the optimal pricing problem under this mechanism. When customers are truthtelling, it is optimal for the seller to use a threshold to

decide whether to accept or reject a registered price, and the price trajectory under the optimal policy has a stochastic cyclic decreasing structure. The case when the customers can strategically react to the price alert mechanism by reporting false valuations is also discussed.

51 A Dynamic Programming Model for Standardized Cargo Revenue Management

Lama Moussawi-Haidar[1], Nagihan Comez Dolgan[2], Fatima Allouch[1], [1]American University of Beirut, Beirut, Lebanon; [2]Ozyegin University, Istanbul, Turkey. Contact: lm34@aub.edu.lb

We consider the resource allocation of a standardized cargo transportation problem, faced by sea freight operators. The standardized cargo capacity of a sea liner is sold to big shippers through allotment contracts or on the spot market. Capacity reserved to allotments is sold in advance and may not be fully utilized due to no-shows. The remaining capacity is sold in the spot market over the entire booking horizon, taking into consideration the allotment no-shows. The objective is to develop and solve a dynamic programming model based on which spot market requests are dynamically accepted/rejected, given the allotment dynamic arrivals.

52 An Integrated Approach for Social Distancing and Revenue Optimization in Long Distance Passenger Trains

Md Tabish Haque, Faiz Hamid, Indian Institute of Technology Kanpur, Kanpur, India. Contact: tabish@iitk.ac.in

The unprecedented spread of COVID-19 has prompted government bodies to implement strict measures to curtail people's mobility. However, they had unintended results owing to a disastrous impact on economy. Train operators also face a similar outturn and require strategies to combat both simultaneously. In this regard, we examine the potential effects of seat inventory management for passenger trains that create stability between safety and economics. A MILP model has been proposed that optimizes operator revenue as well as reduces virus spread. Encouraging results in terms of limiting virus spread and increasing revenue even at higher capacity utilization were found.

53 Reverse Supply Chain Network with Return Products Quality Consideration

Sahar Ebrahimi Bajgani[1], Sara Saberi[1], Fuminori Toyasaki[2], [1]Worcester Polytechnic Institute (WPI), Worcester, MA, [2]York University, Toronto, ON, Canada. Contact: ssaberi@wpi.edu

Reverse logistics activities can be implemented as an agile solution in response to the shortage in production capacity of certain products during the pandemic and a convenient alternative to the raw materials extraction in post pandemic course. However, collecting and inspecting returned products is a complex process due to the different conditions in which the products have been kept. We designed a reverse supply chain network with competing collection centers, 3rd party remanufacturers, and recyclers to define the minimum quality of return products based on customer demands. The equilibrium condition is governed using a variational inequality model.

54 Multilayer Networks with Higher-order Interaction Reveal the Impact of Collective Behavior on Epidemic Dynamics

Jinming Wan, State University of New York at Binghamton, Vestal, NY, Contact: jwan8@binghamton.edu

The ongoing COVID-19 implies that population behavioral response to infection risk and intervention policy could significantly reshape the evolution of spreading dynamics, which is also the major drive underlying the resurgent outbreaks. To reveal such interplays, we present a three-layer network model: the contagion dynamics occur on two physical layers (the two distant communities) following the susceptible-exposed-infectious-recovered (SEIR) principle; agents from those two communities interact on the social layer, and adapt their behaviors in view of infection risk, government intervention, compliance cost, as well as behavioral response of their social contacts.

55 Rearranging the Deck Chairs on the Titanic: A Simulation Model of Behavioral Resource Utilization Under Crisis

James E. Paine, Massachusetts Institute of Technology, Cambridge, MA, Contact: jpaine@mit.edu

'Rearranging the deck chairs on the Titanic' is typically used metaphorically to refer to occupying oneself with trivial activity while ignoring something much more important. However, during an actively unfolding crisis the ability to identify activities as 'trivial' versus 'meaningful' can be unclear, and some activities could prevent a crisis or even recover from it, or conversely consume resources better spent in outright evacuation. This work develops a differential equation model to explore how the actions of the people during an evolving crisis affect both physical and behavioral dynamics, and identifies boundary conditions and separates trivial from meaningful mitigation activities.

56 Opinion-disease Integrated Simulation Model: Examination of Social Features' Impact on Disease Spread

Geonsik Yu[1], Mario Ventresca[2], Michael Garee[3], Yuehwern Yih[4], [1]Purdue University, West Lafayette, IN, [2]Purdue University, Lafayette, IN, [3]Air Force Institute of Technology, Wright-Patterson AFB, OH, [4]Purdue University, West Lafayette, IN, Contact: yu851@purdue.edu

We develop a two-layer epidemic simulation framework that includes intervention, disease dynamics, and opinion dynamics regarding the intervention. Using the framework, we examine the roles, and relative importance of social features - such as news audience polarization, echo chamber structure, and initial opinion distribution - in disease spread.

57 Plausible Screening for Multiple Simulated Responses

Jinbo Zhao, David J. Eckman, Texas A&M University, College Station, TX, Contact: jinbozhao@tamu.edu

Plausible screening is a nascent statistical framework that uses limited simulation experiments and properties of performance measures to screen out unacceptable solutions. Plausible screening is effective on problems with large solution spaces and high simulation cost. We extend plausible screening to the setting of multiple performance measures (responses), as arises in simulation-optimization problems with stochastic constraints or multiple objectives. We provide guarantees on confidence and consistency and demonstrate via numerical experiments how functional properties like convexity, Lipschitz continuity and monotonicity can help to eliminate unacceptable solutions.

58 Fixed Budget Ranking and Selection with Streaming Input Data

Yuhao Wang, georgia institute of technology, atlanta, GA, Contact: yuhaowang@gatech.edu

In a fixed budget ranking and Selection problem with streaming input data, one aims to efficiently identify the best among a finite number of designs by allocating a simulation budget in the presence of streaming input data, which is used to estimate the unknown input distribution. We formulate a stage-wise budget allocation problem and derive the optimality conditions for sampling policy by applying the large deviations theory, based on which we design two dynamic optimal budget allocation procedures tackling the optimality conditions in different ways. We theoretically guarantee their consistency and asymptotic optimality and numerically demonstrate practical efficiency.

59 Optimization of Autonomous Vehicle Model Parameters for Transient Mixed Traffic Network

Jinkun Lee, Matthew Carroll, East Carolina University, Greenville, NC, Contact: leejin18@ecu.edu

As self-driving has become a standard technology in major automobile manufacturers, autonomous vehicles driving with human drivers will impact the performance of current traffic network. Since the transformation of the current road network into autonomous driving network will be a gradual progress depending on the penetration rate of autonomous vehicles, the road traffic network may show a transient system behavior. We investigate the traffic network performance by simulating it with various vehicle models, identify key factors that may impact the traffic flow during the transitional period, and suggest optimal autonomous driving parameters found with genetic algorithm.

60 Min-time Coverage in Constricted Environments

Young In Kim, Georgia Institute of Technology, Atlanta, GA, Contact: ykim902@gatech.edu

This work concerns the employment of networked robotic fleets for the support of inspection operations in subterranean utility and transport networks. We formulate a set of scheduling problems for these operations, and we provide a structural analysis for these problems and an effective and computationally efficient methodology for their solution.

61 Estimating Path Travel Cost in Large-scale Networks Using Machine Learning Techniques

Alireza Rostami, Ali Zockaie, Michigan State University, East Lansing, MI, Contact: darzianr@msu.edu

This study proposes a heuristic algorithm utilizing machine learning methods to predict Origin-Destination (OD) travel distance, time, and cost using historical vehicle trajectory data generated at the DTA level. This study utilizes an ellipse boundary around OD to truncate the network and extract the relevant vehicle sub-trajectories. Numerical results of applying the proposed method to the Greater Chicago network showed promising performance in travel cost measures estimation and faster solution time.

62 Evacuation Route Planning for Alternative Fuel Vehicles

Denissa Sari Darmawi Purba, Eleftheria Kontou, Chrysafis Vogiatzis, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: dpurba2@illinois.edu

As the use of alternative fuel vehicles increased in public, it is important to consider evacuation plans that accommodate these vehicles in the emergency state. Under different alternative fuel vehicle types, plans for conventional vehicles could be infeasible for alternative fuel vehicles due to different fuel range capacity and recharging needs to reach safety. We propose a novel |K|-evacuation tree route plan problem with hop constraints to accomodate refueling needs of *k* vehicle fuel type during evacuation. We implement our model to design evacuation route plan of South Florida network and propose policy recommendations.

63 A Branch-cut-and-price Algorithm for the Dial-a-ride Problem with Minimum Disease-transmission Risk

Shuocheng Guo[1], Iman Dayarian[2], Xinwu Qian[3], Jian Li[4], [1]The University of Alabama, Tuscaloosa, AL, [2]University of Alabama, Tuscaloosa, AL, [3]The University of Alabama, Tuscaloosa, AL, [4]Tongji University, Shanghai, China. Contact: sguo18@crimson.ua.edu

This paper investigates a Risk-aware Dial-a-ride-problem (RDARP) with a particular focus on the disease-transmission exposed risk for onboard passengers in addition to total travel cost. The exposed risk is strongly associated with the dynamic time windows and contact duration for onboard passengers. To effectively solve the RDARP, we propose an exact Branch-Cut-and-Price (BCP) algorithm. Using the column generation method, we develop a tailored labeling algorithm and introduce families of risk-related resources. The numerical results using the real-world paratransit trip data indicate that our BCP algorithm can optimally solve 23 of 30 large instances of 39 to 55 passengers within one hour

64 Optimizing Routing and Sorting of Shipments for India's Largest E-commerce Company

Gowtham Bellala, Aditya Prasanth Bandaru, Vikas Goel, Flipkart, Bangalore, India.

We consider optimal network design for India's largest e-commerce company. At source hubs, it is not feasible to sort shipments for thousands of destination hubs due to layout constraints. Hence we aggregate loads until intermediate hubs, where we resort or cross-dock. We propose an automated network design approach which optimises for speed, cost and ensures network agility and reliability in a reasonable turnaround time. The challenge lies in the amount of path choices (~ 1 Billion). We formulate a large scale network flow model and present specialized algorithms. This enabled significant reduction in turnaround time (14 to 2 days), faster delivery, and improved network cost and reliability.

65 MaaS with UAM

Sungho Kang, Taesu CHOENG, KOREA University, Seoul, Korea, Republic of. Contact: ght2game@korea.ac.kr

We propose a UAM operation strategy to efficiently operate MaaS.

66 Optimizing Multi-trip Mobility Allowance Shuttle Transit (MAST): Capacity Constraints, Valid Inequalities, and Frequency

Reza Shahin[1], Pierre Hosteins[2], Paola Pellegrini[3], Pierre-Olivier Vandanjon[4], [1]University of Gustave Eiffel, VILLENEUVE-D'ASCQ, France; [2]University of Gustave Eiffel, Villeneuve d'Ascq, France; [3]University of Gustave Eiffel, Villeneuve d'Ascq, France; [4]University of Gustave Eiffel, Bouguenais, France. Contact: rezaa.shahin.1992@gmail.com

The Mobility Allowance Shuttle Transit (MAST) system is a type of public transportation where vehicles may deviate from a fixed route to serve clients who wish to get on or off within a service area. We study an extended version of the problem with a fleet of shuttle and a finite shuttle capacity. We study the impact of the shuttles capacity and trip frequency on the level of service and the possibility of rejecting a request. We develop a Mixed-Integer Linear Programming (MILP) and study the numerical impact of several valid inequalities.

67 Rebalancing an E-scooter Sharing System with En Route Charging Capability

Xiangyu Jin[1], Yufeng Cao[1], Yu Yang[2], [1]Shanghai Jiao Tong University, Shanghai, China; [2]University of Florida, Gainesville, FL, Contact: 2016-jinxiangyu@sjtu.edu.cn

Electric scooters (e-scooters) have emerged as a popular means of transport. However, the rapid growth of the e-scooter riding demand imposes significant operational challenges for its operators, especially the charging and rebalancing issues. It is vital for the operators to find efficient ways to accomplish the work while keeping their customers satisfied.

We consider a setting where e-scooters can be charged on the rebalancing truck en route or while the truck is waiting at each site. We proposed an effective algorithm to solve the problem based on Benders decomposition. Finally, we validated the proposed algorithm with extensive numerical experiments.

68 The Stack Loading Problem with Load-bearing Limit

Xinbo ZHANG[1], Minming LI[1], Zhou XU[2], Yingchao ZHAO[3], [1]City University of Hong Kong, Hong Kong, Hong Kong; [2]Hong Kong Polytechnic University, Hong Kong, Hong Kong; [3]Caritas Institute of Higher Education, Hong Kong,

Hong Kong, Hong Kong. Contact: xinbzhang3-c@my.cityu.edu.hk

This paper is the first study on the stack loading problem with the load-bearing constraint with an aim to minimize the number of stacks and the number of blockages. We show that this problem is strongly *NP*-hard even when the number of stacks is given and equals 2. For the case where the number of stacks is given and bottom jobs are fixed, we show that the problem can be solved by dynamic programming in pseudo-polynomial time. For the general problem, based on a two-index integer linear programming formulation and a tabu search heuristic, we develop a binary-search based matheuristic. Our experimental results demonstrate the efficiency and effectiveness of the newly developed matheuristic.

69 How Will Shared Mobility Reshape the Travel Demand: Evidence from Indianapolis

Hao Luo, Hua Cai, Purdue University, West Lafayette, IN, Contact: luo296@purdue.edu

The transportation system has recently been reshaped because of shared mobility. This research conducted a survey study in Indianapolis to analyze how people would shift their decision-making on travel mode choice from traditional modes to shared mobility and multi-modal system. We also developed an agent-based simulation model to investigate the potential impacts of shared mobility on vehicle ownership and travel demand changes at the city level under different future development scenarios. Policies on system integration towards a more sustainable transportation system will be provided based on the research results.

70 An Optimal Order Consolidation Policy in Last-mile Delivery

Seokgi Lee[1], Hyeong Suk Na[2], Yooneun Lee[3], [1]Youngstown State University, Youngstown, OH, [2]South Dakota School of Mines & Technology, Rapid City, SD, [3]University of Dayton, Dayton, OH, Contact: slee10@ysu.edu

As large-scale online markets have a high split rate of orders, consolidating and delivering split orders from the same customer has been addressed as a major problem in leveraging green logistics. In this research, the last-mile logistics situations are analyzed to address two interrelated questions: what would be the optimal order consolidation policy considering expected operational and economic efficiency in the resulting vehicle routing plan. Finally, we develop an integrated decision-making framework that simultaneously determines vehicle routing plans and order consolidation policies by reinforcement learning and feedback control approaches.

71 Staffing of Sequential Heterogeneous Servers Under Uncertain Arrivals

Randy Grivel[1], Berkin Tan Arici[1], Shreyas Ravishankar[1], Ron Askin[2], Jorge A. Sefair[3], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Scottsdale, AZ, [3]University of Florida, Gainesville, FL

Airport security services in the United States can be modeled using sequential heterogeneous servers with dynamic processing rates and pooled resources. Modeling the system as a mixed integer program with an objective of minimizing the expected wait time of passengers under the uncertainty of passenger arrivals improves system performance.

72 A Random Forest Algorithm to Analyze Litter Chemical Dynamics Throughout Decomposition in Agroecosystems

Parvin Mohammadiarvejeh[1], Marshall D. McDaniel[1], Becky Ball[2], Kyle Wickings[3], Guiping Hu[1], [1]Iowa State University, Ames, IA, [2]Arizona State University, Phoenix, AZ, [3]Cornell University, Ithaca, NY, Contact: pmohamm@iastate.edu

Decomposition of plant litter is a critical process in agroecosystems. The litter decomposition has been investigated with the rate of litter mass loss in the current literature, however, the pattern of changes over time in litter chemistry is largely unknown. In this research, we applied the random forest regression model to the archived decomposition samples and data from across the U.S. Long-Term Ecological Research Network to evaluate decomposition rate and remaining mass across decomposition stages as the outcome of dynamic litter chemistry over time.

73 Physics-constrained Deep Active Learning for Spatiotemporal Modeling of Cardiac Electrodynamics

Jianxin Xie[1], Bing Yao[2], [1]The University of Tennessee, Knoxville, Knoxville, TN, [2]The University of Tennessee, Knoxville, Knoxville, TN, Contact: jxie15@vols.utk.edu

This work presents a physics-constrained deep active learning (P-DAL) framework to reconstruct the spatiotemporal cardiac electrodynamics from sparse physical observation. We develop the physics-constrained deep learning (P-DL) framework which integrates the physical laws of the cardiac electrical wave propagation and deep learning to model the heart electrical behavior from sparse sensor measurements. Furthermore, a novel active learning strategy is proposed to seek informative spatial locations on the heart surface for data collection to further increase the predictive power of the P-DL method. The performance of P-DAL framework is evaluated in both healthy and diseased heart systems.

74 A Machine Learning Analysis of the Relationship Between Some Underlying Medical Conditions and Covid-19 Susceptibility

Mostafa Rezapour, Colin Varady, Wake Forest university, Winston Salem, NC, Contact: rezapom@wfu.edu

In this presentation, we investigate the relationship between the COVID-19 vaccines and boosters and the total case count for the Coronavirus across multiple states in the USA. Additionally, we discuss the relationship between several, selected underlying health conditions with COVID-19. To discuss these relationships effectively, we utilize statistical tests and machine learning methods for analysis and discussion purposes. Furthermore, we discuss conclusions made about the relationship between educational attainment, race, and COVID-19 and the possible connections that can be established with underlying health conditions, vaccination rates, and COVID-19 total case and death counts.

75 Towards Futuristic Autonomous Experimentation - A Surprise-Reacting Sequential Experiment Policy

Ahmed Shoyeb Raihan, Imtiaz Ahmed, West Virginia University, Morgantown, WV, Contact: ar00065@mix.wvu.edu

An autonomous experimentation platform is capable of conducting a sequential search for finding suitable manufacturing conditions for advanced materials by itself with minimal human intervention. The core of the intelligent control of such platforms is the policy guiding the sequential experiments which inevitably trades off exploitation versus exploration. We discuss whether such a trade-off is beneficial by measuring the element and degree of surprise associated with the immediate past observation. Using two existing surprise metrics, we devise a surprise-reacting policy which can quickly characterize the overall landscape of a response surface under resource constraints.

76 AI-driven Automated Purchase Order Management System

Bing Zhang[1], Shubhi Asthana[2], Pawan Chowdhary[3], Taiga Nakamura[4], [1]IBM-Research, San Jose, CA, [2]IBM Research - Almaden, SAN JOSE, CA, [3]IBM Research, San Jose, CA, [4]IBM Research-Almaden, San Jose, CA, Contact: bing.zhang@ibm.com

The transactions of goods and services between enterprises are often driven by purchase orders (POs) and invoices. Every month thousands of invoices are billed to customers who settle them. Datasets across POs and invoices that are otherwise in silos need to be mapped for faster and more efficient operational analysis. In addition, the invoices may get into a dispute due to over exhaustion of allocated funds or may be billed to an expired PO. Managing the billing service is a huge undertaking along with increased costs. In this work, we develop an AI-driven purchase order management system to automate PO-invoice mapping and a risk analytics algorithm to decrease disputes as well as increase renewals.

77 A Deep Learning Model for the Classification of Supraspinatus Fatty Infiltration from Shoulder Magnetic Resonance Images

Juan Pablo Saavedra[1], Guillermo Droppelmann[2], Nicolás García[2], Felipe A. Feijoo[3], [1]Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile; [2]MEDS Clinic, Santiago, Chile; [3]Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile. Contact: juan.saavedra.g@mail.pucv.cl

Rotator cuff tears are among the most common conditions of the shoulder. One of the criteria that clinicians use to decide the correct treatment for a patient is the fatty infiltration of the muscle. Patients with low amounts of fatty infiltration in the supraspinatus muscle will probably have better outcomes than those with higher amounts, and thus, assessing the quality of the muscle is crucial for medical staff. In this study, we trained a two-step deep learning model. In the first step, the model performed the segmentation of the region of interest from the image. Then, in the second step, the model classified the image as "risky" or "not risky", based on the the Goutallier's fatty infiltration scale.

78 Collaborative Discrimination-enabled Generative Adversarial Network (CoD-GAN) for Data Augmentation

Ziyang Zhang[1], Yuxuan Li[2], Chenang Liu[2], [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Stillwater, OK, Contact: jan.zhang@okstate.edu

This study aims to modify GAN to optimize data augmentation when data from two classes are imbalanced. Hence, a creative and effective GAN structure, collaborative discrimination-enabled generative adversarial network (CoD-GAN) is proposed. The main novelty lies in integrating multiple discriminators to improve the robustness of its discrimination and the diversity of the synthetic samples. The effectiveness of the proposed method is validated by simulation data and a real-world dataset.

79 Failure-averse Active Learning for Physics-constrained Systems

Cheolhei Lee, Virginia Tech, Blacksburg, VA, Contact: cheolheil@vt.edu

Engineering systems are subject to implicit physics-constraints, while constraints are underestimated in active learning. We develop a failure-averse active learning considering physics constraints. It realizes two tasks: safe variance reduction and safe region expansion, with theoretical guarantees. This method achieved zero-failure in composite structure assembly without knowing explicit failure regions.

80 Traffic Shaping and Hysteresis Mitigation Using Deep Reinforcement Learning in a Connected Driving Environment

Rami Ammourah[1], Alireza Talebpour[2], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois at Urbana-Champaign, Champiagn, IL, Contact: ramiaa2@illinois.edu

A multi-agent deep reinforcement learning framework is proposed for traffic shaping, i.e., maintaining a desirable traffic flow given a certain traffic density. The key advantage of the framework is its ability to mitigate hysteresis phenomena. Partial connectivity is assumed where connected automated vehicles share information amongst each other. A centralized training, centralized execution approach based on the DQN algorithm is adopted where control is defined by signals of acceleration or deceleration commands. We demonstrate the ability of the model to shape the state of traffic, mitigate the negative effects of hysteresis, and even improve traffic flow beyond its original level.

81 Model-informed Generative Adversarial Network (MI-GAN) for Learning Optimal Power Flow

Yuxuan Li, Chenang Liu, Oklahoma State University, Stillwater, OK, Contact: yuxuan.li@okstate.edu

The optimal power flow (OPF) problem remains challenging due to variability, intermittency, and unpredictability of renewable energy brought to power system. The capability of existing optimization approaches is insufficient when the problem scale is large. Hence, this work proposed a novel model-informed GAN (MI-GAN) method to handle the OPF problem, which can ensure optimality, flexibility, and efficiency by a proposed new model-informed generator with a developed recursive iteration algorithm. The numerical experiments using the IEEE test systems showed this method was very promising.

82 Bayesian Optimization Enabled Rapid Calibration of Molecular Modeling Forcefields

Montana Carlozo[1], Bridgette Befort[1], Nilay Kumar[1], Edward Maginn[1], Alexander Dowling[2], [1]The University of Notre Dame, South Bend, IN, [2]The University of Notre Dame, Notre Dame, IN, Contact: mcarlozo@nd.edu

Hydrofluorocarbons (HFCs) must be phased out of use and replaced, but a lack of data on HFCs limits advances in separation processes design. Gaussian process regression can be used with Bayesian optimization (GPBO) to rapidly regress predictive molecular model parameters for HFC data generation to be used in process design. We demonstrate the use of two formulations of GPBO, finding that a formulation which emulates the molecular model output, instead of model error, captures the overall model behavior best for parameter calibration. We compare the results of both formulations to non-linear regression. Future work will include modifying the BO acquisition function to improve accuracy and speed.

83 An Empirical Evaluation of Unfairness Mitigation Algorithms for Predicting Micro-mobility Demand

Ayan Mukhopadhyay, Vanderbilt University, Nashville, TN

Data-driven forecasting models are used for resource allocation, such as in optimizing shared micro-mobility programs by optimizing the location of bike stations. However, such an approach to allocation may unintentionally incorporate implicit bias, resulting in inequity in resource allocation. I will talk about the performance of state-of-the-art unfairness mitigation algorithms coupled with fairness constraints, specifically in the context of predicting micro-mobility demand.

84 Early Disease Prediction of Swine Considering Daily Feed, Water Intake, and Weight Change Pattern Using Machine Learning Models

Saiara Samira Sajid[1], Guiping Hu[1], Jack Dekkers[2], [1]Iowa State University, Ames, IA, [2]Iowa State University, Ames, IA, Contact: sajids@iastate.edu

Swine Farms have a large economic component in livestock farming. Concurrently, swine are susceptible to a larger number of diseases. Hence, diseases have the largest economic impact on the swine industry. We propose Machine Learning (ML) based prediction models to predict the treatment requirement of an individual pig of a batch. The daily feed intake, water intake, and weight change were given as input to the prediction model. We compared several state-of-the-art ML models and found that Random Forest outperforms other models (accuracy of 60.8%). The proposed model ranks swine within a batch based on the probability of getting sick, promoting sustainable pork production.

85 An LSTM-autoencoder Based Online Monitoring Approach for Cyber-physical Attack Detection in Additive Manufacturing

Zhangyue Shi[1], Chenang Liu[2], [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Stillwater, OK, Contact: zhshi@okstate.edu
How to effectively monitor and accurately detect cyber-physical attacks becomes a critical barrier for the broader adoption of additive manufacturing (AM) technology. In this study, we propose a machine learning-driven online side channel monitoring approach for AM process monitoring. A data-driven feature extraction approach based on LSTM-autoencoder is developed to detect unintended process/product alterations caused by cyber-physical attacks. Both supervised and unsupervised monitoring schemes are implemented based on the extracted features. Case study in FFF process demonstrates the effectiveness of the proposed method.

86 Analysis of Occurrence Pattern in Wildfire Cases in California Using NLP Methods

Seonho Woo[1], Seungho Woo[2], [1]University of Michigan - College of Engineering, Ann Arbor, MI, [2]Purdue University, West Lafeyette, IN, Contact: clairewo@umich.edu
As the climate goes drier, keeping track of increasing wildfire cases is helpful to be prepared for this natural disaster. Natural Language Processing methods are used to extract key quantitative data for damage from online articles, which is a reasonable means for data collection. Analysis of terminologies using various methods is conducted to retrieve information listed in the text. Mapping and a pattern analysis are done by using the mapper feature in the nltk package to demonstrate the damage size and location. This could track the actual wildfire cases and show the pattern of the trend. This study could be expanded into the larger locational aspect, and add more factors in tracking the major causes.

87 Multiclass Classification of Detected Anomalies by Combining Root Cause Analysis and Machine Learning Techniques

Pooyan Mobtahej, Lamar University, Beaumont, TX
A gas compressor system consists of different components in which any defects in each of them could cause the overall system failure which is costly. Therefore, the early diagnosis of failures in compressor systems is essential to reduce the risk of system shutdown and increase production line reliability. Hence, this research proposes a hybrid anomaly detection approach by employing both Root Cause Analysis and Machine Learning decision algorithms to combine for the detection of each component failure and conduct a multi-class classification of unseen anomalies captured in time-series cleaned data. 10-Fold cross-validation was conducted to evaluate the performance of the models. The proposed method for decision tree-based multiclass classification has been chosen from the evaluated methods as the best-scored model with a 99.99% AUC and Accuracy score.

88 Targeting High-value Customers: Optimizing Marketing Strategy Through Consumer Behavior Analysis

Ilyas Ustun, Mengfan Ying, DePaul University, Chicago, IL, Contact: ilyasustun@gmail.com
This poster presents the usage of machine learning models to identify high-value customers. From the transaction data, Recency, Frequency, and Monetary (RFM) values have been calculated. These RFM values have been used in the K-means algorithm to cluster the customers into different segments. Customer lifetime value is obtained from the RFM values, and the clusters are ranked accordingly to identify high-value customers. Using customer demographics and past purchases, machine learning algorithms have been applied to classify new customers. The proposed approach has been used in a case study to better serve the customer base of a medium-sized bike and cycling accessories company.

89 Data-driven Adaptive Testing Resource Allocation Strategies for Real-time Monitoring of Infectious Diseases

Xin Zan[1], Jaclyn Hall[2], Tom Hladish[3], Xiaochen Xian[1], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL, [3]University of Florida, Gainesville, FL, Contact: xin.zan@ufl.edu
Infectious diseases have continued to be a major global public health threat and effective methods are in critical need to quickly detect disease outbreaks. However, limited testing availability that leads to insufficient data poses challenges to effective monitoring in practice. By integrating nonstationary MAB techniques on top of a physics-informed model, this work proposes adaptive allocation strategies to intelligently allocate limited testing resources among communities, which enables collection of high-quality testing data for quick outbreak detection. Theoretical analysis and a comprehensive simulation study are conducted to evaluate the performance.

Sunday, 2 PM–3:15 PM

SD01

CC - Room 101
Data Mining Paper Competition II
Award Session

Session Chair

Young Woong Park, Iowa State University, Ames, IA

Session Chair
Ying Lin, University of Houston, Houston, TX

1 Projected Randomized Smoothing for Certified Adversarial Robustness

Samuel Pfrommer, Brendon Anderson, Somayeh Sojoudi, University of California, Berkeley, Berkeley, CA

We propose a classifier architecture that first projects onto a low-dimensional approximation of the data manifold and then applies a standard classifier. By performing randomized smoothing in the low-dimensional projected space, we characterize the certified region of our smoothed composite classifier back in the original input space and prove a tractable lower bound on its volume. We show experimentally that classifiers without the initial projection are vulnerable to perturbations that are normal to the data manifold yet are captured by the certified regions of our method. We compare the volume of our certified regions against various baselines and show that our method improves on the state-of-the-art by many orders of magnitude.

2 Exploring the Whole Rashomon Set of Sparse Decision Trees

Rui Xin[1], Takuya Takagi[2], Chudi Zhong[1], Zhi Chen[1], Margo Seltzer[3], Cynthia Rudin[1], [1]Duke University, Durham, NC, [2]Fujitsu Laboratories Ltd., Tokyo, Japan; [3]The University of British Columbia, Vancouver, BC, Canada.

In any given machine learning problem, there may be many models that could explain the data almost equally well. The Rashomon set is the set of these all almost-optimal models. Rashomon sets can be extremely complicated, particularly for highly nonlinear function classes such as decision trees. We provide the first method for completely enumerating the Rashomon set for sparse decision trees. We show three applications of the Rashomon set: 1) it can be used to study variable importance for the set of almost-optimal trees, 2) the Rashomon set for accuracy enables enumeration of the Rashomon sets for balanced accuracy and F1-score, and 3) the Rashomon set for a full dataset can be used to produce Rashomon sets for subsets of the dataset.

3 Federated Gaussian Process: Convergence, Automatic Personalization and Multi-fidelity Modeling

Xubo Yue, Raed Al Kontar, University of Michigan, Ann Arbor, Ann Arbor, MI

In this paper, we propose FGPR: a Federated Gaussian process (GP) regression framework that uses an averaging strategy for model aggregation and stochastic gradient descent for local client computations. Notably, the resulting global model excels in personalization as FGPR jointly learns a global GP prior across all clients. The predictive posterior then is obtained by exploiting this prior and conditioning on local data which encodes personalized features from a specific client. Theoretically, we show that FGPR converges to a critical point of the full log-likelihood function, subject to statistical error. Through extensive case studies we show that FGPR excels in a wide range of applications and is a promising approach for privacy-preserving multi-fidelity data modeling.

4 PERCEPT: A New Online Change-point Detection Method using Topological Data Analysis

Xiaojun Zheng[1], Simon Mal[1], Liyan Xie[2], Yao Xie[3], [1]Duke University, Durham, NC, [2]The Chinese University of Hong Kong, Hong Kong, Hong Kong; [3]Georgia Institute of Technology, Atlanta, Georgia.

Topological data analysis (TDA) provides a set of data analysis tools for extracting embedded topological structures from complex high-dimensional datasets. We propose a new method, called PERsistence diagram-based ChangE-PoinT detection (PERCEPT), a topology-aware, non-parametric framework for online high-dimensional change-point detection. PERCEPT follows two key steps: it first learns the embedded topology as a point cloud via persistence diagrams, then applies a non-parametric monitoring approach for detecting changes in the resulting point cloud distributions. We demonstrate the usefulness of PERCEPT in two applications on solar flare monitoring and human gesture detection.

Sunday, 2 PM–3:15 PM

SD03

CC - Room 103
Digital Twins for Accelerated Discovery of Climate and Sustainability Solutions
General Session

Session Chair
Levente Klein, IBM

1 Super-resolution of Turbulent Flows in the Absence of the High-resolution Ground Truth

Kyongmin Yeo[1], Malgorzata Zimon[2], Mykhaylo Zayats[3], Sergiy Zhuk[3], [1]IBM Research, Yorktown Heights, NY, [2]IBM Research, Warrington, United Kingdom; [3]IBM Research,

Dublin, Ireland. Contact: kyeo@us.ibm.com
Super-resolution (SR) refers to the problem of reconstructing high-resolution (HR) information from low-resolution (LR) data. SR of physical data has attracted a great attention with the advent of deep learning. While most of the SR models assume existence of HR ground truth data to train a deep learning model, in real-life problems, such HR ground truth data is scarce. Here, we present a deep learning model for SR of turbulent flows trained without such HR ground truth. We propose to use the conservation laws to regularize the solution of the SR model. It is shown that the SR model can reliably reconstruct unseen high-resolution turbulent flows.

2 Some Recent Advances on Statistical Learning for Remote Sensing Data and Wildfire Risk Assessment on Networks

Guanzhou Wei[1], Xiao Liu[1], Feng Qiu[2], [1]University of Arkansas, Fayetteville, AR, [2]Argonne National Lab, Lemont, IL, Contact: gwei@uark.edu
This talk introduces some of our recent work on statistical learning for (1) wildfire smoke propagation modeling using remote sensing data, and (2) wildfire risk assessment for power grids. Under the first topic, we focus on the suppression of Gibbs phenomenon for a recently proposed physics-informed statistical spatio-temporal model. Under the second topic, we describe a new statistical model for point processes on linear networks that enables us to assess wildfire risks on power grids.

3 Digital Twin Based Framework for Joint Optimization of Yield, GHG Emissions, Revenue and Soil Carbon Sequestration for Agriculture

Ranjini Guruprasad, [1</sup]
Agriculture contributes about 26% to global GHG emissions. Reducing GHG emissions impacts the farming inputs and in turn, the agricultural yield and revenue. Hence, food companies want to jointly optimize yield, revenue and GHG emissions. In addition to reducing GHG emissions, food companies are adopting farming practices to sequester carbon in the soil to have a positive environmental impact and increase revenue. In this talk, we present a comprehensive framework that includes revenue estimation models and digital twin (includes physics based models) to jointly optimize revenue, yield, GHG emissions and amount of soil carbon sequestered. The framework performs counterfactual analysis to recommend farming practices based on geos and periods of interest to increase/maintain yield, reduce GHG emissions and increase the carbon sequestered in the soil and revenue.

4 Geospatial Multi-Model Carbon Sequestration and Green House Gas Emission Framework

Ademir Ferreira da Silva[1], Levente Klein[2], Jitendra Singh[3], [1]IBM Research Brazil, Rio de Janeiro, Brazil; [2]IBM, New York, NY, [3]IBM Research India, Gurgaon, India. Contact: ademir.ferreira@br.ibm.com
Climate Change mitigation efforts require accurate assessment of local GHG emissions and carbon sequestration (CS) at less than 1km2 spatial resolution with flexibility to adjust based on local model and user input. Current approaches of GHG emissions rely on generic and coarse models not amenable to capture the local variations necessary to make these data useful for operational decisions. We demonstrate a geospatial framework where CS in soil and forest is combined with emission of CO2, CH4 and N2O from land management. The framework uses machine learning techniques on satellite and ground measurement data for land-cover classification, data imputation and multi-model validation, allowing estimation of CS and GHG emissions at a farm level.

Sunday, 2 PM–3:15 PM

SD04

CC - Room 104

Recent Statistical Innovations for Analyzing Big and Complex Data: Methods and Applications

General Session

Session Chair

Trambak Banerjee, University of Kansas, Lawrence, KS

1 Community Gifting and Recipients Engagement with Peers and Influencers Evidence from Natural Experiments on Twitch

Alexander Chaudhry[1], Yang Wang[2], Erya Ouyang[2], Xueming Luo[2], [1]Southern Utah University Leavitt School of Business, Cedar City, UT, [2]Temple University Fox School of Business and Management, Philadelphia, PA
Community gifting on live streaming platforms enables a user to donate gifts to other members of the community. The authors exploit community gifting's random assignment on Twitch as a collection of natural experiments in a difference-in-differences framework. The results demonstrate that receiving a gift increases financial engagement with peers but not streamers while social engagement with both peers and streamers increases. The authors reveal that the sentiment of social engagement reflects gift recipients' elevated

happiness. Moreover, a novel measure of chat continuity is used to reveal that gift recipients, while surprised by a gift, join the ongoing conversation in the stream. The combined results of increased engagement volume, happiness, and chat continuity indicate that community gifting can improve the recipients' engagement with the community.

2 Evaluating Mental Health Care from a Natural Language Perspective: How Consistent is Your Teletherapist?

Courtney Paulson, 1</sup

Modern healthcare is increasingly embracing the advantages of telehealth, particularly in the wake of COVID-19 and other recent community health concerns. Patients and providers alike often appreciate the flexibility of conducting visits and updates via video call, text message, or phone. One area of telehealth that has seen particular growth is teletherapy, or the practice of providing mental health care through methods other than in-person visits. But how do we know if the care a patient is receiving through teletherapy matches the expectation of a more traditional patient-therapist relationship? In this study, we consider the text of thousands of messages between deidentified patients and their therapists as well as survey and other data provided by patients and the teletherapy platform. By combining natural language processing methodology (e.g., Latent Dirichlet Allocation for topic sorting) with machine learning methodology (e.g., penalized regression methods), we investigate characteristics of the teletherapy experience such as response time, message length, and message content to determine the effect such measures have on therapy satisfaction and overall outcomes.

3 An Efficient Monte Carlo EM Clustering Algorithm in GLMM

Rashmi Ranjan Bhuyan[1], Gourab Mukherjee[1], Wreetabrata Kar[2], [1]University of Southern California, Los Angeles, CA, [2]Krannert School of Management, Purdue University, West Lafayette, IN, Contact: bhuyanr@usc.edu

The use of generalized linear mixed-effects models (GLMM) is popular across social and medical sciences. High dimensionality and class imbalance are two extremely common characteristics in such datasets. Under these settings, fitting GLMMs and estimating all the effects become immensely difficult. We propose a Monte Carlo EM algorithm to recover the heterogeneous effects in imbalanced GLMM and simultaneously implement model based clustering. We provide theoretical guarantees for consistent estimates of the clustering and other effects. The algorithm is designed to work in the high dimensional regime, and it scales up efficiently. We compare the performance of the proposed algorithm on a range of simulation setups and observe encouraging performance. We demonstrate the applicability of our method by analyzing consumer behavior in email marketing dataset.

4 Large-scale Importance Selection on Heteroscedastic Contenders

Luella Fu[1], Bowen Gang[2], Gareth James[3], Wenguang Sun[3], [1]San Francisco State University, San Francisco, CA, [2]School of Management, Fudan, China; [3]Marshall School of Business, Los Angeles, CA, Contact: luella@sfsu.edu

Choosing candidates to whom a limited set of resources will be distributed is a pervasive dilemma. In multiple testing procedures that can be used to choose such candidates, power is traditionally defined as the number or proportion of correctly selected non-null hypotheses. We generalize power so that researchers can better select more desirable testing units and propose a specific formulation to capture not only if a unit has been correctly categorized as null or alternative but also to better reward the detection of larger effect sizes. We demonstrate the effectiveness of the proposed method in picking out mutual funds with positive returns.

Sunday, 2 PM–3:15 PM

SD05

CC - Room 105

Complex Data Modeling and Analysis in Smart Manufacturing

General Session

Session Chair

Shenghan Guo, Arizona State University, Gilbert, AZ

1 Regression Trees on Grassmann Manifold for Adapting Reduced-order Models

Xiao Liu, University of Arkansas, Fayetteville, AR, Contact: liuxiaodnn_1@hotmail.com

Reduced-Order Models (ROMs) often lack robustness against the change of parameters. This talk proposes to use regression trees to learn the mapping between parameters and POD bases that span the low-dimensional subspace onto which the full-order model is projected. Motivated by the fact that a subspace spanned by a POD basis can be viewed as a point in the Grassmann manifold, we propose to grow a tree by splitting the tree node to maximize the Riemannian distance between the two subspaces spanned by the predicted POD bases on the left and right daughter nodes. Five numerical examples are presented to demonstrate the performance of the proposed method, and compare the proposed tree-based method to the existing interpolation method for POD basis and the use of global POD basis.

2 A Deep-learning-based Surrogate Model for Thermal Signature Prediction in Laser Metal Deposition

Shenghan Guo[1], Weihong Guo[2], Linkan Bian[3], Yuebin Guo[2], [1]Arizona State University, Mesa, AZ, [2]Rutgers, The State University of New Jersey, Piscataway, NJ, [3]Mississippi State University, Mississippi State University, MS, Contact: shenghanguo@gmail.com

Transient thermal signatures generated during Laser metal deposition (LMD), such as the in-situ thermal images of melt pool, contain rich information about process performance and defects. This paper develops a deep-learning-based surrogate model, called LMD-cGAN, to predict and emulate the transient thermal signatures in LMD. The model generates images for the thermal dynamics of melt pool conditionally on the deposition layer. It enables early prediction of future-layer thermal signatures for an in-process part based on its early-layer thermal signatures. A physics-guided image selection mechanism is integrated with LMD-cGAN to calibrate the predictions against physical benchmarks of transient melt pool for the process. The effectiveness and efficiency of the proposed method are demonstrated in a case study on the LMD of Ti-4Al-6V thin-walled structures.

3 Closed-loop Machine Learning and Compensation for Geometric Accuracy Control of Additively Manufactured Products

Wenbin Zhu[1], Arman Sabbaghi[2], [1]Purdue University, West Lafayette, KS, [2]Purdue University, West Lafayette, IN, Contact: sabbaghi@purdue.edu

Additive manufacturing (AM), or 3D printing, systems enable direct printing of physical products from computer-aided design (CAD) models. One of the significant limitations of AM is shape deviations between the printed product and the nominal CAD. This talk presents a closed-loop machine learning and compensation framework for improved accuracy control in AM. The closed-loop nature is fully sequential in that it requires printing only one new shape at a time, and accurate products can be printed in a small number of iterations. As demonstrated in our case studies using a Markforged Metal X AM machine, our framework can reduce shape inaccuracies by 30% to 60% in at most two iterations. Our closed-loop framework addresses the significant challenge of "few shot" learning and control of AM systems by means of knowledge transfer across different products and iterations in AM.

4 Tensor-on-tensor Regression Neural Networks for Process Monitoring with High Dimensional Data

Qian Wang, Kamran Paynabar, Georgia Institute of Technology, Atlanta, GA, Contact: wang.qian@gatech.edu

Modern technology enables the collection of enormous amount of measurements over processes in the areas such as manufacturing. The regression modeling between the collected high dimensional (HD) data is crucial for understanding the underlying system. HD data are heterogeneous including profiles, images and point clouds, usually formed into tensors. Linear methods, mostly tensor techniques, have been discussed in the literature to model the relationship between HD process variables while capturing their spatial structure and reduce high dimensionality. However, most of the real-world processes possess nonlinear nature which fails to be captured by these methods. This article proposes novel tensor-on-tensor regression neural networks to model nonlinear relationship between sources of HD data, whose performance is evaluated using simulation and case studies.

Sunday, 2 PM–3:15 PM

SD06

CC - Room 106

Computational Social Science

General Session

Session Chair

Seyed Mohamad Hosseinioun, UIC, Chicago, IL

Session Chair

Aida Sanatizadeh, University of Illinois at Chicago, IL

1 Why are U.S. Parties so Polarized? A "Satisficing" Dynamical Model

Vicky Chuqiao Yang, MIT, Cambridge, MA, Contact: vicky.chuqiao.yang@gmail.com

Since the 1960s, Democrats and Republicans in US Congress have taken increasingly polarized positions, despite the lack of clear evidence for voters doing the same. We explain this apparent contradiction by developing a dynamical model that predicts ideological positions of political parties. Our approach integrates satisficing decision making---voters settle for candidates who are "good enough." We test the model using data from the US Congress over 150 years and find that our predictions are consistent with the two major political parties' historical trajectories. In particular, the model explains how polarization between parties could be a consequence of increasing ideological purity within the parties.

2 Quantifying Public Uses and Public Funding of Science

Yian Yin, Northwestern University

Knowledge of how science is consumed in public domains is essential for understanding the role of science in human society. Here we examine public use and funding of science, by linking 36M scientific publications from all fields to their upstream funding support and downstream uses across government documents, news media, and marketplace invention. We find that different public domains draw in specialized ways across scientific fields. Amidst these differences, we find universal alignment between what the public consumes and what is highly impactful within science. A field's public funding is further strikingly aligned with the field's collective public use. Overall, public uses of science present a rich landscape of specialized consumption, yet collectively science-society interface with remarkable assignment between scientific use, public use, and funding.

3 Firms' Returns to Search and Their Knowledge

Seyed Mohamad Hosseinioun, UIC, Chicago, IL

Innovation is the outcome of a search process for better solutions and is integral to firms' business. There is tension between local search, which leads to competence rigidity, and distant search, which is costly and uncertain. Despite rich research in balancing local and distant search, we do not yet understand why some firms are better suited for one vs. the other. We argue firm's knowledge generality is the key determinant of its search behavior. We consider the search space a network, wherein nodes are technical domains and edges are established search paths between them. Hence, firms' knowledge generality allows for a more central position in the search space. We examine how firm's knowledge moderates search using cross-sectionally and longitudinally rich data on firms' patents. Finally, we examine returns to search and how firm's knowledge influences such returns.

4 Unsupervised Embedding of Trajectories Captures the Latent Structure of Mobility

Jisung Yoon[1], Dakota Murray[2], Sadamori Kojaku[3], Rodrigo Costas[4], Woo-Sung Jung[5], Stasa Milojevic[3], Yong-Yeol Ahn[3], [1]Northwestern University, Evanston, IL, [2]Northeastern University, Boston, MA, [3]Indiana University, Bloomington, IN, [4]Leiden University, AX Leiden, Netherlands; [5]POSTECH, Pohang, Korea, Republic of. Contact: jisung.yoon92@gmail.com

Human mobility drives major societal phenomena including economies and innovation. Historically, mobility was constrained by geographic distance, however, in the globalizing world, language, culture, and history are increasingly important. We propose using the neural embedding model word2vec for studying mobility and capturing its complexity. Word2ec is shown to be mathematically equivalent to the gravity model of mobility, and using three human trajectory datasets, we demonstrate that it encodes nuanced relationships between locations into a vector-space, providing a measure of effective distance. Focusing on the case of scientific mobility, we show that embeddings uncover cultural, linguistic, and hierarchical relationships at multiple levels of granularity. Connecting neural embeddings to the gravity model opens up new avenues for the study of mobility.

Sunday, 2 PM–3:15 PM

SD07

CC - Room 107

Emerging Machine Learning Algorithms for Advanced Manufacturing

General Session

Session Chair

Ying Lin, University of Houston, Houston, TX

Session Chair

Chenang Liu, Oklahoma State University, Stillwater, OK

1 Grouping and Spatially Correlated Sparse Bayesian Learning with Application to Multi-stage Assembly Systems

jihoon Chung, Zhenyu James Kong, Virginia Tech, Blacksburg, VA, Contact: zkong@vt.edu

Grouping and Spatially correlated Sparse Bayesian Learning with Application to Multi-Stage Assembly Systems This paper addresses the problem of fault diagnosis in multi-station assembly systems. The main challenges to be resolved in this work include (1) the number of measurements is less than the process errors, which is typical in practice but results in an ill-posed estimation problem, (2) there exist non-stationary patterns of process faults among the samples, and (3) there exist spatial correlations among the process faults. To address these challenges, a novel hierarchical Bayesian model, which is Grouping and Spatially correlated Sparse

Bayesian Learning (GSSBL), is proposed in this work. The actual autobody assembly process is also used to illustrate the superiority of the proposed method.

2 Solving Supply-demand Matching of Manufacturing Resources Using Model-free RL Algorithms

Saunak Kumar Panda, University of Houston, Houston, TX, Contact: spanda@cougarnet.uh.edu

We consider the problem of dynamically matching supply-demand quantities of heterogeneous types of manufacturing resources. We model it using an MDP framework where the outstanding demand is the state vector with the optimal action being the supply-demand quantities matched to maximize the total discounted reward. Preliminary results show that increase in the state vector dimension exponentially increases the number of feasible actions, which greatly increases the solution time by model-based methods like dynamic programming. This has motivated us to turn to model-free reinforcement learning (RL) methods like Q-learning and Deep Q network algorithms like DQN and DDPG. We further develop smart action exploration and action manipulation strategies for DQN and DDPG respectively to improve the performance. Finally, we compare the performance of all these algorithms.

3 Enhance In-situ Anomaly Detection Performance Using Knowledge Distillation in Additive Manufacturing System

Zhangyue Shi, Chenang Liu, Oklahoma State University, Stillwater, OK, Contact: zhshi@okstate.edu

The incorporation of advanced online sensing technology in the manufacturing system provides valuable data to achieve efficient in-situ process monitoring. Several machine learning based in-situ monitoring methods have been developed to detect both internal and external quality issues. However, machine learning based methods have comparably high requirement on data quality and quantity, which hinders broader application of machine learning methods. To resolve these challenges, this study develops a knowledge sharing framework based on knowledge distillation to effectively share the informative knowledge learnt by the data-rich agent with data-poor agents. Using the distilled knowledge, anomaly detection accuracy of the data-poor agents could be improved with the help from the data-rich agent.

4 An Engineering-informed Automated Point-cloud Segmentation Algorithm for Geometric Quality Assessment of Thick Layers in Additively Manufactured Metallic Structures

Cesar Alexander Ruiz, Qiang Huang, University of Southern California, Los Angeles, CA

Additive manufacturing (AM) of complex metal parts promises to improve the sustainability of the aerospace and oil industries. Wire-arc AM (WAAM) offers high deposition rates on large printing areas by welding a few thick layers. However, WAAM technologies suffer from poor geometric accuracy due to unstable high temperature processes. Moreover, partial layer melting and severe out-of-plane layer displacement difficult the identification of each layer for building a prescriptive model for geometric accuracy improvement. Standard semantic segmentation and clustering algorithms cannot process dense point clouds with the overlapping structures observed in WAAM. In this talk, we propose an efficient ML algorithm that utilizes the knowledge of the as-deposited geometry to select features to identify the boundaries between overlapping layers.

Sunday, 2 PM–3:15 PM

SD08

CC - Room 108

Big Data and Deep Learning

Contributed Session

Session Chair

Minh Nguyen, University of Hawaii at Manoa, Honolulu, HI

1 Determinants for Intention to Purchase a Mobile Device: A User-centric Approach

Yashica Pandey, Ahamed Shamly Anvar Mackey, University of North Texas, Denton, TX

There has been a substantial increase in mobile device usage in the last decade among students. To target this segment, mobile companies must take a user-centric approach to understand the factors for mobile device purchase. Survey data from the University students were analyzed utilizing a user-centric approach to identify determinants for intention to use a mobile device.

2 The Impact of Buyers' Bidding Dynamics on Sellers' Pricing Strategy: A Machine Learning Approach

Yeun Soo Park, Gu Pang, Joseph Sanderson, University of Birmingham, Birmingham, United Kingdom. Contact: yxp089@student.bham.ac.uk

The information asymmetry associated with remanufactured products appears to be worse than for their new product counterparts. This is likely due to the high-level uncertainty and perceived risks. We collect eBay auction data of remanufactured electronics to explore how buyers bidding dynamics impact sellers' pricing strategy and how such dynamics advance the buyers' knowledge on information asymmetry. Using machine learning methods, our study suggests that existing models based on statistical analysis are less capable of identifying the non-linear relationships. Our results show advanced machine learning models better predict non-linear relationships.

3 Hyperparameter Optimization over Data Hierarchy for Model Selection in Time Series Forecasting

Arindam Jati[1], Vijay Ekambaram[1], Brian Quanz[2], Wesley Gifford[2], Pavithra Harsha[3], Stuart Siegel[2], Chandra Narayanaswami[2], [1]IBM Research, Bangalore, India; [2]IBM Research, Yorktown Heights, NY, [3]IBM Research, Pleasantville, NY

Time series data is sometimes associated with a hierarchy. The data at the bottom level is often sparse and incoherent (for example, in the retail domain), which makes it hard to obtain optimized forecasting models. We propose a novel model selection method for time series forecasting, that exploits the data hierarchy during the hyperparameter optimization (HPO) of the model being trained at the bottom level, by leveraging the better predictability of the higher-level aggregated time series and incorporating the prediction errors at all levels in the HPO objective. Experiments on several public hierarchical time series datasets demonstrate the efficacy of the proposed method over standard model selection techniques.

4 Actual Events Vs. Perceived Reporting: Modeling Firm Performance Under Environmental Uncertainty Using Machine Learning

Minh Nguyen, University of Hawaii at Manoa, Honolulu, HI, Contact: duyminh@hawaii.edu

Not all companies respond the same to natural disaster events. This study investigates two ways that natural disasters affect firm performance: actual events vs. perceived reporting. In this study, I consider the billion-dollar natural disasters as the actual events and the number of words related to natural disasters in the Management Discussion and Analysis section in Form 10-Ks filing by the U.S. public companies as the perceived reporting. The results show that both actual events and perceived reporting of natural disasters this year negatively affects return on assets in the next year. Comparing among classification and regression trees (CART), neural networks, and linear regression models, I find that CART and neural networks outperform linear regression models in predicting U.S. firm performance under environmental uncertainty.

Sunday, 2 PM–3:15 PM

SD09

CC - Room 109

Data Mining Flash Session IV

Flash Session

Session Chair

Dan Li, Clemson University, Clemson, SC

1 Analysis of Human Behavior in Human Robot Interaction for Manufacturing

Sara Masoud, Wayne State University, Detroit, MI, Contact: saramasoud@wayne.edu

Despite its complexity, human behavior follows structured principles. Creation of more reliable and efficient collaborative robotic environments becomes possible through better understanding the underlying concepts of human behavior. Previously, robots served in production lines in co-existing capacities, where no interaction took place between the operators and robots. Industry 5.0 has equipped us with technologies such as industrial internet of things, big data, and artificial intelligence, facilitating the realization of full collaborative environments, where robots can interact with humans in unseen situations through sensing, processing, and predicting human behaviors.

2 Decision Focused Utility Learning

Harshal D. Kaushik, Virginia Tech, Blacksburg, VA

From the available finite set of actions, how can we design the utility of players that are competing against each other? This question arises naturally in many real-life scenarios as its famous counterpart of conventional game theory. In this work, we consider a mathematical program with equilibrium constraints and propose a game-theoretic pipeline that spans from data, to prediction, to a downstream optimization problem.

3 High-throughput Characterization via Automated Sensing and Machine Learning

Junru Zhang[1], Blake Johnson[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Blacksburg, VA, Contact: junru6@vt.edu

High-throughput characterization (HTC) of composition-process-structure-property relations is essential for accelerating materials manufacturing paradigms. Here, we present a new method for HTC of hydrogel library rheological properties via robotically-directed sensing. We also demonstrate that supervised machine learning enables accurate classification of material phase using sensor data. Ultimately, creating HTC methods for soft materials that synergize with well plate formats can accelerate the pace of soft materials, biomaterials, and sensors research across various fields as well as improve capabilities for quality assurance and control of hydrogel-based products

4 Multi-task Learning for Pricing

Yuhang Wu, Columbia University, New York, NY, Contact: yw3453@columbia.edu

Multi-task Learning For Pricing Multi-task Learning For Pricing Multi-task Learning For Pricing

5 Fairness in Federated Learning

Raed Al Kontar, University of Michigan, Ann Arbor, MI

We propose GIFAIR-FL: a framework that imposes Group and Individual FAIRness to Federated Learning settings. By adding a regularization term, our algorithm penalizes the spread in the loss of client groups to drive the optimizer to fair solutions. Our framework GIFAIR-FL can accommodate both global and personalized settings. Theoretically, we show convergence in non-convex and strongly convex settings. Our convergence guarantees hold for both i.i.d. and non-i.i.d. data. To demonstrate the empirical performance of our algorithm, we apply our method to image classification and text prediction tasks.

6 Evaluation of Privacy Preservation Capacity of Thermal History Features in Metal-based Additive Manufacturing

Mahathir Bappy[1], Wenmeng Tian[2], [1]Mississippi State University, Starkville, MS, [2]Mississippi State University, Mississippi State, MS, Contact: mmb888@msstate.edu

Large-scale data sharing can promote the performance for metal-based additive manufacturing (AM) certification. However, the broader adoption of the sharing platform is significantly hindered by the AM user's intention of intellectual property (IP) protection. This work evaluates the capacity of privacy preservation of the state-of-the-art feature extraction methods, which were originally proposed for AM process anomaly detection. Specifically, the extracted features are assessed for their capacity to disclose printing trajectory related information. Subsequently, their capacity to facilitate privacy preserving AM certification is discussed.

7 Time Series Analysis for Interval-valued Data: Theory and Applications

S. Yaser Samadi[1], Lynne Billard[2], [1]Southern Illinois University, Carbondale, IL, [2]University of Georgia, Athens, GA, Contact: ysamadi@siu.edu

Many series of data record individual observations as intervals, such as stock market values with daily high-low values, or min and max temperatures, recorded over time. With the advent of supercomputers, datasets can be extremely large, and it is frequently the case that observations are aggregated into intervals, histograms, or other forms of so-called symbolic data. In this talk, we present an interval-valued autoregressive model. ML estimators are derived by using the ideas of composite likelihood and the pairwise likelihood functions, and their asymptotic properties are derived. Simulation studies show that the new estimators perform considerably better than those obtained previously.

8 Online Point Cloud Fusion for Quality Assurance of Additive Manufacturing

Chen Kan, University of Texas at Arlington, Arlington, TX

This study develops a new monitoring framework that leverages online point cloud sensing and modeling to detect and characterize geometric defects in additive manufacturing (AM). We evaluated and validated the developed framework in the fused filament fabrication process. Results have shown that the developed framework effectively captures and characterizes geometric defects of each printed layer and it has a great potential to be used for online quality assurance of AM.

9 Machine Learning-based Process Modeling for Superconductor Manufacturing

Mai Li, Shenglin Peng, Ying Lin, Qianmei Feng, Wenjiang Fu, University of Houston, Houston, TX, Contact: ylin58@uh.edu

With high efficiency and low energy loss, high-temperature superconductors (HTS) have demonstrated their profound applications in various capital-intensive systems, such as energy and transportation. However, the wide commercialization of these applications has not been achieved due to the difficulty in producing large-scale superconductor tapes with uniform performance. To help achieve the uniform performance of large-scale HTS tapes, this study employed machine learning techniques to model the uniformity of HTS tapes in terms of various summary statistics and identified critical process parameters that need to be closely monitored and controlled.

10 Cyberattack Detection in Multi-stage Manufacturing Systems

Dan Li, Clemson University, Greenville, SC

The digitization and automation in the era of Industry 4.0 has enabled more accurate and efficient manufacturing systems. However, these data intense manufacturing systems also have increased vulnerability to cyberattacks. In fact, manufacturing industry has become the top target of cyberattacks. This presentation focuses on data integrity cyberattacks that perturbs sensor and control data in multi-stage manufacturing systems. The objective is to develop a data-driven framework that helps address the challenges in real-time attack detection, identification, and localization.

Sunday, 2 PM–3:15 PM

SD11

CC - Room 111
Application of AI on Digital Platforms
General Session

Session Chair
Keran Zhao, University of Houston, Stafford, TX

Session Chair
Yumei He, Tulane University, Houston, TX

1 Content Creator Versus Brand Advertiser? The Effect of Inserting Advertisements in Videos on Influencers

Tengteng Ma[1], Yingda Lu[2], Yuheng Hu[2], Xi Chen[3], Yuxin Chen[4], [1]University of Illinois-Chicago, Chicago, IL, [2]University of Illinois-Chicago, Chicago, IL, [3]Zhejiang University, Zhejiang, China; [4]New York University - Shanghai, Shanghai, China.

Influencer advertising has become an indispensable component of online marketing due to the exponential growth of social influencers and their influence. We empirically examine the instantaneous and longer-term influence of inserting advertisements in videos on influencers' reputations. We further investigate the moderator effect when influencers demonstrate stronger endorsement by showing their faces during advertisements. Our result suggests that inserting advertisements have a negative impact on both instantaneous and longer-term viewer engagement; advertisements with influencers' face showing moderate the negative effect of advertisements on viewers' instantaneous response, while the different impact between advertisements with/out influencers showing their faces is not significant in the longer term.

2 Modeling Co-engagement Patterns in Brand Information Networks

Pankhuri Malhotra[1], Yaxin Cui[2], Keran Zhao[3], [1]University of Oklahoma, Norman, OK, [2]Northwestern University, Evanston, IL, [3]University of Houston, Stafford, TX, Contact: yaxincui2023@u.northwestern.edu

Information networks have become pervasive with the rise of electronic interactions, and their social and economic values have been explored by research across multiple domains. While most existing research focuses on descriptive and predictive aspects of information networks, statistical analysis of their "generative features" has been largely ignored. Our goal is to build large-scale brand information networks using Twitter followership data and to model the generative aspects of the observed network structures. We employ Exponential Random Graph Models to reveal a mix of network and brand characteristics that contribute to the formation of links between brands. Since links between brands arise from the aggregated interest patterns of Twitter users, the ERGM model reveals the characteristics associated with high user co-engagement patterns on social media.

3 The Role of Dislike Rating in Digital Media Platform: A Natural Experiment

Ahreum Kim, Yingda Lu, Tengteng Ma, Ali Tafti, University of Illinois at Chicago, Chicago, IL, Contact: akim239@uic.edu

The like and dislike buttons enable users to simply represent their opinions by rating with a single click of a button. This study investigates the effect of the change of the like and dislike rating features on user engagement in a digital media platform. We leverage a unique exogenous shock in which YouTube's recently made the number of dislike buttons hidden from the public. We study if the change of rating feature of YouTube affected the consumption and participation engagement behaviors, represented as the number of views, likes and comments and sentiment scores of the comments. We also look into if there are relative changes on such engagement behaviors compared to the viewership. We employ a DID method to understand the role of the dislike button in digital media platforms and provide managerial implications.

4 Recommending for a Three-sided Food Delivery Marketplace: A Multi-objective Hierarchical Approach

Yuyan Wang[1], Long Tao[2], Xian Xing Zhang[3], [1]Google Brain, Mountain View, CA, [2]Uber, San Francisco, CA, [3]Pinterest, San Francisco, CA, Contact: yuyan@alumni.princeton.edu

We develop MOHR, a general recommendation framework for three-sided food delivery platforms that optimizes multiple objectives for the eaters, restaurant partners and delivery partners, and addresses the challenge of hierarchical food recommendation where a recommendation item can be either a single restaurant or a group of similar restaurants. We combine machine learning with scalable multi-objective optimization to improve eater happiness, marketplace fairness and partner earnings, and design a probabilistic structural model for hierarchical recommendation which accounts for users' scrolling patterns. MOHR is launched globally at Uber Eats, one of the largest food delivery platforms in the world. It led to a significant increase in user conversion, retention and gross bookings, which combined translate to $1.5M weekly gain in revenue.

Sunday, 2 PM–3:15 PM

SD12

CC - Room 113

Incorporating AI into Healthcare Delivery

General Session

Session Chair

Ilgin Dogan, University of California, Berkeley, Berkeley, CA

Session Chair

Anil Aswani, UC Berkeley, Berkeley, CA

1 Multi-Armed Bandits for Repeated Principal-Agent Models with Unobserved Agent Rewards

Ilgin Dogan[1], Anil Aswani[2], Zuo-Jun Max Shen[3], [1]University of California, Berkeley, Berkeley, CA, [2]UC Berkeley, Berkeley, CA, [3]University of California Berkeley, Berkeley, CA, Contact: ilgindogan@berkeley.edu

We study designing data-driven incentives for repeated principal-agent games under adverse selection. The principal's problem comprises estimating the agent's unknown utility model with a finite set of actions and designing adaptive incentives to steer the agent's decisions by only watching their past actions. The agent trains a parallel learning algorithm on top of these incentives to maximize their expected utilities. This dynamic interaction brings a trade-off to the principal between learning the agent's model consistently *(exploration)* and maximizing their expected net reward *(exploitation)*. First, we propose a statistically consistent estimator for a non-parametric agent model. Then, we prove that the proposed bandit policy for the principal attains a low regret. Lastly, we show our framework is applicable to the incentive programs for medical adherence.

2 When Machines Will Take Over? Algorithms for Human-Machine Collaborative Decision Making in Healthcare

Mehmet Eren Ahsen[1], Mehmet U.S. Ayvaci[2], Radha Mookerjee[3], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]The University of Texas at Dallas, Richardson, TX, [3]University of Texas- Dallas, Richardson, TX, Contact: ahsen@illinois.edu

We study a hospital's optimal acquisition of single or multiple predictive AI algorithms for redesigning work to allocate tasks between humans and machines. We analytically characterize whether and when human-machine collaboration strategy is desirable against the machine-alone strategy or human-alone strategy. We use data from a recent crowdsourced deep-learning mammography challenge to demonstrate the value of the optimal use of AI in radiology. Our findings can inform efforts in reimagining work in the age of AI.

3 Incorporating Fairness into Incentive Design in Principal-Agent Models with Adverse Selection and Moral Hazard

Yoon Lee, Ilgin Dogan, Anil Aswani, Zuo-Jun Max Shen, UC Berkeley, Berkeley, CA, Contact: yllee@berkeley.edu

A limitation of existing approaches for incentive design in cyber-physical systems (CPS) is that they do not incorporate fairness. Fairness is crucial for incentives because improper design can harm people of certain classes (e.g., race or gender). In this study, we develop optimization problems for CPS that incorporate notions of fairness into the model. Here, we formulate quantitative notions of fairness in the settings of principal-agent models with adverse selection and moral hazard. We derive the policy structure for an optimal fair contract, discuss the intuition of this optimal design, and provide a numerical case study to show how fairness affects incentive design in CPS.

4 Power and Resistance to Medical AI in Treatment Planning Decisions

Eugene Chan[1], Ali Gohary[2], [1]Toronto Metropolitan University, Toronto, ON, Canada; [2]Monash University, Caulfield East, Australia. Contact: ehchan@outlook.com

Patient empowerment is a guiding principle in the healthcare literature. But, we posit that power increases resistance toward medical AI in the treatment planning stage of the healthcare journey. This is because power increases autonomy, and there is the misperception that medical AI takes away—or at least reduces—patient autonomy. We find support for our hypotheses in four studies. Our research contributes to an understanding of how power is relevant to healthcare customers and healthcare outcomes. Our work also investigates why people resist medical AI at the treatment stage of the healthcare journey beyond existing examinations at the diagnosis stage. Importantly, our work emphasizes the need to correct what patients know and believe about medical AI, in both the treatment planning as well as other stages of a patient's medical decision-making.

Sunday, 2 PM–3:15 PM

SD13

CC - Room 114

Search Optimization and Threat Analytics

General Session

Session Chair

Jeremy Eckhause, RAND Corporation, Arlington, VA

1 **Adversarial Deep Reinforcement Learning Enabled Threat Analytics Framework for Constrained Spatio-temporal Movement Intelligence Data**

Dinesh Sharma, Ankit Shah, Soumyadeep Hore, Jalal Ghadermazi, University of South Florida, Tampa, FL

Intelligence, surveillance, and reconnaissance (ISR) systems assist the defense and military in their tactical operations by gathering movement intelligence data for tracking adversaries and their activities in an area-of-interest. However, short track durations and discontinuous coverage results in significant spatio-temporal gaps in the collected data. As a result, the ISR analysts are unable to connect the incomplete set of movements to detect threats in the form of salient activities of the adversaries. To this regard, we develop a novel threat analytics framework that consists of a deep reinforcement learning-based adversarial agent and a machine learning-based threat detector to help analysts identify salient adversarial activities. The experiment results on simulated data show that the proposed framework identifies, on an average, 99% of the threats.

2 **On Solving Fortification Games: A Heuristically-Enhanced Exact Algorithm**

Ramy Abdallah[1], Elkafi Hassini[2], Wael El-Dakhakhni[3], [1]DeGroote School of Business, McMaster University, Hamilton, ON, Canada; [2]McMaster University, Hamilton, ON, Canada; [3]McMaster University, Hamilton, ON, Canada. Contact: ramy.fakhry@mcmaster.ca

This research examines a special class of tri-level optimization problems. In general terms, the three-level non-cooperative game, with perfect information. We propose a heuristically-enhanced exact algorithm for solving the aforementioned class of tri-level problems, where the most lower-level problem can be NP-hard. Moreover, we rely on heuristics gained from structural domain-knowledge of the application to enhance the formation of the feasible region. We demonstrate the effectiveness of our proposed solution on two applications; defending critical infrastructure, and the capacitated lot-sizing problem with a the capability of interdiction and fortification. We test our solution approaches on three electrical networks and randomly generated instances of lot-sizing problems.

3 **Uav Search Optimization for Recording Emerging Targets with Camouflaging Capabilities**

John Becker[1], Rajan Batta[2], Adil Baran Narin[3], [1]University at Buffalo, Buffalo, NY, [2]University at Buffalo (SUNY), Buffalo, NY, [3]University at Buffalo, Buffalo, NY, Contact: becker6@buffalo.edu

This extension to work in the emerging target information gathering domain introduces a camouflaging component to target behavior and also allows for multiple UAVs. Our extension considers that emerged targets will camouflage themselves and become undetectable after a period of time according to independent uniform distributions. We also investigate the impact of using multiple UAVs for this operation scenario. We generate routes using the Team Orienteering Problem with Time Windows, and evaluate these routes using a series of simulations. We perform a factorial experiment to study the impact of network structure, camouflaging distribution, and UAV service time on the number of targets detected. Additionally, a framework is developed for comparing routes by determining the probability that a route will out-perform the other route(s) being considered.

Sunday, 2 PM–3:15 PM

SD14

CC - Room 115

Large-scale Data Analytics for Transportation Systems (CAV + Shared Mobility)

Joint Session

Session Chair

Sean Z. Qian, Carnegie Mellon University, Pittsburgh, PA

Session Chair
Wei Ma, The Hong Kong Polytechnic University, Kowloon

1 **A Unified Network Equilibrium for E-hailing Platform Operation and Customer Mode Choice**
Xu Chen, Columbia University, New York, NY, Contact: xc2412@columbia.edu
This work aims to combine both economic and network user equilibrium for ride-sourcing and ride-pooling services, while endogenously optimizing the pooling sequence of two origin-destination (OD) pairs. With the growing popularity of ride-sourcing and ride-pooling services provided by transportation network companies (TNC), there lacks a theoretical network equilibrium model that accounts for the emerging ride-pooling service, due to the challenge in enumerating all possible combinations of OD pairs pooling and sequencing. This paper proposes a unified network equilibrium framework that integrates three modules, including travelers' modal choice between e-pooling and e-solo services, e-platforms' decision on vehicle dispatching and driver-passenger matching, and network congestion.

2 **Identifying Critical Transfer Zones to Coordinate Transit with On-demand Services Using Crowdsourced Trajectory Data**
Jiahua Qiu[1], Yue Jing[2], Wang Peng[1], Yujie Hu[1], Lili Du[1], [1]University of Florida, Gainesville, FL, [2]University of Florida, GAINESVILLE, FL, Contact: jq22@ufl.edu
This study develops a data-driven approach for identifying critical transfer zones in the city to facilitate the coordination of transit and on-demand services. First, we mesh the trajectory data with an optimal 3D grid. Built upon that, we study the cube trajectory density of each mode and present the results by heatmaps. After that, we explore two patterns on heatmaps through clustering algorithms: the ridesharing swarm (RS) zones and the "sandwich pattern" (SP) zones. Our numerical analysis confirms that these RS zones are well correlated to the promising areas for integrating transit and on-demand services; the SP zones help discover first/last mile (FLM) gaps. Last, we adopt ConvLSTM network to predict the FLM gaps so that adaptive services can be planned. A case study based on the field data of Chengdu city confirms the effectiveness of our analysis approach.

3 **Using Connected Automated Vehicles as Mobile Controllers in Single-lane Roundabouts**
Veronica Diaz Pacheco[1], Ali Hajbabaie[2], Ramin Niroumand[2], [1]University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico; [2]North Carolina State University, Raleigh, NC
This study utilizes connected automated vehicles (CAV) as mobile controllers to improve traffic operations in single-lane roundabouts. CAVs negotiate the right of way with each other and control the flow of vehicles into the roundabout to improve traffic operations and safety. We have formulated this concept as a mixed-integer non-linear program and have utilized alternating direction method of multipliers to find near-optimal solutions. The numerical results showed that CAVs improved both traffic operations and safety significantly.

Sunday, 2 PM–3:15 PM

SD15

CC - Room 120
Health Policy Modeling and Analysis
General Session

Session Chair
Jagpreet Chhatwal, Harvard Medical School, Mass General Hospital, Boston, MA

Session Chair
Ali Hjaar, MGH Institute for Technology Assessment / Harvard Medical School, Boston, MA

1 **A Model-based Study of Preventions and Outbreak Response Options to Eliminate Circulating Vaccine-derived Poliovirus Type 2**
Yuming Sun[1], Pinar Keskinocak[1], Stephanie Kovacs[2], Lauren N. Steimle[1], [1]ISyE Georgia Tech, Atlanta, GA, [2]Centers for Disease Control and Prevention, Atlanta, GA, Contact: ysun608@gatech.edu
The Global Polio Eradication Initiative coordinated global cessation of type 2 containing oral poliovirus vaccine (OPV) in 2016, following the eradication of wild poliovirus type 2. The polio program continues to respond to circulating vaccine-derived poliovirus type 2 (cVDPV2) outbreaks through supplementary immunization activities using monovalent OPV type 2 (mOPV2). However, the attenuated live virus in mOPV2 can, in rare occurrence, mutate to regain neurovirulence and cause cVDVP2 outbreaks in areas with low population immunity. In our study, we build a compartmental model to capture dynamics of poliovirus transmission involving OPV virus reversion and evaluate different preventions and outbreak response options to achieve a polio free world. We focus on Northern Nigeria in our study given its ongoing cVDPV2 transmission.

2 **At What Prevalence of Resistance Should Empiric Antibiotic Treatment for Gonorrhea Change? A Cost-effectiveness Analysis**

Xuecheng Yin[1], Minttu Rönn[2], Song Li[3], Yue Yuan[4], Thomas L. Gift[5], Joshua A. Salomon[6], Yonatan H. Grad[7], Reza Yaesoubi[1], [1]Yale School of Public Health, New Haven, CT, [2]Harvard T.H. Chan School of Public Health, Boston, MA, [3]Zhejiang University, Hangzhou, China; [4]Altfest Personal Wealth Management, New York, NY, [5]Centers for Disease Control and Prevention, Atlanta, GA, [6]Stanford University School of Medicine, Palo Alto, CA, [7]Harvard T. H. Chan School of Public Health, Boston, MA, Contact: xuecheng.yin@yale.edu

Common diagnostic tests for gonorrhea do not provide information about the susceptibility of infection to antibiotics. Guidelines recommend changing antibiotics used for empiric therapy once resistance prevalence exceeds 5%. However, the basis for this threshold is not clear. We developed a model of gonorrhea transmission to project gonorrhea-associated costs and loss in quality-adjust life-years (QALYs) under different switch thresholds among men who have sex with men in the US. Using cost-effectiveness analysis, we identify hypothetical switch thresholds for varying values of willingness-to-pay per QALY and showed the health and economic burden of gonorrhea and the effective lifespan of antibiotics depends on the selected threshold.

3 **Evaluating Deceased-donor Kidney Allocation Policies via a Discrete-event Simulation Model**

Kirthana Hampapur, Pinar Keskinocak, David Goldsman, Georgia Tech, Atlanta, GA, Contact: kirthana@gatech.edu

The allocation of organs for transplantation is a complex process that requires policy makers to consider many factors, including the efficiency of the process and equity among the candidates waiting to receive a life-saving transplant. In the United States, there is a large gap between the supply and demand of organs, especially in certain geographical regions. Because of this disparity, a candidate's place of listing is among the most-significant factors impacting their timely access to transplant. Thus, there is an urgent need to develop and evaluate allocation policies considering equity and health outcomes. We developed a discrete-event simulation model that mimics the current deceased-donor kidney allocation system. Using the model, we quantified the differences among different allocation policies by comparing their system- and candidate-level outcomes.

4 **Optimal Vaccination Campaigns Under Opinion and Physical Networks**

Serin Lee, Shan Liu, Zelda B. Zabinsky, University of Washington, Seattle, WA, Contact: serinlee@uw.edu

As the anti-vaccination movement has increased significantly, governments are trying to prevent the spread of dis- and misinformation about vaccines. Using coupled dynamics of disease transmission in physical networks and opinion propagation in virtual networks, we identify optimal vaccination campaigns that minimize the burden of infectious diseases. We use a networked compartmental model consisting of several groups, representing opinion characteristics. We identify an optimal policy regarding vaccination campaigns that yields lowest deaths. The model is sensitive to vaccine effectiveness, size of anti-vaccination population, opinion and physical network structure, and power of persuasion.

Sunday, 2 PM–3:15 PM

SD16

CC - Room 121

Operations Research for Medical Decision Making

General Session

Session Chair

Lauren N. Steimle, ISyE Georgia Tech, Atlanta, GA

1 **Collaborative Simulation Modeling to Estimate the Impact of the Covid-19 Pandemic on Breast Cancer Mortality in the U.S.**

Oguzhan Alagoz[1], Kathryn Lowry[2], Allison Kurian[3], Jeanne Mandelblatt[4], Mehmet A. Ergun[5], Hui Huang[6], Sandra Lee[7], Clyde Schechter[8], Anna Tosteson[9], Diana Miglioretti[10], Amy Trentham-Dietz[1], Sarah Nyante[11], Karla Kerlikowske[12], Brian Sprague[13], Natasha K. Stout[14], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Washington, Seattle, WA, [3]Stanford University, Palo Alto, CA, [4]Georgetown University, Washington, DC, [5]Istanbul Technical University, Istanbul, Turkey; [6]Dana Farber Cancer Institute, Boston, MA, [7]Dana-Farber Cancer Institute and Harvard Medical School, Boston, MA, [8]Albert Einstein College of Medicine, Bronx, NY, [9]Dartmouth College, Hanover, NH, [10]University of California at Davis, Davis, CA, [11]University of North Carolina at Chapel Hill, Chapel Hill, NC, [12]University of California at San Francisco, San Francisco, CA, [13]University of Vermont, Burlington, VT, [14]Harvard Medical School/Harvard Pilgrim Health Care Institute, Boston, MA, Contact: alagoz@engr.wisc.edu

The coronavirus disease 2019 (COVID-19) pandemic has disrupted breast cancer control through short-term declines in screening and delays in diagnosis and treatments. We utilized three established National Cancer Institute's Cancer

Intervention and Surveillance Modeling Network (CISNET) breast cancer models to estimate the impact of COVID-19 on future breast cancer mortality between 2020 and 2030. The models considered reductions in mammography screening use, delays in symptomatic cancer diagnosis, and reduced use of chemotherapy for women with early-stage disease for the first 6 months of the pandemic with return to prepandemic patterns after that time. We also conducted sensitivity analyses to determine the effect of key model parameters, including the duration of the pandemic impact, on our results.

2 Unsupervised Clustering Analysis Using Non-Surgical Care and Surgical Care Features for Trauma/Non-Trauma Centers

Xiaonan Sun, Shan Liu, Charlie Mock, Monica Vavilala, Eileen Bulger, Rebecca Maine, University of Washington, Seattle, WA, Contact: xnsun@uw.edu

Trauma center (TC) designation standards establish the key resources and processes for each TC level to ensure injured patients receive appropriate care. These standards do not proscribe which injuries or procedures each TC should do, and little information exists about this variation across TCs in practice. We performed 3 sets of unsupervised clustering algorithms to a statewide hospital discharge database to determine whether different hospital features including surgical and non-surgical care for trauma and non-trauma patients can distinguish TCs level. The clusters only partially aligned with the TC levels, suggesting unsupervised machine learning could provide insight into the key features that can help optimal designate TC levels.

3 Machine Learning to Estimate Risk of Adverse Maternal Outcomes in a Cohort of Nulliparous Women

Lauren N. Steimle[1], Meghan Meredith[2], [1]Georgia Tech ISyE, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA

Racial/ethnic minority and rural populations are disproportionately affected by comorbid conditions and preventable adverse maternal outcomes. We present risk prediction models for adverse maternal outcomes that incorporate interactions between comorbid conditions. We leverage machine learning methods and consider clinical, lifestyle, and demographic information as potential risk factors to better understand their associations with adverse maternal outcomes. We discuss the implications for clinical practice.

4 Quickest Change Detection and Sequential Hypothesis Testing for Statistically Periodic Data

Taposh Banerjee, University of Pittsburgh, Pittsburgh, PA, Contact: taposh.banerjee@pitt.edu

In many anomaly detection problems in science and engineering, observed data often exhibit nonstationary statistical behavior that is repeated after a fixed amount of time. A new class of stochastic processes called independent and periodically identically distributed (i.p.i.d.) processes is introduced to model such data. Theory and algorithms are developed for sequential analysis problems in i.p.i.d. processes. In the optimal algorithms for these problems, a sequence of statistics is computed over time and an alarm is raised the first time the sequence touches a periodic sequence of thresholds. It is also shown that single-threshold algorithms are asymptotically optimal for both problems as the error rate goes to zero.

Sunday, 2 PM–3:15 PM

SD17

CC - Room 122
Panel: Finding Research Success in the Medical Community
Panel Session

1 HAS Panel: Finding Research Success in the Medical Community

Christopher Sun, Massachusetts Institute of Technology, Cambridge, MA

With the increasing complexity of healthcare problems, amounts of health data, and stakeholder openness to data-driven decision making, there is both a need and opportunity to innovate in healthcare through analytics. But given the multidisciplinary nature of this field and the dependency on collaborators and medical expertise, how does one navigate conducting research in this area? In this session, panelists will discuss how those in the OR/OM community can establish health-related research programs, reach a broader medical audience with their work, and find success within the medical community. Time will be provided for questions from the audience.

Session Chair

Christopher Sun, Massachusetts Institute of Technology, Cambridge, MA

2 Panelist
Gian-Gabriel P. Garcia, Georgia Institute of Technology, Atlanta, GA

3 Panelist
Joel Goh, NUS Business School, Singapore, Singapore.

4 Panelist
Hummy Song, University of Pennsylvania, Philadelphia, PA, Contact: hummy@wharton.upenn.edu

5 Panelist
Nikolaos Trichakis, MIT, Cambridge, MA

Sunday, 2 PM–3:15 PM

SD18

CC - Room 123
Meet HC Dept Editors
Panel Session

Session Chair
Serhan Ziya, University of North Carolina, Chapel Hill, NC

1 Meet Health Care Department Editors
Serhan Ziya, University of North Carolina, Chapel Hill, NC, Contact: ziya@unc.edu
In this panel session, healthcare department editors or editors-in-chief will provide update on their journals, discuss the types of papers their journals particularly seek, and answer questions from the audience.

2 Panelist
Mariel Sofia Lavieri, University of Michigan, Ann Arbor, MI

3 Panelist
Oguzhan Alagoz, University of Wisconsin-Madison, Madison, WI

4 Panelist
Paul Brooks, Virginia Commonwealth University, Richmond, VA

5 Panelist
Carri Chan, Columbia Business School, New York, NY

6 Panelist
Greg Zaric, Western University, London, ON, Canada.

7 Panelist
Diwakar Gupta, University of Texas, Austin, TX

Sunday, 2 PM–3:15 PM

SD19

CC - Room 124
Healthcare
Contributed Session

Session Chair
Yijie Chen, University of Arizona, Tucson, AZ

1 Smart Product-service Systems in the Healthcare Industry
Yeneneh Negash, Asia University, Taichung, Taiwan.
Conditions regarding the adoption of smart product-service systems (PSS) remain unclear, requiring the identification of driving attributes & the attributes' interrelationship for its implementation in the health care industry. Data were collected from healthcare industry practitioners. Exploratory factor analysis determines the attributes' structure & validity. In addition, 17 practitioners who treat a patient with chronic conditions are interviewed to understand the interrelationship among the attributes. The fuzzy decision-making trial & evaluation laboratory determines the interrelationship of aspects and criteria. 24 criteria are found to be valid drivers of smart PSS adoption. Intelligent connected products & stakeholder communication are the causal attributes of improving digital health services adoption & providing alternative user schemes.

2 Information Discloser in the Context of Smart IoT: A Systematic Literature Review and Future Research Agenda
M A Shariful Amin[1], Abhijeet Kumar[2], Gayle Prybutok[3], Victor R. Prybutok[3], Vess Johnson@unt.edu[1], [1]University of North Texas, Denton, TX, [2]University of North Texas, Denton, TX, [3]University of North Texas, Denton, TX
This research aims to study the privacy information disclosure in the context of smart IoT: a PRISMA-style systematic literature review and future research agenda. Only peer-reviewed scholarly publications were analyzed. The study reveals an exponential growth in the number of articles published in the last decade. A wide variety of information discloser related publications and research design were indicating a promising future research potentiality. The paper also highlights key insights for the prime research contexts and identifies research gaps and future research directions.

3 Optimal Timing to Initiate Renal Replacement Therapy Among Critically Ill Patients

Han Zhou, Jingui Xie, Technische Universität München, Heilbronn, Germany. Contact: han.zhou@tum.de

Whether and when to initiate renal replacement therapy (RRT) is a controversial question in critical care. Benefits of delaying therapy include enabling a substantial number of patients to recover from acute kidney injury without undergoing RRT, and avoiding exposure to an unnecessary therapy with its negative side effects and costs. On the other hand, early therapy could improve electrolyte and fluid balance, enhance the removal of toxins, and thereby prevent potential life-threatening harm. Thus, there is a trade-off between short-term benefits and long-term recovery risks. Aiming to identify a treatment policy to minimize the mortality of a patient, we develop Markov decision processes. We prove conditions that establish the structural properties of the optimal solution. To estimate model parameters, we utilize instrumental variables and prediction methods.

4 Sensor-based Co2 Monitoring System and Simulation for Human Respiratory

Yijie Chen, Young-Jun Son, University of Arizona, Tucson, AZ, Contact: yijiechen@email.arizona.edu

Exhaled CO2 accumulates near the face during regular human breathing, forming a bubble-shape CO2 zone. And, the CO2 bubble may impair human cognitive abilities as the CO2 concentration increases. In this study, we designed a non-invasive sensor-based system to monitor CO2 concentration around human face under different situations, and developed a continuous time CO2 dispersion model based on discrete CO2 sensory data. In addition, we integrated the CO2 distribution model with a time-series-based dynamic model of the human breath cycle to better understand the fluctuation of CO2 bubble with self-adaption in the human body. The integrated model can be utilized to predict human physiological responses and cognitive performance under varying CO2 levels, as well as make recommendations for optimal ventilation scenarios.

Sunday, 2 PM–3:15 PM

SD20

CC - Room 125

Decision Support for Executives

General Session

Session Chair

Jen McIntosh, Department of Defense

1 The Importance of Promoting a Common Frame of Reference to Ensure Effective Decision-making Between Information Technology and Business Organizations

Efrain Rodriguez, Department of Defense, Fort George G. Meade, MD, Contact: frao74@gmail.com

At the Department of Defense, we see Information Technology (IT) organizations as key mission enablers, allowing Business/Mission units to effectively execute their chartered functions. Often times, IT and Business/Mission Organizations make Operations and Tactical decision unilaterally, driven by their own priorities and budget constraints, leading to second/third order unintended consequences, impacting how each organization operates in support of time sensitive/mission critical activities. This presentation will discuss the benefits of promoting the creation of a common frame of reference framework, establishing a common ground for both organizations to gauge mission cross-organization impacts, promoting effective communication between IT and Business/Mission, allowing for proper activity orchestration.

2 Starting by Stopping: Perspectives on Getting Unstuck

Lincoln J. Chandler, Chandler Decision Services, Chicago, IL

In this talk, I will share a collection of tools and tactics that have helped my clients become unstuck when working with, and acting on, data. Over time, these tools have helped clients across the private, public, and nonprofit sectors:
*Cultivate the will to take action
*Improve their ability to collaborate across various groups of stakeholders
*Develop a shared, structured approach to decision making
*Gain confidence in connecting strategic goals to daily activities
Using examples inspired by one of my longest client relationships, I'll share my perspective on the challenges we faced and the lessons learned along the way.

3 Practical Recommendations for Presenting Analytics to Executives

Brian L. Morgan, US Navy, Monterey, CA

Senior executives must often synthesize information from a multitude of sources prior to making a decision. The ability to present analytic work to executive-level decision makers is a necessary soft skill for every operations research professional. The panelist introduces a number of practical recommendations, applicable in a wide variety of government and business environments, that are motivated from over five years of military service performing analysis on the Navy Headquarters staff in the Pentagon.

4 Anatomy of a Decision: Guiding NSA's Covid-19 Response with Data Analysis

Kyle Hovey, Raleigh, NC

COVID-19 highlighted the importance of quick, data-driven decision making to respond to rapidly changing conditions. Decision makers required actionable, sustainable, and straightforward metrics they trusted to affect positive change. These types of metrics desired by leaders are often at odds with the complex nuances of real systems and the difficulty of analyzing messy or incomplete datasets. We discuss the data analysis process that guided NSA's COVID-19 response and the necessary considerations when building metrics to bridge the gap between data analyst and decision makers.

5 Decide Better - How An Entrepreneur and Educator Embraced Decision Science

Matthew Brady, University of Colorado Boulder, Boulder, CO, Contact: matthew.brady@colorado.edu

How do you decide who to hire, when a phase-gate has been achieved, or which project to resource next? Chances are, you rely on intuition... which could otherwise be known as habits, biases, and, group-think. What if you could elevate your decision-making... to decide using information. To decide better?

This presentation will engage the audience with real examples of how leading companies are using structured Decision Science techniques, and how individuals, teams, and entire organizations can be empowered to use these techniques. Further, demonstrations of how Behavioral Science can be incorporated to allow for qualitative aspects like post-mortems (and pre-mortems!).

Attendees will leave informed on these innovative uses of analytics to support decision-making, and equipped with tools and examples to see the world a little differently.

Sunday, 2 PM–3:15 PM

SD21

CC - Room 126

Decision Making with Societal Impact

General Session

Session Chair

Nicolo Bertani, Universidade Católica Portuguesa, Fontainebleau, France.

1 Ambiguity in Voting

Ilke Aydogan[1], Yu Gao[2], Ning Liu[3], Uyanga Turmunkh[4], [1]IESEG School of Management, Lille, France; [2]Guanghua School of Management, Beijing, China; [3]Beihang University, Beijing, China; [4]IESEG School of Management, Lille, France. Contact: u.turmunkh@ieseg.fr

Riker and Ordershook (1968) proposed that voters' beliefs about the closeness of an election outcome is a key determinant of their decisions to participate in the election. To date, however, direct tests of the determinants of voting behavior have found little support for the influence of beliefs, finding instead that voting behavior is mostly driven by factors other than beliefs, e.g., the perceived level of importance attached to the election outcome. This is puzzling, because presumably the importance attached to an election outcome ought to be moderated by whether or not people consider their votes to have any impact on bringing about the outcome in the first place. In this paper, we hypothesize that beliefs about closeness, like most beliefs about real-world events, cannot easily be probabilized. Ambiguity (unknown probabilities) plays a role.

2 Attribute Ambiguity and Justification in Environmental Decision Making

Nicolo Bertani[1], Enrico Diecidue[2], Anouk Festjens[3], [1]Universidade Católica Portuguesa, Lisbon, Portugal; [2]INSEAD, Fontainebleau, France; [3]Maastricht University, Maastricht, Netherlands.

The environmental consequences of our actions are plagued by uncertainty: their severity, likelihood, and time horizon are deeply ambiguous. We devise a lab experiment to study and compare attitude towards risk and towards ambiguity when choices entail real environmental consequences. We explore the differential role of attribute ambiguity, as well as the effect of accountability on environmental choices. We operationalize real environmental incentive 1) by offering the participants the possibility to nullify CO_2 certificates and 2) by asking them to justify their choices. Understanding environmental choices in the face of uncertain information is key to foster more conscious environmental behavior.

3 Overestimation of Foregone Alternatives as a Hidden Source of Regret

Johannes Müller-Trede[1], Daniel Feiler[2], [1]IESE Business School, Barcelona, Spain; [2]Dartmouth College, Tuck School, Hanover, NH, Contact: jmuller@iese.edu

Past research has established that observing the outcome of the foregone alternative is an important driver of feeling regret. We predict and empirically demonstrate a seemingly opposite result: Decision-makers are more likely to experience regret when they do *not* observe the outcome of a foregone alternative than when it is revealed. Our prediction draws on the observation that when there are many alternatives to choose from under uncertainty, the perceived attractiveness of the almost-chosen alternative tends to exceed its reality. In four pre-registered studies, we find that participants predictably overestimate the foregone path, and that this overestimation causes undue regret.

4 **Big Moves: Understanding Migration and Relocation Dynamics**

Isabella Loaiza, MIT, Cambridge, MA, Contact: isal@mit.edu

The challenge of making relocation decisions is fertile ground to pose a new direction in the quest for extended human intelligence. This paper explores the impact of social connectivity, job history, and homphily on the decision to relocate and migrate, and suggests ways in which these insights can be used to build systems to aid in relocation decisions.These systems seek to foster social learning between community members to improve the match between migrants and their potential new communities so that both can reap the benefits of the move. This approach stands in contrast to top-down approaches that use algorithms to match individuals and places, as is the case for some refugee relocation programs.

Sunday, 2 PM–3:15 PM

SD22

CC - Room 127

Role of Diversity in Operations Management

General Session

Session Chair

Hessam Bavafa, Wisconsin School of Business, Madison, WI

Session Chair

Vanitha Virudachalam, Gies College of Business, UIUC, Champaign, IL

1 **Why Harry Won't Meet Sally: Gender Disparity in Online Learning Forums**

Helen Zhihan Wang, Jun Li, Andrew Wu, Ross School of Business, University of Michigan, Ann Arbor, MI, Contact: helwang@umich.edu

Education technology innovations such as Massive Open Online Courses (MOOCs) platforms could potentially enable a more inclusive learning environment by delivering education to traditionally-disadvantaged learners. However, inclusivity does not necessarily translate into equal treatment on the platform. Utilizing a large-scale, interaction-level dataset on 174 courses on Coursera, we uncover a noted gender disparity in learners' interaction with the teaching staff. Also, we show that receiving staff response in forum leads to significant improvement in course passing rate. Our results provide direct managerial implications to platform managers and course providers. A more equal and inclusive online learning environment could be achieved with gender-sensitive platform design, which could potentially be achieved through simple user interface changes.

2 **Female Representation at Different Organizational Levels and Firm Environmental Footprint**

Priyank Arora[1], Vivek Astvansh[2], Zach Sheffler[3], [1]University of Massachusetts Amherst, Easthampton, MA, [2]Kelley School of Business, Indiana University Bloomington, Bloomington, IN, [3]University of Massachusetts Amherst, Amherst, MA, Contact: zsheffler@isenberg.umass.edu

Research has documented that female representation at firm leadership levels impacts firm financial performance. Recent research has extended these insights to relate female representation to firm's supply chain and sustainability performance. We add to this evidence by examining whether and when female representation at multiple organizational levels impacts a firm's environmental footprint. Our specification includes firm and year fixed effects with a three-stage least squares method to control for the endogeneity of female representation. Results suggest that female representation on the TMT lowers environmental footprint. Interestingly, female representation on the board weakens this effect.

3 **The Impact of the Gig-economy on Financial Hardship Among Low-income Families**

Kaitlin Daniels, Washington University in St. Louis, Olin Business School, Saint Louis, MO

The gig-economy offers workers discretion over their work schedules at the expense of traditional worker guarantees. We study the impact of this new work arrangement on the financial health of workers. We find a differential impact across workers with different earning potential outside of gig work.

4 **Going the Distance: Commute to the Capitol, Workplace Flexibility, and Female Participation in Politics**

Vanitha Virudachalam[1], Dawson Kaaua[2], [1]Gies College of Business, UIUC, Champaign, IL, [2]Georgetown University,

Washington, D.C., DC
Women have been shown to prefer jobs with a better work-life balance across many fields. Given that serving as a state political representative requires a significant amount of travel between one's home district and the state capitol, this suggests that long commute times may reduce the number of women that seek political office in the United States. We investigate whether this is true and, if so, potential policies to mitigate this effect. Leveraging differences in distance to the state capitol among legislative districts, we conduct a two-stage least squares analysis to show that state legislative districts with a higher percentage of female candidates tend to be closer to the state capitol. Then, using a conjoint survey experiment, we find that paid parental leave is the policy most likely to temper the differential effect of a longer commute time on women entering politics.

Sunday, 2 PM–3:15 PM

SD23

CC - Room 128
Editorial
Panel Session

Session Chair
Justin J. Boutilier, University of Wisconsin - Madison, Fitchburg, WI

Session Chair
Mahyar Eftekhar, Arizona State University, Tempe, AZ

1 **Moderator**
Justin J. Boutilier, University of Wisconsin - Madison, Madison, WI
This panel session will host four editors from departments or areas that encompass public sector operations research / operations management from the journals Management Science, Operations Research, Manufacturing and Service Operations Management, Transportation Science, and Production and Operations Management. During the first portion of the session, the moderators will facilitate a discussion where the panelists will discuss their views on public sector research and share their insights about how to publish public sector research in their journals. During the second portion, we will open the floor for audience Q&A.

2 **Panelist**
Subodha Kumar, Fox School of Business, Temple University, Philadelphia, PA

3 **Panelist**
Ozlem Ergun, Northeastern University, Boston, MA

4 **Panelist**
Karen Smilowitz, Northwestern University, Evanston, IL

5 **Panelist**
Jayashankar M. Swaminathan, University of North Carolina Chapel Hill, Chapel Hill, NC

Sunday, 2 PM–3:15 PM

SD24

CC - Wabash 1
Artelys Corp / Frontline Systems, Inc
Technology Tutorial

1 **Nonlinear Optimization Using Artelys Knitro**
Richard Waltz, Artelys, Los Angeles, CA, Contact: richard.waltz@artelys.com
Nonlinear optimization is used in many applications in a broad range of industries such as economy, finance, energy, health, 3D modeling, and marketing. With four algorithms and great configuration capabilities, Artelys Knitro is the leading solver for nonlinear optimization and demonstrates high performance for large scale problems. This session will introduce you to Artelys Knitro, its key features and modeling capabilities, with a particular emphasis on the latest major improvements including recent advances in solving mixed-integer nonlinear optimization problems. We will also provide benchmarks highlighting the power of Knitro to efficiently solve large-scale, nonlinear models with hundreds of thousands of variables and constraints.

Sunday, 2 PM–3:15 PM

SD26

CC - Wabash 3
Urban Mobility and Logistics: Responsiveness and Sustainability
Joint Session

Session Chair
Sheng Liu, University of Toronto, Toronto, ON, Canada.

1 Prescriptive PCA: Dimensionality Reduction for Two-stage Stochastic Optimization

Ho-Yin Mak[1], Long He[2], [1]University of Oxford, Oxford, United Kingdom; [2]George Washington University, Washington

We consider a prescriptive analytics context that involves a learning phase of learning a low-dimensional representation of a set of high-dimensional data, and an optimization phase of solving a stochastic program with random parameters specified by said representation. We develop a prescriptive dimensionality reduction framework that aims to minimize the degree of suboptimality in the optimization phase. We show that prescriptive dimensionality reduction can be performed via solving a distributionally-robust optimization problem, which admits a semidefinite programming relaxation. Computational experiments based on a warehouse transshipment problem and a vehicle repositioning problem show that our approach significantly outperform principal component analysis with real and synthetic datasets.

2 Activated Benders Decomposition for Paratransit Workforce Scheduling Under Cancellation Uncertainty

Kayla Spring Cummings[1], Alexandre Jacquillat[2], Vikrant Vaze[3], [1]Massachusetts Institute of Technology, Allston, MA, [2]MIT Sloan School of Management, Cambridge, MA, [3]Dartmouth College, Hanover, NH, Contact: kaylac@mit.edu

Paratransit operators receive advance reservations but also face trip cancellations and driver no-shows. Our 2-stage stochastic program optimizes driver itineraries in reservation-based systems while capturing routing adjustments following disruptions. We incorporate a shareability network representation from Santi *et al.* (2014) to tightly embed 2nd-stage routing operations at the cost of exponential size. Our exact, generalizable *Activated Benders Decomposition (ABD)* algorithm exploits linking relationships between 1st and 2nd stages to construct global optimality cuts from restricted subproblems with a primal-dual approach. Strengthened *locally Pareto-optimal cuts* are adapted from Magnanti and Wong (1981). We use data from a major provider to show that ABD scales and outperforms many benchmarks. Our model enables flexible, robust driver shifts.

3 A Fast Column-generation-based Heuristic for Electric Bus Scheduling

Guy Desaulniers[1], Juliette Gerbaux[1], Quentin Cappart[2], [1]Polytechnique Montreal & Gerad, Montreal, QC, Canada; [2]Polytechnique Montréal, Montreal, QC, Canada. Contact: guy.desaulniers@gerad.ca

Planning the operations of electric vehicles is challenging as it includes battery recharging operations during the day. In this paper, we consider the multi-depot electric vehicle scheduling problem (MDEVSP) with a piecewise-linear recharging function and capacitated recharging stations that consists in determining the schedules of electric buses to cover at minimum cost a daily set of timetabled bus trips. We develop an iterative heuristic that solves at each iteration a reduced MDEVSP by column generation. The reduction is obtained by selecting a small subset of arcs to consider in the network for generating bus schedules. This selection is based on weights assigned to the arcs that are initially set using a machine learning model and, then, updated at each iteration according to the current solution and additional information collected during the solution process.

4 The Multi-depot Electric Vehicle Scheduling Problem with Stochastic Travel Time and Energy Consumption

Léa Ricard[1], Guy Desaulniers[2], Andrea Lodi[3], Louis-Martin Rousseau[4], [1]Universite de Montreal, Montreal, QC, Canada; [2]Polytechnique Montreal & Gerad, Montreal, QC, Canada; [3]Cornell Tech, New York, NY, [4]Polytechnique Montreal, Montreal, QC, Canada. Contact: lea.ricard@umontreal.ca

Zero emission policies in urban centers are forcing many transit agencies to convert their fleets to electric buses. The shorter driving range and the need for special charging infrastructure, among other things, must be taken into account when planning and scheduling electric buses. This talk presents the Multi-Depot Electric Vehicle Scheduling Problem with Stochastic Travel Time and Energy Consumption (S-MDEVSP). Vehicles are allowed to be partially recharged and a non-linear charging function is considered. Our model takes advantage of the full information on the current state of charge that is available in operation by allowing planned charge time to be extended when energy consumption deviations are observed. We formulate the S-MDEVSP as an integer program and a column-generation-based heuristic is provided to solve real-life instances.

Sunday, 2 PM–3:15 PM

SD27

CC - Room 138

Designing More Sustainable Supply Chains

General Session

Session Chair
Robert Swinney, Duke University, Durham, NC

Session Chair
Ali Kaan Tuna, Duke University, Durham, NC

1 Waste Not Want Not? The Environmental Implications of Quick Response and Upcycling
Xiaoyang Long[1], Luyi Gui[2], [1]University of Wisconsin-Madison, Madison, WI, [2]The Paul Merage School of Business, UC Irvine, Irvine, CA, Contact: luyig@uci.edu
Overproduction is often cited as the fashion industry's biggest environmental issue, as textile production is notoriously resource intensive and pollutive, and much of the textile produced may end up as "deadstock" fabric or finished products that do not sell. In this paper, we study two major approaches commonly adopted by the fashion industry to address this issue: quick response, whereby finished product inventory is replenished on demand, and upcycling, whereby deadstock fabric is reused to make new clothes.

2 Ride-hailing Platforms in the Presence of Dual Distribution Channels
Jianing Li, Gokce Esenduran, Purdue University, West Lafayette, IN, Contact: li3193@purdue.edu
We consider a dual-distribution channel in the auto industry where a manufacturer sells cars to a dealer and a rental agency. With the ride-hailing platform's entrance, some customers may rely on using the platform instead of buying/renting a car, while some others who buy a car may choose to provide rides on the platform. In this paper, constructing a detailed consumer utility model, we identify how the dealer and rental agency decisions, and thus the total ownership change after the platform's entrance. Our results show that when the unit manufacturing cost is sufficiently high, the number of rental cars decreases while the number of cars sold increases leading to an increase in the overall ownership and thus the environmental impact.

3 Circular Diffusion: The Missing Link in Circular System Design
Clara Carrera[1], Atalay Atasu[1], Luk N. Van Wassenhove[2], [1]INSEAD, Fontainebleau, France; [2]INSEAD, Fontainebleau Cedex, France. Contact: clara.carrera@insead.edu
The transition into a circular economy entails non-ownership-based business models (e.g., leasing) and new product designs (e.g., modular product architectures). In this paper, we leverage a new product diffusion approach to formally model the forward and reverse flows in such new systems. In our model, forward flows capture new leases and replacements, and reverse flows capture end-of lease returns (in reusable form or to be disposed of). The formal characterization of these flows allows us to demonstrate that the recycling needs in these systems exhibit uneven multi-peak volumes over time and that remanufacturing needs exhibiting relatively stable flows over a short time span. Motivated by an industry partner's practice, we further analyze how a firm's optimal lease duration and new product introduction timing choices influence these flows and disposal needs.

4 Are Fast Supply Chains Sustainable?
Ali Kaan Tuna, Robert Swinney, Duke University, Durham, NC, Contact: alikaan.tuna@duke.edu
We consider the environmental implications of a critical decision made by many firms: whether to adopt a responsive supply chain (prioritizing speed) or an efficient supply chain (prioritizing cost). We analyze a model wherein responsiveness increases marginal costs, decreases leadtimes, and changes the per-unit environmental impact of production. We distinguish between responsive nearshore and offshore supply chains: in the former, responsiveness is achieved by reducing the physical distance between source and destination, while in the latter, it is achieved by using expedited production and transportation methods. We observe that, regardless of how it is achieved, firms will likely have the greatest incentive to invest in responsiveness when it is most detrimental to the environment. We also discuss the implications of our observations for policymakers as well.

Sunday, 2 PM–3:15 PM

SD28

CC - Room 139
Data Driven Operations: Balancing Privacy and Efficiency
General Session

Session Chair
Karan Girotra, Cornell Tech/Johnson Cornell University, New York, NY

Session Chair
Lorraine Yuan, Cornell Tech and Johnson College of Business, New York, NY

1 Privacy, Service-levels and Firm Profits in the (Customer-)data Driven News Vendor
Lorraine Yuan[1], Elena Belavina[2], Karan Girotra[1], [1]Cornell Tech/Johnson Cornell University, New York, NY, [2]Cornell

University, New York, NY, Contact: hy557@cornell.edu

The use of customer data (demographics, past purchases, etc.) for inventory management can improve firm profits and customer service levels. Yet, large-scale use of such data in production environments increases the risks of breaching customers' privacy. In this study, we adapt state of the art data-driven algorithms for Newsvendor decisions to prescribe privacy-preserving ordering quantities. We derive bounds on the tradeoff between firm profitability, consumer surplus, and privacy loss. The ordering quantity prescribed by our algorithm achieves approximately optimal expected profit and consumer surplus, while sacrificing only a negligible degree of privacy. However, the misalignment of customer and firm incentives may lead to underuse or overuse of private information, compared to the goldilocks privacy level prescribed by our algorithm.

2 Differential Privacy in Personalized Pricing with Nonparametric Demand Models

Yining Wang[1], Xi Chen[2], Sentao Miao[3], [1]University of Texas at Dallas, Richardson, TX, [2]New York University, New York, NY, [3]McGill University, Montreal, QC, Canada. Contact: ynwang.yining@gmail.com

In the recent decades, the advance of information technology and abundant personal data facilitate the application of algorithmic personalized pricing. However, this leads to the growing concern of potential violation of privacy due to adversarial attack. To address the privacy issue, this paper studies a dynamic personalized pricing problem with unknown nonparametric demand models under data privacy protection. Two concepts of data privacy, which have been widely applied in practices, are introduced: central differential privacy (CDP) and local differential privacy (LDP), which is proved to be stronger than CDP in many cases. We develop two algorithms which make pricing decisions and learn the unknown demand on the fly, while satisfying the CDP and LDP gurantees respectively.

3 Privacy-Preserving Personalized Revenue Management

Yanzhe (Murray) Lei[1], Sentao Miao[2], Ruslan Momot[3], [1]Smith School of Business, Queen's University, Kingston, ON, Canada; [2]McGill University, Montreal, QC, Canada; [3]Ross School of Business, University of Michigan, Ann Arbor, MI, Contact: momot@umich.edu

We examine how data-driven personalized decisions can be made while preserving consumer privacy. Our setting is one in which the firm chooses a personalized price based on each new customer's vector of individual features; the true set of individual demand-generating parameters is unknown to the firm and so must be estimated from historical data. We extend this estimate-then-optimize framework of personalized pricing by requiring also that the firm's pricing policy preserve consumer privacy, or (formally) that it be differentially private. Our analysis suggests that with sufficient amount of historical data in hand, firms can achieve privacy at a cost of the same order as the loss in revenue due to estimation error. We also extend our analysis to the setting of personalized assortment optimization.

4 Learner-Private Convex Optimization

Dana Yang[1], Jiaming Xu[2], Kuang Xu[3], [1]Cornell University, Ithaca, NY, [2]Duke University, Durham, NC, [3]Stanford Graduate School of Business, Stanford, CA, Contact: dana.yang@cornell.edu

Convex optimization with feedback is a framework where a learner relies on iterative queries and feedback to arrive at the minimizer of a convex function. The paradigm has gained significant popularity recently thanks to its scalability in large-scale optimization and machine learning. The repeated interactions, however, expose the learner to privacy risks from eavesdropping adversaries that observe the submitted queries. In this work, we study how to optimally obfuscate the learner's queries in convex optimization with first-order feedback, so that their learned optimal value is provably difficult to estimate for the eavesdropping adversary.

Sunday, 2 PM–3:15 PM

SD29

CC - Room 140
Incentives and Risk
General Session

Session Chair
Nitin Bakshi, University of Utah, Salt Lake City, UT

1 Peer Reporting to Avoid Disasters: The Externalities of Misplaced Ethics

Nitin Bakshi, Manu Goyal, University of Utah, Salt Lake City, UT, Contact: manu.goyal@eccles.utah.edu

In team settings that are vulnerable to disasters, it is critical to mitigate the propensity for moral hazard, and induce prompt reporting of any shirking. However, agents can free-ride, which exacerbates moral hazard; and deep-rooted loyalty considerations prevent peer reporting. We study moral hazard and peer reporting in a team of one principal and two agents. One of the agents may be loyal: doesn't shirk (loyalty to principal) and doesn't report shirking (peer loyalty). We show that even a small probability of such a loyal agent engenders *tacit collusion*: shirking happens and goes unreported even by a rational agent. Thus, the principal cannot resolve moral hazard despite attractive contracts and rewards (for peer reporting). We label the moral compulsion for loyalty as *misplaced ethics*, the externalities of which must be recognized, understood and corrected.

2 Recommender Systems with Privacy Concerns

Can Kucukgul[1], Ozalp Ozer[2], Shouqiang Wang[1], [1]The University of Texas at Dallas, Richardson, TX, [2]Amazon, Richardson, TX

The hallmark feature of digital platforms is their capability of keeping track of users' online browsing activities and using this information to personalize recommendations. Various regulations are established to grant users of these platforms the right to privacy, i.e., they can choose whether to share their personal data with the platforms for product recommendation purposes. Using an information design framework, we study how an online platform should design its recommender policy under such regulatory provisions. We show that when the platform and users' incentives are sufficiently aligned, it is optimal for the platform to adopt a personalized recommender policy. Perhaps surprisingly, when the incentives are sufficiently misaligned, we find that the right to privacy may in fact reduce the overall user surplus.

3 Optimal Delay Messages

Laurens G. Debo[1], Seyed Iravani[2], Robert Shumsky[1], Sina Ansari[3], Liu Zhonghao[2], [1]Dartmouth College, Hanover, NH, [2]Northwestern University, Evanston, IL, [3]Driehaus College of Business, DePaul University, Chicago, IL, Contact: laurens.g.debo@tuck.dartmouth.edu

When customers wait for service, providers often announce forecast information about delays to reduce customer uncertainty and anxiety. Forecasts, however, are imperfect and when delays are longer than predicted, customers can be disappointed. Here we examine how to design delay forecasting and message systems that take into account both the anxiety caused by uncertainty and the relative disappointment of customers when delays are longer than expected.

4 Firm-level Supply Chain Risk and Performance Implications

Keno Theile[1], Christian Hofer[2], Kai Hoberg[3], [1]Kuehne Logistics University, Hamburg, Germany; [2]University of Arkansas, Fayetteville, AR, [3]Kühne Logistics University gGmbH, Hamburg, Germany. Contact: keno.theile@the-klu.org

Supply chain risk—broadly defined as the collection of vulnerabilities that emerge along a firm's supply chain and have the potential to affect the firm adversely—is of great concern to both managers and investors. We propose a firm-specific measure of supply chain risk based on a textual analysis of quarterly conference calls. Leveraging this measure of supply chain risk, we investigate its effects on operational and financial performance. Addressing these questions adds both nuance and breadth to the existing literature and paves the way for further empirical research.

Sunday, 2 PM–3:15 PM

SD30

CC - Room 141

Supply Chain Risk Management

General Session

Session Chair

Florian Lucker, Bayes Business School, London, London, United Kingdom.

Session Chair

Oben Ceryan, 1</sup

1 The Effects of Cyberattacks Along the Supply Chain

Yiyi Fan, Lancaster University, Lancaster, United Kingdom. Contact: y.fan1@lancaster.ac.uk

Cybersecurity risks in supply chains are not well understood, despite growing interest by the media and policymakers. Although we are often aware of the impact on individual firms, such firms are often embedded in global supply chains which are digitally connected, and so successful cyberattacks may impact many customers and suppliers of the target firms. Even if major organisations have a good level of cybersecurity, they may still be vulnerable because of the weaknesses elsewhere in their supply chain. This study examines the wealth effects - and their determinants - of cyberattacks on suppliers and customers of the target firms. I also analyse the target firms' responses to the disruptions caused by cyberattacks.

2 Building Resilience Through Supply Chain Finance (SCF): An Empirical Investigation

Begimai Marlenova[1], David Wuttke[2], Eve Rosenzweig[3], [1]Technical University of Munich, Heilbronn, Germany; [2]Technical University of Munich, Heilbronn, Germany; [3]Emory University, Atlanta, GA

COVID-19 has disrupted many supply chains around the world. In this paper, we examine the various ways buyers and their suppliers can use SCF to mitigate the effects of such disruptions. We rigorously test several hypotheses using a global dataset provided by a leading SCF provider.

3 Risk-sensitive Optimal Execution via a Conditional Value-at-risk Objective

Seungki Min[1], Ciamac Cyrus Moallemi[2], Costis Maglaras[2], [1]Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of; [2]Columbia University, New York, NY, Contact: skmin@kaist.ac.kr

We consider a liquidation problem in which a risk-averse trader tries to minimize the conditional value-at-risk (CVaR) of the implementation shortfall when liquidating a fixed quantity of an asset in the presence of market impact and random price fluctuations. Remarkably, we are able to derive closed-form expressions for the optimal dynamic (adaptive) liquidation strategy and its value function, and show that this optimal dynamic policy exhibits "aggressiveness-in-the-money" and outperforms the optimal static policy by 5-15% for moderate levels of risk aversion. In its derivation, we exploit the dual representation of CVaR to convert the problem to a continuous-time, zero sum dynamic game, and leverage the idea of state-space augmentation.

4 Limiting the Impact of Supply Chain Disruptions in the Face of Distributional Uncertainty in Demand

Anna Timonina-Farkas, EPFL, TOM, St.-Sulpice VD, Switzerland.

Service level requirements play a crucial role in eliminating stock-outs in a production pipeline. However, delivering a specific service level can become an unattainable goal given the various uncertainties influencing both the production pipeline and customer demand and causing the manufacturer to adapt the initial strategy in response to disruptions. Such deviations from optimality frequently result in unexpected (and potentially very high) costs and are complex to manage. On the one hand, the manufacturer can use a robust or distributionally robust approach to prepare for the worst-case disruption, ensuring that the realized cost will be lower than the estimated cost with high probability. On the other hand, this solution may lead to overly conservative production schedules. In this work, we take a different approach and develop a bilevel stochastic optimization model with chance constraints, which allows us to make the production more predictable in the event of disruptions by driving costs and optimal schedules closer to the benchmark for each scenario considered. We introduce doubly probabilistic service level requirements to account for two interdependent layers of uncertainty, i.e., production disruptions and distributional uncertainties in customer demand. This allows us to make high-quality production decisions with only a limited understanding of the demand pattern. Approximating the problem for numerical solution, we guarantee tight optimality gaps for high service levels and propose an efficient solution scheme, combining robust scenario reduction with a customized Benders decomposition procedure.
In the managerial section, we use the Omega x Swatch MoonSwatches example to demonstrate that a desirable doubly probabilistic service level can be attained for disruptions with a drop in demand. In the case of disruptions followed by a peak in demand, one can tighten the optimality gaps if the service level is reduced.

Sunday, 2 PM–3:15 PM

SD32

CC - Room 143

Emerging Issues in Supply Chain and Marketing

General Session

Session Chair

Yulan Amanda Wang, The Hong Kong Polytechnic University, Kowloon, Hong Kong.

Session Chair

Xin Wang, The Hong Kong University of Science and Technology, Kowloon

1 A Model of Coalition Reward Programs

Yan Liu[1], Jingmai Wang[1], Yulan Amanda Wang[1], Dan Zhang[2], [1]The Hong Kong Polytechnic University, Kowloon, Hong Kong; [2]University of Colorado, Boulder, CO, Contact: yan.y.liu@polyu.edu.hk

This paper studies the optimal design of coalition reward programs. A coalition reward program consists of n independent and symmetric firms, each of which sells a non-durable product to infinitesimal customers over an infinite horizon. Time is continuous, and a customer visits each firm following a Poisson process at a rate lambda. Thus, a customer visits the coalition at a rate nlambda. Any purchase from a firm in the coalition earns the customer a reward that can be redeemed across the firms before the reward expires. The coalition manager chooses the price, the reward, the expiration term, and the size n to maximize the program's long-term average revenue. We analyze the coalition's optimal decisions based on the customer's behavior and compare the coalition's profit with that of the proprietary reward program. Finally, we investigate how to determine the optimal size.

Sunday, 2 PM–3:15 PM

SD33

CC - Room 144
Sustainability in Supply Chain and Retail
General Session

Session Chair
Guangzhi Shang, Florida State Unviersity, Los Angeles

1 **The Role of Supply Chain in Retailer Take-back: An Empirical Study**
Yuqi Peng[1], Yan Dong[2], Sriram Venkataraman[2], Mark Ferguson[2], [1]Salisbury University, Salisbury, MD, [2]University of South Carolina, Columbia, SC, Contact: yqpeng@salisbury.edu
While manufacturers are regulated to take back their end-of-life products, retailers are not. From a supply chain perspective, we empirically investigate why retailers have the incentive of offering take-back services. We find that a retailer's take-back decision can be affected by its manufacturing suppliers and its market competition.

2 **Examining Sustainability as a Service Model in Retail**
Huseyn Abdulla[1], Seulchan Lee[2], Han Kyul Oh[3], [1]Haslam College of Business, University of Tennessee - Knoxville, Knoxville, TN, [2]Michigan Technological University, Houghton, MI, [3]Tilburg University, Tilburg, Netherlands. Contact: habdulla@utk.edu
As the pressure from investors, government institutions, and consumers on firms to improve environmental sustainability performance increases, new business models emerge to facilitate the firms' sustainability efforts while generating profit. One such model, known as Sustainability as a Service (SaaS), helps retailers to estimate and offset emissions from the delivery of online orders in real-time. In this paper, we analytically examine this new business model in the context of an online retailer who has made a sustainability commitment to become carbon neutral and a SaaS provider.

3 **Making the Case for Sustainable Supply Management: Supply Chain Transparency and Ethical Consumption**
Yanji Duan[1], John Aloysius[2], Christian Hofer[2], [1]University of North Florida, Jacksonville, FL, [2]University of Arkansas, Fayetteville, AR, Contact: yanji.duan@Unf.edu
Can firms recoup the cost of engaging in and disclosing sustainable supply management (SSM) efforts? We conduct a field experiment to investigate whether consumers will favor or pay a premium for products from firms that disclose SSM information over those do not. We find conclusive evidence that consumers will *buy more* from firms that disclose SSM and mixed evidence that some consumers may be also willing to *pay more* for products from such firms. Consistent with the individual-level findings, the analysis of firm-level archival data from U.S. manufacturing industries shows that providing SSM information in CSR reports results in a greater relative change in market share than when there is no SSM information. The empirical evidence suggests that firms can indeed benefit from engaging and communicating SSM efforts.

Sunday, 2 PM–3:15 PM

SD34

CC - Room 145
Supply Chains
Contributed Session

Session Chair
James Edward Paine, Massachusetts Institute of Technology, Cambridge, MA

1 **Multiechelon, Multicommodity Supply Chain Design with Uncertain Demand from a Climate Change Mitigation Perspective**
Reza Alizadeh[1], Janet K. Allen[2], Farrokh Mistree[2], [1]University of Oklahoma, TULSA, OK, [2]University of Oklahoma, Norman, OK, Contact: REZA.ALIZADEH@OU.EDU
Supply chains (SC) generate about 42% of greenhouse gas. Thus, designing a green supply chain (GSC) is a reasonable solution to mitigate climate change. A multi-channel, multi-echelon supply chain is designed using a bi-level, mixed-integer programming model. On the upper level, the layout of the SC, including the network of customers, stores, and warehouses, and the number and location of stores and warehouses for two channels of in-store and online shopping are determined to find a low-cost and low emission configuration. On the lower level, the tour distance for the online shopping channel is modeled as a TSP and solved using an evolutionary algorithm. In this study, we present

a surrogate-assisted optimization approach to reduce the inordinate amount of function evaluations of the lower-level search conducted for evaluating each upper-level solution.

2 Comparisons of Behavioral Model-based and Fully Model-free Cost Minimizing Agents in a Simulated Multi-echelon Supply Chain

James E. Paine, Massachusetts Institute of Technology, Cambridge, MA, Contact: jpaine@mit.edu

Behavioral Operations Management research emphasizes behavioral influences on supply chain phenomenon and correspondingly leverages behavioral models to suggest interventions. However more recently model-free approaches have also seen success. Using a simulated model of a multi-echelon supply chain built from prior behavioral research, this work develops algorithmic approaches towards mitigating the costs of bullwhip using both model-based approaches alongside model-free optimization and reinforcement learning approaches. This work directly compares the performance of these approaches under various combinations of information availability and agent environmental assumptions. In doing so, this work emphasizes the complementary nature of model-based and model-free approaches in approaching behaviorally grounded supply chain management problems.

3 An Optimal Tree Search Algorithm for TSp with History-and-Payload Based Risk Measure

Hyungjoo Cha[1], Chanho Lee[1], Joonyup Eun[2], Taesu Cheong[1], [1]Korea University, Seongbuk-Gu, Korea, Republic of; [2]Korea University, Seongbuk-Gu, Korea, Republic of. Contact: hyungjoo_cha@korea.ac.kr

In this talk, we introduce an optimal tree search algorithm to solve the traveling salesman problem regarding the risk current freight residual possesses. Although the past studies dealt with the risk minimization transportation problems, most of them heavily rely on complex optimization techniques. However, in this research, we present an optimal tree search-based algorithm, without the use of a state-of-the-art solver. The problem is also formulated in non-linear mixed-integer linear programming. The computational results show that the proposed search algorithm outperforms the mathematical model in terms of search efficiency and solution quality.

4 A Mixed Integer Linear Model for Biomass Supply Chains

Nasim Zandi Atashbar[1], Christian Prins[2], Nacima Labadie[2], Kuntal Bhattacharyya[1], [1]Indiana State University, Terre Haute, IN, [2]University of Technology of Troyes, Troyes, France. Contact: nzandiatashba@sycamores.indstate.edu

Biomass is a critical source of renewable energy. Efficient biomass supply chains must be designed to provide bio-refineries with adequate quantities of biomass at reasonable prices, and at appropriate times. This paper proposes a multi-period mixed-integer linear programming model to optimize a multi-biomass supply chain for several bio-refineries, both at the tactical as well as at strategic levels. Our model minimizes total costs, including biomass production, storage, handling, refineries setup, and transportation, while satisfying the demand of refineries in each period.

Sunday, 2 PM–3:15 PM

SD39

CC - Room 201

Optimization under Uncertainty: Theory and Applications (iii)

General Session

Session Chair

Elizabeth Jordan, University of Maryland, College Park, MD

1 Evidence-based Simulation-based Optimization of Resources and Improvement of Patient Flows in a Multi-Specialty Clinic Design

Maryam Hosseini[1,2], Alice M. Gittler[2], Mohammad T. Khasawneh[1], [1]Binghamton University, Binghamton, NY, [2]EwingCole, New York, NY, Contact: mhossei1@binghamton.edu

A fundamental activity in designing a floor layout for a multispecialty clinic is predicting the consequences of different alternative design options while providing a balance between future demand and needed resources. This study proposes an iterative approach in which different scenarios with consideration of future demand and self-service technology adoption rates were tested and evaluated while the model iteratively refreshed and inspired the evolution of design alternatives. Discrete event simulation (DES) combined with mixed-integer nonlinear programming is used for optimizing resources under demand uncertainty and scheduling policies. The results give insight to a multidisciplinary collaborative team to build consensus around a new layout by understanding the optimal capacity for the waiting and registration areas while meeting the constraints.

2 On-street Parking Space Allocation Considering Double-parking Impact, Modal Priority, and Parking Time Limit

Xiaoyu Ma[1], Xiaozheng He[2], [1]Rensselaer Polytechnic Institute, Troy, NY, [2]Rensselaer Polytechnic Institute, Troy, NY, Contact: max8@rpi.edu

The conflict between increasing and diversified parking demand in limited space calls for integrated curb space management for cities. Among all users, freight and service vehicles can cause severe congestion when their parking needs are unsatisfied. However, parking allocation solutions rarely account for this impact. To this end, this study proposes an optimization model for multimodal parking allocation. The model optimizes parking space allocation and parking time limit for cars while considering the impact of freight vehicles' double parking. The model also formulates vehicles' arrival and parking duration as random variables to ensure parking service reliability. Numerical results suggest a high priority of parking allocation to freight and service vehicles while setting a proper car parking time limit can further improve overall serviceability.

3 Optimizing Thresholds of Multi-tiered Non-pharmaceutical Intervention Strategies During a Pandemic

Elizabeth Jordan, Shapour Azarm, University of Maryland, College Park, MD

For mitigating the effects of COVID-19, or any pandemic, non-pharmaceutical intervention strategies can be used to follow a multi-tiered approach. Typically, certain policies (e.g., social distancing, masking) are adopted once some threshold values are set, following a community incidence rate (e.g., number of infections/100,000 population). However, these thresholds are often set rather arbitrarily. Our aim in this research is to develop an approach for optimized thresholds which can be maintained against uncertainty and/or over time. Practical implications of the proposed approach with corresponding results will be discussed.

Sunday, 2 PM–3:15 PM

SD40

CC - Room 202

Conic Optimization: Methods and Applications

General Session

Session Chair

Bissan Ghaddar, 1</sup

1 Learning for Spatial Branching: An Algorithm Selection Approach

Bissan Ghaddar[1], Ignacio Gómez-Casares[2,3], Julio González-Díaz[2,3], Brais González-Rodríguez[2,3], Beatriz Pateiro-López[2,3], Sofía Rodríguez-Ballesteros[2], [1]Ivey Business School, London, ON, Canada; [2]Universidad de Santiago de Compostela, Santiago de Compostela, Spain; [3]CITMAga, Santiago de Compostela, Spain. Contact: ignaciogomez.casares@usc.es

The use of machine learning techniques to improve the performance of branch-and-bound optimization algorithms is a very active area in the context of mixed integer linear problems, but little has been done for non-linear optimization. To bridge this gap, we develop a learning framework for spatial branching and show its efficacy in the context of the Reformulation-Linearization Technique for polynomial optimization problems. The proposed learning is performed offline, based on instance-specific features and with no computational overhead when solving new instances. Novel graph-based features are introduced, which turn out to play an important role for the learning. Experiments on different benchmark instances from the literature show that the learning-based branching rule significantly outperforms the standard rules.

2 Computing and Applying Tailored Power Flow Approximations and Relaxations in Power System Optimization Problems

Daniel Molzahn, Georgia Institute of Technology, Atlanta, GA, Contact: dan.molzahn@gmail.com

Relaxations and approximations of the power flow equations are key tools for addressing challenges associated with nonlinearities inherent to power system optimization problems. This presentation discusses recent developments in power flow relaxations and approximations, including methods for tightening relaxations by exploiting coordinate transformations, data-driven techniques for constructing approximations that are tailored to specific systems and operating ranges of interest, and approaches for recovering feasible solutions that utilize many types of information from an inexact solution. Results demonstrate the benefits of tailoring power flow relaxations and approximations relative to traditional methods used for several applications.

3 On Semidefinite Representations of Second-order Conic Optimization Problems

Pouya Sampourmahani[1], Mohammadhossein Mohammadisiahroudi[2], Tamás Terlaky[2], [1]Lehigh University, Bethlehem, PA, [2]Lehigh University, Bethlehem, PA

Current literature states that Second-order Conic Optimization (SOCO) problems can be embedded in Semidefinite Optimization (SDO) problems using the arrow-head notation. However, primal-dual SOCO pairs cannot be embedded simultaneously without losing duality. To map SOCO properly, we introduce admissible mappings that preserve both feasibility and optimality. We also discuss how the optimal partition of SOCO problems map to the ones of their SDO counterparts.

4 A Machine Learning Approach to Solving Large Bilevel and Stochastic Programs: Application to Cycling Network Design

Bo Lin, Timothy Chan, Shoshanna Saxe, University of Toronto, Toronto, ON, Canada. Contact: imbo.lin@mail.utoronto.ca

We present a novel ML-based approach to solving bilevel programs that involve a large number of independent followers, which as a special case include two-stage stochastic programming. We propose an optimization model that explicitly considers a sampled subset of followers and exploits a machine learning model to estimate the objective values of unsampled followers. Unlike existing approaches, we embed machine learning model training into the optimization problem. We prove bounds on the optimality gap of the generated leader decision as measured by the original objective function that considers the full follower set. Using real and synthetic instances of a cycling network design problem, we demonstrate the strong computational performance of our approach versus baseline methods.

Sunday, 2 PM–3:15 PM

SD41

CC - Room 203

Stochastic and Robust Optimization for the Emerging Transportation Problems

General Session

Session Chair

Luying Sun, 1</sup

Session Chair

Weijun Xie, Virginia Tech, Blacksburg, VA

1 On a Fair and Risk-averse Urban Air Mobility Demand Problem Under Demand and Capacity Uncertainties

Luying Sun[1], Weijun Xie[1], Peng Wei[2], [1]Virginia Tech, Blacksburg, VA, [2]George Washington University, Washington

Demand capacity balancing in Urban Air Mobility (UAM) is critical to mitigate potential traffic congestion and address operating uncertainty. This paper studies a fair and risk-averse UAM model to minimize the overall route and delay cost, achieving fairness as well as efficiency while hedging against future demand and capacity uncertainties. We show that the proposed model is NP-hard in general and can be strengthened by developing valid inequalities and stronger formulations. To solve it, we develop customized decomposition methods with effective cut-generating procedures. Our numerical study demonstrates the efficacy of the proposed methods.

2 Robustness Analysis of Demand Capacity Balancing for Advanced Air Mobility Operations

shulu chen[1], Peng Wei[2], Antony D. Evans[3], Maxim E. Nova[3], [1]George Washington University, Washington, DC, [2]George Washington University, Washington, [3]Airbus UTM, Sunnyvale, CA, Contact: shulu@gwu.edu

Demand capacity balancing (DCB) has been proposed as a strategic mechanism to balance efficiency and predictability for Urban Air Mobility (UAM) operations when operational uncertainties are high. In this presentation, we implement DCB in coordination with a tactical deconfliction system to ensure safe and efficient UAM and seek to analyze the robustness of the deconfliction system by introducing additional sources of uncertainty. We model three uncertainty factors - canceled and delayed flights, variable flight performance, and dynamic weather conditions - which are then applied to a hypothetical UAM network to test system robustness. The results suggest that DCB may be a feasible mechanism to ensure safe and efficient UAM operations. The results also reveal some early insights into interactions between the strategic DCB and the tactical deconfliction.

3 Airline Disruption Management with Delay Ledgers

Christopher Chin, Massachusetts Institute of Technology, Cambridge, MA

When disruptions result in reduced capacities at airports, airlines may be interested in swapping slots with each other. One approach to identify optimal slot swaps between airlines would be for airlines to share specific delay costs of each flight, but doing this could reveal sensitive business practices. We propose the use of a procedure called the Delay Ledger Mechanism (DeLed), which enables airlines to identify a set of beneficial slot swaps across a network of airports while ensuring that no private flight-specific valuations are shared. DeLed is guaranteed to lower airline delay costs, incentivizes truthful airline participation, and supports flexible airline privacy preferences. We evaluate DeLed across 30 days with 8 major US airlines, resulting in average reductions in private delay costs of 8-22% per day compared to current approaches.

Sunday, 2 PM–3:15 PM

SD42

CC - Room 204

Computational Optimization and Software for PSE and Grid Applications

General Session

Session Chair

Oluwamayowa Amusat, Lawrence Berkeley National Laboratory, Berkeley, CA

1 Transmission Constraint Screening for Production Cost Modeling at Scale

Bernard Knueven, National Renewable Energy Laboratory, Golden, CO

Transmission constraint calculation and screening, for both unit commitment and economic dispatch, is a critical feature of a performant solution method, but one that is often overlooked in the literature. In this talk, we will discuss the transmission constraint calculation and screening algorithm implemented in the open-source Egret package for electrical grid optimization and compare it against the more straightforward approach Egret originally implemented. Finally, we discuss the implications for transmission constraint sharing within a production cost modeling simulation.

2 Advances in Solving Infinite-dimensional Optimization Problems with Infiniteopt.jl

Joshua Pulsipher[1], Carl Laird[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Fayetteville, AR

Infinite-dimensional optimization (InfiniteOpt) problems are ubiquitous with challenging application classes in process systems engineering. InfiniteOpt.jl builds upon a unifying abstraction InfiniteOpt problems to provide a powerful tool for modeling and solving these problems in new and innovative ways. This talk will present recent and ongoing advances to InfiniteOpt.jl that enable a wide collection of transformation methods to be used to solve InfiniteOpt problems.

3 Co-optimizing the Design and Operation Strategy of Solid Oxide Fuel Cell-based Hydrogen-electricity Co-production Systems

Nicole Cortes[1], John C. Eslick[2], Alexander Noring[2], Naresh Susarla[2], Chinedu Okoli[2], Miguel A. Zamarripa[2], Arun Iyengar[2], Anthony P. Burgard[3], David C. Miller[3], Douglas Allan[2], Alexander Dowling[4], [1]University of Notre Dame, Notre Dame, IN, [2]National Energy Technology Laboratory Site-support Contractor, Pittsburgh, PA, [3]National Energy Technology Laboratory, Pittsburgh, PA, [4]University of Notre Dame, Notre Dame, IN, Contact: ncortes@nd.edu

Energy infrastructures and markets are becoming more volatile, requiring more flexible energy systems, such as Integrated Energy Systems (IES). Market analysis of IES is challenging, requiring models of system operations as well as capturing complex economic interactions. In this work, we present a framework for optimization-based market-informed techno-economic analysis (TEA) of IES, formulated as a generalized disjunctive programming (GDP) model and embedded with surrogates derived from detailed process models in the IDAES platform. We demonstrate the platform's capabilities by optimizing system design and operation of solid oxide fuel cell (SOFC)-based IES that coproduce electricity and hydrogen. We find that SOFC systems offer economic and technical advantages over alternatives, which is consistent with prior TEA.

4 Cost Optimization of Desalination Systems Using WaterTAP Incorporating Detailed Water Chemistry Models

Oluwamayowa O. Amusat[1], Adam A. Atia[2], Timothy V. Bartholomew[2], [1]Lawrence Berkeley National Laboratory, Berkeley, CA, [2]National Energy Technology Laboratory, Pittsburgh, PA, Contact: oluwamayowa.amusat@gmail.com

The Water treatment Technoeconomic Assessment Platform (WaterTAP) seeks to advance next generation water treatment technologies by providing a computational tool to assess the viability of technologies within a treatment train. WaterTAP is an open-source Python-based model library that is based on the IDAES Platform, an advanced process systems engineering tool. WaterTAP and IDAES provide modular, multi-hierarchical, customizable, and equation-oriented software tools that support advanced modeling and optimization capabilities. In this work, we demonstrate the capabilities of WaterTAP for the cost optimization of desalination plants with state-of-the-art detailed modeling of water chemistry and properties.

Sunday, 2 PM–3:15 PM

SD43

CC - Room 205
Nonlinear and Stochastic Optimization
General Session

Session Chair
Baoyu Zhou, Lehigh University, Bethlehem, PA

Session Chair
Raghu Bollapragada, The University of Texas at Austin, Austin, TX

1 Inexact Proximal Gradient Methods with Optimal Support Identification

Yutong Dai, Daniel P. Robinson, Lehigh University, Bethlehem, PA, Contact: yud319@lehigh.edu

We consider the proximal-gradient method for minimizing an objective function that is the sum of a smooth function and a non-smooth convex function. A feature that distinguishes our work from most in the literature is that we assume that the associated proximal-gradient subproblem does not admit a closed-form solution. To address this challenge, we study two *adaptive* and *implementable* termination conditions that dictate how accurately the proximal-gradient subproblem must be solved. We prove that the iteration complexity for the resulting inexact proximal-gradient method to reach an □ first-order stationary point is O(□^-2). In addition, using the overlapping group L1 regularizer as an example, we propose a new approach for approximately solving the proximal-gradient subproblem, and then establish the support identification complexity result.

2 A Trust Region Method for the Optimization of Noisy Functions

Shigeng Sun[1], Jorge Nocedal[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: shigengsun2024@u.northwestern.edu

Classical trust region methods were designed to solve problems in which function and gradient information are exact. This paper considers when there are bounded errors (or noise) in the above computations and proposes a simple modification of the trust region method to cope with these errors. The new algorithm only requires information of the size of the errors in the function evaluations and has no additional computational cost. It is shown that, when applied to a smooth (but not necessarily convex) objective function, the iterates generated visit a neighborhood of stationarity infinitely often, and that the rest of the sequence cannot stray too far away, as measured by function values. Numerical results illustrate the classical trust region algorithm may fail in the presence of noise, and the proposed algorithm ensures steady progress towards stationarity in these cases.

3 Balancing Communication and Computation in Gradient Tracking Distributed Optimization

Gupta Shagun[1], Raghu Bollapragada[2], [1]University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, Austin, TX, Contact: shagungupta@utexas.edu

Gradient tracking optimization algorithms have received significant attention over the past years for distributed optimization over networks due to their ability to converge to the solution under a constant step size. At every iteration, these algorithms require a computation step of calculating gradients at each node and a communication step to share the iterate and a gradient estimate among nodes. The complexity of these two steps varies significantly across different applications of distributed optimization. We present variations of the push-pull gradient methods to decompose and provide flexibility among the communication and computation steps within iterations. We illustrate the performance and flexibility of the proposed variations on quadratic functions and classification problems.

Sunday, 2 PM–3:15 PM

SD44

CC - Room 206
Network Optimization and Applications
General Session

1 The Service Agent Transport Interdiction Problem

Ankan Mitra[1], Jorge A. Sefair[2], Matthew J. Bays[3], [1]Arizona State University, Tempe, AZ, [2]University of Florida, Gainesville, FL, [3]Naval Surface Warfare Center, Panama City Division, Panama City, FL, Contact: amitra16@asu.edu

We study the interdiction variant of the service agent transport problem (SATIP). The goal of SATIP is to schedule a set of transport and service agents to complete a set of tasks in a network in the presence of an adversary. Service agents move on their own or using fast-moving autonomous transport agents. The budget-constrained adversary aims to maximize the mission's completion time (all tasks) by delaying service or transport tasks. We present a branch-and-cut algorithm to solve this two-stage interdiction problem as a single stage mixed-integer linear program. We also propose network reduction techniques and valid inequalities to strengthen the model.

Session Chair
Ankan Mitra, Arizona State University, Tempe, AZ

2 Models and Network Insights for Edge-based Districting

Zeyad Kassem, Adolfo R. Escobedo, Arizona State University, Tempe, AZ, Contact: zekassem@asu.edu

We introduce an edge-based districting optimization model with no pre-fixed centers to partition a road network into a given number of compact, contiguous, and balanced districts. The model is applicable to logistics applications. The model has cut set-based contiguity constraints and is paired with an iterative branch and bound algorithm with a cut generation scheme (B&B&Cut). We show that the underlying problem is NP-hard. Moreover, we derive network insights, from which cutting planes that enable a reduction in the solution space can be generated. The cuts are tested on road networks with up to 500 nodes and 687 edges, leading to speed up in computational time up to almost 27x relative to the computational time of solving the optimization model exactly with only B&B&Cut.

3 An Integer Programming Approach for Hydropower Planning in a Single Reservoir River System

Fatemeh Karamyar[1], Jorge A. Sefair[2], Yuhang Wei[1], John Sabo[3], [1]Arizona State University, Tempe, AZ, [2]University of Florida, Gainesville, FL, [3]Tulane University, New Orleans, LA, Contact: fkaramya@asu.edu

We present a mixed-integer programming model for hydropower operations planning in a single-reservoir river system. The proposed model schedules water release from a reservoir with the objective of maximizing hydropower generation. This problem incorporates realistic features such as power generation constraints and reservoir's characteristic features. Our modeling approach includes a discretization of the reservoir's water level along with function approximations to simplify the nonconvex dynamics of the system. We also propose a methodology to produce easy-to-use operational curves that prescribe the reservoir's water release based on upstream conditions. We test our methods using real data from the Lower Mekong Basin in Southeast Asia.

Sunday, 2 PM–3:15 PM

SD45

CC - Room 207
Semi-random Models
General Session

Session Chair
Noemie Perivier, 1</sup

Session Chair
Eric Balkanski, Columbia University, Cambridge, MA

1 The Power of Greedy for Online Minimum Matching on the Line

Noemie Perivier, Columbia University, New York, NY

We consider the online minimum matching problem on the line, where n requests that arrive in an online manner must be immediately and irrevocably matched to a given set of n servers and the goal is to minimize the sum of the distances between the matched pairs. This is a central problem in applications such as ride-hailing platforms and food delivery services. Despite achieving a worst-case competitive ratio that is exponential in n, the simple greedy algorithm, which matches each request to its nearest available free server, performs extremely well in practice. A major question is thus to explain this strong empirical performance. In this talk, we aim to understand the role of randomization in greedy's performance. In particular, we prove optimal or near-optimal bounds on greedy's competitive ratio in different scenarios, improving over several results from the literature.

2 The Simultaneous Semi-random Model for TSP

Eric Balkanski, Yuri Faenza, Mathieu Kubik, Columbia University, New York, NY

Worst-case analysis is a performance measure that is often too pessimistic to indicate which algorithms we should use in practice. For Euclidean TSP, local search performs very well in practice even though it achieves an Omega(log n / log log n) worst-case approximation. A natural alternative approach to worst-case analysis in such cases is semi-random models. In this talk, we propose a novel semi-random model, called the simultaneous semi-random model, where an instance over n points consists of the union of an adversarial instance over (1-□)n points and a random instance over □n points. As with smoothed analysis, this model interpolates between distributional analysis and worst-case analysis. In contrast to smoothed analysis, it trades off allowing some completely random points in order to have other points that exhibit an arbitrary structure.

3 Smoothed Analysis of Online Decision Making

Abhishek Shetty[1], Nika Haghtalab[1], Tim Roughgarden[2], [1]University of California Berkeley, Berkeley, CA, [2]Columbia University, New York, NY, Contact: shetty@berkeley.edu

We establish novel techniques to analyze algorithms in the smoothed analysis model for online decision making. In this model, at each step, an adversary chooses the input from distribution with density bounded above by the uniform distribution. Crucially, these techniques hold for adaptive adversaries that can choose distributions based on the decisions of the algorithm and the previous realizations of the inputs. Our technique effectively reduces the setting of adaptive adversaries to the simpler oblivious adversaries. The main application is to show that, in this model, online learning is as easy as offline learning. That is, we show that the regret against smoothed adversaries is captured by the offline complexity measure, VC dimension. Furthermore, we design efficient algorithms for online learning, circumventing impossibility results in the worst case.

4 Budget-Smoothed Analysis for Submodular Maximization

Junyao Zhao, Aviad Rubinstein, Stanford University, Stanford, CA

The greedy algorithm for monotone submodular maximization subject to cardinality constraint guarantees a 1−1/e approximation. Although it is well-known that this guarantee is tight in the worst case for any efficient algorithm, experiments show that greedy performs better in practice. We observe that for many applications in practice, the distribution of the budgets (i.e., cardinality constraints) is supported on a wide range, and moreover, all the existing hardness results break under a large perturbation of the budget. To understand the effect of the budget, we introduce the budget-smoothed analysis. We prove that greedy is optimal for every budget distribution and enjoys provably better approximation guarantees under realistic budget distributions. On the hardness side, we construct hard functions that are fairly robust to all the budget distributions.

Sunday, 2 PM–3:15 PM

SD46

CC - Room 208

Data-driven Decision-making for Urban Transportation

General Session

Session Chair

Julia Y. Yan, University of British Columbia, Vancouver, BC, Canada.

Session Chair

Arthur J. Delarue, Lyft, Cambridge, MA

1 Small is Beautiful: A Scalable Iterative Heuristic for Shared Micromobility Network

Pushpendra Singh[1], Vikrant Vaze[2], [1]Dartmouth College, Hanover, NH, [2]Dartmouth College, Hanover, NH, Contact: pushpendra.singh.th@dartmouth.edu

Shared micromobility systems (SMS), e.g., bike-sharing, are experiencing strong revival after a sudden disruption in the early months of COVID-19 pandemic. With over half of US car trips being under 5 miles long, SMS offers tremendous sustainability promise. The key question is: Can we design superior SMS networks lowering travel times & raising reliability without increasing costs? We formulate a non-convex mixed integer program (NCMIP) for strategic SMS design, endogenizing demand & approximating operating & rebalancing dynamics. We design an original fast iterative heuristic to solve this NCMIP. Our heuristic provides provably near-optimal solutions in much smaller runtimes compared to state of the art exact methods & scales successfully to real-world instances. Results highlight the drivers of our superior network design, & shows strong systemwide benefits.

2 Learning While Repositioning in On-demand Vehicle Sharing Networks

Shunan Jiang[1], Hansheng Jiang[2], Zuo-Jun Max Shen[3], [1]University of California, Berkeley, Berkeley, CA, [2]University of California, Berkeley, Berkeley, CA, [3]University of California Berkeley, Berkeley, CA, Contact: shunan_jiang@berkeley.edu

We consider the on-demand vehicle repositioning problem with a fixed number of vehicles distributed across multiple locations. Due to uncertainty in both customer arriving and vehicle returning, the service provider needs to periodically reposition the vehicles while minimizing the total costs of repositioning labor and lost sales. Existing literature assumes that the demand distribution is either known or can be simulated effectively from samples collected beforehand. In contrast, we develop an online learning method to dynamically reposition vehicles without knowing the demand distribution in advance. We study the performance of our algorithm by comparing it with the best generalized base-stock policy. We prove that the T-period regret of our algorithm is bounded sublinearly. Numerical experiments on synthetic data demonstrate the effectiveness of our method.

3 Online Facility Location

Junyu Cao[1], Wei Qi[2], Yan Zhang[3], [1]The University of Texas at Austin, Austin, TX, [2]McGill University, Montreal, QC, Canada; [3]McGill University, Montreal, QC, Canada. Contact: yan.zhang13@mail.mcgill.ca

We formulate an online facility location problem, joint with operational-level decisions. The scope of facility location problems continues to expand, while the models of facility location problems have been so far largely restricted to be in a static, offline fashion, prescribing one-shot facility placement based on past and current data on hand. In an online setting, the decision maker is subject to parameter uncertainties. However, she is able to adjust facility locations over time while updating her parameter estimation from historical observations. To this end, we propose an online algorithm that integrates the continuous approximation approach. The algorithm is both computationally efficient and has a near-optimal regret guarantee.

4 On-demand Multi-modal Transit: Design, Operations, and Pilots

Pascal Van Hentenryck, ISyE Georgia Tech, Atlanta, GA

This presentation gives an overview of On-Demand Multi-Modal Transit Systems (ODMTS) which combines fixed rail and bus routes with on-demand shuttles to serve the first and last mile. It considers the design of ODMTS (which bus routes to open), their operations, and report experience with MARTA Reach, an ODMTS pilot in Atlanta.

Sunday, 2 PM–3:15 PM

SD47

CC - Room 209

Application of AI in Prediction and Train Operation of Railway Systems

General Session

Session Chair

Jiateng Yin, Beijing Jiaotong University, Beijing, China.

Session Chair

Boyi Su, 1</sup

1 Resource-Directive Train Rescheduling with Cross-Layer Problem Decomposition

Shuguang Zhan[1], S. C. Wong[2], Jiemin Xie[3], Xuesong Zhou[4], [1]Hefei University of Technology, Hefei, China; [2]The University of Hong Kong, Hong Kong, China; [3]Sun Yat-sen University, Guangzhou, China; [4]Arizona State University, Tempe, AZ, Contact: shuguangzhan@hfut.edu.cn

In a disrupted situation, balancing and coordinating temporal and spatial capacity-allocation among a large number of disrupted trains constitute a challenging problem. Herein, a resource allocation-oriented perspective is taken, and a multi-commodity flow-based integer linear-programming model is introduced to solve the train-rescheduling problem. We systematically define resource space-time networks (RSTNs) and assign resources to trains with different priorities. A cross-layer decomposition approach is used to decompose the optimization model. Conflicts between different classes of trains are directly mitigated via an explicit phase of resource division in an RSTN. The alternating direction method of multipliers (ADMM) is applied to further decompose the network flow subproblem. Near-optimal solutions can be obtained in a short computational time.

2 A Deep Reinforcement Learning Approach for the Traffic Management of High-speed Railways: Comparison and Case Studies

Jiateng Yin, Beijing Jiaotong University, Beijing, China.

Our study proposes a deep reinforcement learning (DRL) approach for rescheduling the trains in case of disruptions. We develop a deep learning based value functionapproximation technique combined with a greedy algorithm, in order to further improve the training efficiency of the deep neural network. We use the Beijing-Zhangjiakou high-speed railway network as the simulation environment and conduct several sets of experiments. We also compare the DRL approach with several benchmarks, such as MIP, greedy, and other heuristics rules.

Sunday, 2 PM–3:15 PM

SD48

CC - Room 210

Transportation Networks

General Session

Session Chair

Rob A. Zuidwijk, Erasmus University Rotterdam, Rotterdam, Netherlands.

1 An Algorithm for Winter Road Maintenance During Snowy Weather Condition that Generates the First-tier Road Network & Design Vehicle Routing

Jiajun Pang[1], Irina Benedyk[2], [1]University at Buffalo, SUNY, Buffalo, NY, [2]University at Buffalo, SUNY, Buffalo, NY, Contact: jiajunpa@buffalo.edu

The snowy weather conditions result in significant adverse impacts on traffic. In reality, the road networks can be only plowed in sequence based on predefined priority. However, it is critical to consider the connectivity of the first-tier roadway networks to guarantee the accessibility, mobility, and equity of communities during heavy snow events. This study proposes an algorithm based on the set covering problem that generates a first-tier road network with the highest priority. The routing schedule for plowing/salting the first-tier road network is a model based on the dynamic traveling salesman problem that responds to real-time information on traffic and road conditions. The proposed method is able to improve the equity of traveling during snowy conditions and allow the transportation system operator to allocate resources in a more efficient and timely manner.

2 Setting up a Refueling Infrastructure for Public Transportation Services Conducting Dedicated Urban Delivery Operations

Sara F. Abu Aridah[1], Omar Abbaas[1], Jose Antonio Ventura[2], [1]Pennsylvania State University, State College, PA, [2]Pennsylvania State University, University Park, PA

This study considers the continuous deviation-flow refueling station location problem for vehicles traveling along dedicated routes on a transportation network. The objective is to optimally locate a set of refueling stations along the network to serve the vehicles on the dedicated routes, like public transportation vehicles. The proposed algorithm finds the candidate locations along all line segments in the network that can hold refueling stations. The set of candidate locations can then be used in a set covering model that minimizes the number refueling stations required to cover all routes, or maximize the amount of flow covered by a predetermined number of stations.

3 Vulnerability of Collaborative Transport Networks Under Disruptions

Rob Zuidwijk[1], Camill Harter[2], Otto Koppius[3], [1]Erasmus University Rotterdam, Rotterdam, Netherlands; [2]Erasmus University-Rotterdam, Rotterdam, Netherlands; [3]Erasmus University, Rotterdam ZH, Netherlands. Contact: rzuidwijk@rsm.nl

Collaboration in transport enables efficient use of transport resources operated by different organizations, but also comes with dependencies, which can have an adverse impact under disruption. While the synergy potential of collaborative transport is widely addressed in literature, existing transportation research models are less able to capture dependencies induced by collaboration and the concomitant vulnerabilities. We fill this gap by establishing a novel multi-layer network model capturing the functional dependence between the physical transport network, impacted by the disruptions, and the network of carrier collaborations, which is being disrupted. We show that market structure, represented by disparity in carrier sizes, has a non-trivial impact: Networks are most vulnerable if they have intermediate disparity in carrier sizes.

Sunday, 2 PM–3:15 PM

SD49

CC - Room 211

Inventory Vehicle Routing

General Session

Session Chair

Jose Santiago, 1</sup

1 EMbark: ExxonMobil’s LNG Shipping Optimization

Jose S Rodriguez[1], Kevin C. Furman[2], Mustafa Kilinc[2,2], [1]ExxonMobil, Houston TX, TX, [2]ExxonMobil, Houston, TX

EMbark: ExxonMobil’s LNG Shipping Optimization; J.S. Rodriguez, M. Kilinc, K. Furman; ExxonMobil Upstream Research Company; EMbark - a best-in-class LNG shipping optimization software - has the goal to optimize schedule economics to reduce cost, ensure operability, mitigate and quickly recover from disruptions, and capture value opportunities in ExxonMobil’s operations. Highly sophisticated mathematical methods automatically generate LNG shipping and logistics schedules that meet all constraints and optimize economics. In this presentation, we will provide an overview of EMbark’s capabilities. We will discuss the MILP formulations implemented in EMbark, the matheuristic algorithms that are based on large neighborhood search operators, and the computational results obtained for a set of real business cases collected since the application’s deployment.

2 Workload Balancing in Periodic Distribution Scheduling and Routing Optimization

Aliakbar Izadkhah[1], Akang Wang[2], Jose M. Lainez-Aguirre[3], Jose M. Pinto[4], Chrysanthos E. Gounaris[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Shenzhen Research Institute of Big Data, Shenzhen, China; [3]Digital Americas, Linde PLC, Woodlands, TX, [4]Digital Americas, Linde PLC, Danbury, CT, Contact: aizadkha@andrew.cmu.edu

When planning last-mile delivery operations, objectives such as balancing the daily served load are often viewed as equally important to the classical focus on limiting routing costs. However, cost-efficient routes stemming from traditional periodic vehicle routing problem solutions often represent a very uneven load for distribution, with some days being extremely burdensome for the fleet, while other days requiring only very little effort to execute. In this work, we integrate an epsilon-constraint method with a branch-price-and-cut routing solver, introducing also relevant strengthening inequalities, to co-optimize daily load levels alongside routing costs.

3 Modelling a Cyclic Maritime Inventory Routing Problem

Sebastian Urrutia[1], Lars Magnus Hvattum[2], Amir Zojaji[2], Kiarash Soltaniani[2], [1]Molde University College - Science College in Logistics, -, Norway; [2]Molde University College - Science College in Logistics, Molde, Norway. Contact: sebastian.a.urrutia@himolde.no

The inventory routing problem (IRP) arises when a company is responsible for the transport of goods from a production site to consumption sites, as well as maintaining proper inventory levels in the clients. Typically, IRPs are solved for a fixed time horizon leading to solutions with poor decisions near the end of the time horizon. In this work we model a cyclic maritime IRP, where the goal is to have a stable system: at the end of the planning horizon, all vessels and all inventory levels should be identical to where they started out. This ensures that the solution can be executed indefinitely, and there are no end-of-horizon effects. In order to obtain feasible cyclic solutions we consider all initial inventory levels and the initial position of each vessel as decision variables. These are usually consider as parameters in the maritime IRP literature.

4 Mobile Parcel Lockers with Individual Customer Service

Jan Fabian Ehmke[1], Rico Kötschau[1], Ninja Soeffker[2], [1]University of Vienna, Vienna, Austria; [2]University of Vienna, Wien, Austria. Contact: jan.ehmke@univie.ac.at

To handle the ongoing growth of last-mile deliveries, we propose to integrate the individuality of customers in the planning process. We present a mixed-integer program to evaluate different innovative delivery services: fixed parcel lockers, mobile parcel lockers, attended home deliveries, and their combinations. A fixed fleet is applied to maximize the number of customers served, respecting individual customer preferences in terms of their willingness to travel and time window flexibilities. We evaluate the impact of structural demand differences and different fleet sizes, as well as the operational fleet utilization and the individual customer experience. Results show the potential to increase the number of customers served by about 12-17% through the use of mobile parcel lockers while considering individual customer preferences.

Sunday, 2 PM–3:15 PM

SD50

CC - Room 212
eBusiness
General Session

Session Chair
Yumei He, Tulane University, Houston, TX

1 Algorithmic Bias in Online Game Matchmaking

Xingchen Xu[1], Yifan Yu[2], Wendao Xue[2], Yong Tan[1], [1]University of Washington, Seattle, WA, [2]University of Washington, Seattle, WA, Contact: xcxu21@uw.edu

Matchmaking algorithms, which allocate multiple players into games, can affect players' experience and further influence their engagement. Reinforcement learning algorithms are widely adopted to understand players' dynamic behavior and optimize engagement. However, combining simulation study and empirical analyses, we find that although reinforcement learning can increase players' activity, it will also induce unintended bias. Our research offers important implications to both academia and industry.

2 Understanding Partnership Formation and Repeated Contributions in Federated Learning: An Analytical Investigation

Mochen Yang, University of Minnesota, Minneapolis, MN

Limited access to large-scale data is a key obstacle to building machine learning (ML) applications, partly due to a reluctance of information exchange among data owners out of privacy and data security concerns. To address this ``information silo'' problem, federated learning (FL) techniques have been proposed to enable decentralized model training via an orchestrating central server. However, practical adoption of FL is partly limited by a lack of understanding of the economic incentives and trade-offs involved in partnership formation and long-term contributions. We take an analytical approach to answer two questions: (1) when do data owners prefer to form a FL partnership over building ML models by themselves, and (2) how can different contractual mechanisms be used to promote repeated contributions to FL (the cooperative outcome that benefits all participants).

3 Correcting Missing Value Bias Caused by Platform Content Management

Mengke Qiao[1], Qinglai He[2], [1]University of Science and Technology of China, Hefei, China; [2]University of Wisconsin - Madison, Madison, WI

Social media and user-generated content platforms increasingly enable content moderation and user self-deletion to manage their online content. These rising platform content management pose a missing data challenge for researchers who collect available online data for their empirical study. Researchers may obtain biased estimation results in their empirical analyses without carefully assessing and addressing the missing data issue. We propose theoretical formulas to correct the estimation bias caused by platform content management using identified partial missing data. Our simulation results indicate that our proposed method can effectively reduce the estimation bias in MNAR compared to two traditional missing values handling methods, LD and MAR. Furthermore, we conduct real-world applications with Reddit data and validate our model effectiveness.

4 Improving Fairness and Efficiency Using Estimates of User Preferences for Profile Characteristics in Online Marketplaces

Emil Palikot[1], Yuan Yuan[2], Dean Karlan[3], Susan Athey[1], [1]Stanford University, Stanford, CA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Kellogg School of Management, Northwestern University, Stanford, IL, Contact: palikot@stanford.edu

We consider the problem of a marketplace seeking to balance fairness and efficiency when users have preferences for features revealed in images. In the setting of a microlending marketplace, we use observational data to estimate the effects of image features on funding rates. We find that lenders prefer non-body shot images of smiling female borrowers. To address the potential for confounding, we conduct an experiment with recruited subjects, who choose between profiles generated using Generative Adversarial Networks that differ in the chosen features; the results are consistent with the observational data estimates. Finally, high-performing borrowers are more likely to smile and not use body shots which exacerbate inequities. Simulations of counterfactual policies show that recommending profile images can reduce inequity without sacrificing efficiency.

Sunday, 2 PM–3:15 PM

SD51

M - Santa Fe
Doing Good with Good OR
Award Session

Session Chair

Natalia Summerville, Memorial Sloan Kettering Cancer Center, Cary, NC

Session Chair

Josiah Green, 1</sup

1 Prediction-Driven Surge Planning with Application in the Emergency Department

Yue Hu, Columbia University, New York, NY

We consider the nurse staffing problem arising in emergency departments where the base staffing decision is typically made months in advance while the surge staffing decision is made only hours prior to the actual start of the shift. We develop a unified framework that consists of 1) a two-stage prediction model for patient demand, and 2) a prediction-driven staffing rule with supporting theoretical guarantees. The proposed framework was approved for pilot implementation at a partner hospital starting from April 11, 2022.

2 Optimization & Planning of Limited Resources for Assisting Non-Profits in Improving Maternal Health

Aditya Mate, Harvard University, Cambridge, MA

NGOs working to address woeful maternal mortality rates via automated messaging programs are faced with dwindling engagement rates, severely hurting the health outcomes for expectant mothers. Our partner NGO has limited intervention resources to encourage beneficiaries to improve engagement. To maximize the benefit of these interventions, we use OR tools to optimally plan the resource allocation. Our first-of-its-kind, large-scale field trial deploying our algorithm, involving 23,000 beneficiaries over a period of 7 weeks, showed that it cut engagement drops by ~30% compared to the status quo

3 Designing School Choice for Diversity in San Francisco

Katherine Mentzer, Stanford University, Stanford, CA

Many cities have adopted school-choice policies with the goal of reducing school segregation resulting from residential segregation. We worked with the San Francisco Unified School District (SFUSD) to design a new policy for student assignment system that optimizes for the district's goals of diversity, predictability, and proximity. To develop potential policies, we used optimization techniques to design and evaluate the drawing of zones, student priority rules, and reserved seats. Our work informed the design and approval of a zone-based policy for use starting the 2025-26 school year.

4 Optimizing Vaccine Distribution in Developing Countries under Natural Disaster Risk

Bonn Kleiford Seranilla, Université du Luxembourg, Esch-sur-Alzette, Luxembourg.

We present Project FALCON - an optimization tool aiming to assist local government units to select optimal facilities for their COVID-19 vaccination rollout plans. These optimal facility locations do not only incur minimum total operations costs but also hedge from the risk of natural disasters. It was implemented in a highly urbanized, flood-prone city in the Philippines, Cagayan de Oro, which posted one of the highest vaccination rates in the country by the start of 2022, inoculating more than 89% of the target population. Project FALCON yields 30-40% lower cost than a baseline approach.

5 Discovering Opportunities in New York City's Discovery Program

Xuan Zhang, Columbia University, New York, NY

Discovery program is a policy used by NYC DOE to increase admissions for disadvantaged students at specialized high schools (SHS). However, empirical analyses from recent academic years show that the current implementation could hurt disadvantaged students and unintentionally create an incentive to under-perform. We explore two alternative policies that can be used to address these issues with minimal modification: JSA and MR. We characterize a condition (high competitiveness) under which JSA dominates MR. Thus, we propose a change to JSA, given the competitive nature of the NYC SHS market.

Sunday, 2 PM–3:15 PM

SD52

M - Lincoln

Scheduling in Supply Chain and Healthcare

General Session

Session Chair

Zhi-Long Chen, University of Maryland, MD

1 Coordinating Parallel Batch Scheduling with Job Compatibility

Zhixin Liu[1], Guo-Qiang Fan[2], Jun-Qiang Wang[3], [1]University of Michigan-Dearborn, Dearborn, MI, [2]Xidian University, Xi'an, China; [3]Northwestern Polytechnical University, Xi'an, China. Contact: zhixin@umich.edu

We consider parallel batch machine scheduling with job compatibility. Each job has a processing time interval. A parallel batch machine can process several jobs as a batch simultaneously given that the total size of jobs in the batch does not exceed the machine capacity and the processing time intervals of any two jobs in the batch overlap. The processing time of a batch is the maximum normal processing time of jobs in the batch. Each job can select a machine for its processing to minimize its completion time. The system aims to minimize the makespan. We design an FCBLNPT coordination mechanism, and an LNPT algorithm to obtain a Nash equilibrium. We prove that the set of all Nash equilibria is precisely the set of schedules that can be obtained by the LNPT algorithm. We find an upper and a lower bounds of the price of anarchy of our FCBLNPT coordination mechanism.

2 Fulfillment Scheduling for Buy-online-pickup-in-store Orders

Zhi-Long Chen[1], Xueqi Wu[2], [1]University of Maryland, College Park, MD, [2]SJTU, Shanghai, China. Contact: zlchen@umd.edu

We study fulfillment scheduling decisions of BOPS orders destined for a single store of a retailer. BOPS orders can be either processed at a fulfillment center (FC) and delivered to the store, or processed at the store without needing delivery. Two types of trucks are available to deliver the BOPS orders fulfilled at the FC: prescheduled trucks that are already committed to replenishing store inventory and have some spare capacity that can be utilized, and additional trucks that can be hired from 3PL providers. The retailer needs to find where to fulfill each order, how to deliver the orders fulfilled at the FC to the store, and how to schedule the orders processed at the store such that all orders are ready for pick up by their deadlines at the minimum total cost. We study various cases of the problem by designing exact and heuristic algorithms, and derive important managerial insights.

3 Appointment Scheduling in Multi-stage Outpatient Clinics under Patient Heterogeneity

Pelin Kesrit[1], Chelliah Sriskandarajah[2], Jon M. Stauffer[2], [1]Mays Business School Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: pkesrit@mays.tamu.edu

We design effective appointment schedule templates, based on the block scheduling concept, for two-stage outpatient clinics under patient heterogeneity having different mean service times. Our objective is to find daily appointment schedules that minimize a weighted sum of patients' waiting time, the physician's and physician assistant's idle time, and overtime.

Sunday, 2 PM–3:15 PM

SD53

M - Denver
Service Science Flash Session
Flash Session

Session Chair
Felix Papier, Essec Business School, Cergy Pontoise Cedex, France.

1 Common Value Procurement Auctions with Resale

Bernardo (Bernie) F. Quiroga[1], Rodrigo Harrison[2], Roberto Muñoz[3], [1]West Virginia University, Morgantown, WV, [2]Adolfo Ibanez University, Peñalolén, Santiago, Chile; [3]Universidad Técnica Federico Santa María, Vitacura, Santiago, Chile. Contact: bfquirog@uc.cl

We study the effects of resale opportunities on auction bidding behavior under asymmetric information and common values. The information asymmetry arises due to the combination of (a) new information on the worth of the auctioned contract obtained by the winner after the auction, and (b) a potential negative shock received by the winner after the auction that forces the sale of the contract regardless of its true worth. We analyze the bidding behavior under different informational scenarios and discuss policy implications for each of them.

2 Social Learning with Polarized Preferences on Content Platforms

Bharadwaj Kadiyala[1], Dongwook Shin[2], [1]University of Utah, Salt Lake City, UT, [2]HKUST Business School, Clear Water Bay, Hong Kong.

Motivated by a number of socioeconomic and political issues that attract polarizing beliefs in the society, we study the impact of such beliefs on content consumption and production on a platform. Consumers are initially uninformed about the content quality but they learn about it using aggregate consumption metrics on the platform. We find that a social learning (SL) mechanism can mislead consumers to incorrectly perceive low-quality content to be of higher quality. SL may lower the incentive for the content provider to improve the content quality, and the platform may prefer to facilitate SL by displaying consumption metrics to mask the underlying low quality of the content.

3 A Multi-treatment Forest Approach for Analyzing the Heterogeneous Effects of Team Familiarity

Minmin Zhang[1], Guihua Wang[1], Wallace J. Hopp[2], Michael Mathis[3], [1]University of Texas at Dallas, Richardson, TX, [2]University of Michigan, Ann Arbor, MI, [3]University of Michigan Medical School, Ann Arbor, MI

We examine the effect of team familiarity on the speed of surgical procedures and extend the literature on team dynamics by examining whether the effect of team familiarity is heterogeneous across patients. Because we use multiple variables to measure team familiarity, we first develop a new approach, which we call the "MT forest" approach, to estimate the heterogeneous effects of multiple treatments. Then, we apply the MT forest approach to an orthopedic surgery setting to estimate the heterogeneous effects of team familiarity on surgery duration. Finally, we develop an optimization model to assess the value of leveraging team familiarity to better match surgical teams with patients.

4 Market Thickness and Pooling Efficiency in Meal-Delivery Platforms

Wenchang Zhang[1], Ruomeng Cui[2], Zhanzhi Zheng[3], [1]Kelley School of Business, Indiana University, Bloomington, IN, [2]Emory University, Decatur, GA, [3]University of North Carolina at Chapel Hill, Chapel Hill, NC

While meal-delivery platforms are racing to expand their size, little is known about how the expansion has influenced restaurant performance. Adding more restaurants that are close to each other (i.e., *market thickness* increases) may improve drivers' delivery efficiency because drivers can travel shorter distances to pick up multiple orders (i.e., *pooling efficiency*). Yet, restaurants can be hurt by increased market thickness due to cannibalization. We build a stylized model to predict how delivery time and customers' behaviors change as the market thickens. Then, we empirically examine the model's predictions using proprietary data from a leading meal-delivery platform in China.

5 Can Autonomous Vehicles Solve the Commuter Parking Problem?

Neda Mirzaeian[1], Soo-Haeng Cho[2], Sean Z. Qian[2], [1]University of Texas at Dallas, Dallas, TX, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: neda.mirzaeian@utdallas.edu

We investigate the effect of autonomous vehicles (AVs) on the morning commute, and characterize a user equilibrium for commuters by developing a continuous-time model that takes into account parking fees and traffic congestion as key economic deterrents to driving. We illustrate our results using data from Pittsburgh, and show that AVs result in a high total system cost. To reduce this cost, a social planner can regulate commuters' decisions by adjusting parking fees and congestion tolls, and/or adjusting infrastructure (e.g., converting downtown parking spots to drop-off spots). Our results indicate that these measures can reduce the total system cost substantially (e.g., by 70% in Pittsburgh).

6 Embedding Sustainability in Digital Servitization Journeys

Juliana Hsuan, Copenhagen Business School, Frederiksberg, Denmark.

“Embedding sustainability in digital servitization journeys” - Servitization is about competing through value propositions that integrate service with product offerings, prominently strategized by manufacturing companies. Digital servitization integrates product, service and software into the offerings. As manufacturers embrace sustainability into their strategic agenda, they have to consider the tradeoffs and risks (between standardization and innovation) in the configuration of required resources for business model innovation. This flash talk shares insights from an ongoing servitization project in Denmark and suggests opportunities for research.

7 A Semi-parametric Bayesian Model for Call Center Arrivals

Kaan Kuzu[1], Refik Soyer[2], Murat Tarimcilar[3], [1]Univ of Wisconsin-Milwaukee, Milwaukee, WI, [2]George Washington University, Washington, DC, [3]The George Washington University, Washington, DC, Contact: kuzu@uwm.edu

We use a Bayesian framework to forecast call arrivals by proposing a nonparametric form for the intensity function and introduce a robust semi-parametric model. The model is suitable for analyzing both interval censored count data and time of arrival data and can capture both monotonic and non-monotonic call arrival intensity. We consider a Markov evolution of daily effects on the intensity function and implement the model on two real call center data sets. We show that our proposed model has robust performance and provides higher accuracy than existing models.

8 Market Thickness in Online Food Delivery Platforms: The Impact of Food Processing Times

Yanlu Zhao[1], Felix Papier[2], Chung-Piaw Teo[3], [1]Durham University Business School, Durham, United Kingdom; [2]Essec Business School, Cergy Pontoise Cedex, France; [3]National University of Singapore Business School, Singapore, Singapore. Contact: felix.papier@gmx.de

Online food delivery (OFD) platforms are expanding rapidly worldwide; the pace of this expansion accelerated during the COVID-19 pandemic. We develop real-time algorithm to match drivers with orders on OFD platforms. The algorithm uses the (highly variable) food processing time to delay the assignment of drivers to orders to thicken the `market’ of orders and drivers. We evaluate the performance of our policy on a simplified model and derive the quasi-convexity of the total costs, implying that an intermediate level of thickness is optimal. Numerical experiments based on a real dataset from Meituan show that our policy reduce total costs by 42% compared to matching policies that are currently in use.

Sunday, 2 PM–3:15 PM

SD54

M - Marriott 1

Stochastic Systems Under Large Scales, Sudden Demands, and Large Deviations

General Session

Session Chair

Andrew Daw, University of Southern California, Marshall School of Business, Los Angeles, CA

1 An Asymptotic Systemic Failure Time Result for Mixed Coherent Systems

Guido Lagos[1], Javiera Barrera[2], Juan Valencia[3], Pablo Romero[4], [1]Universidad Adolfo Ibanez, Vina del Mar, Chile; [2]Universidad Adolfo Ibanez, Penalolen, Chile; [3]Universidad de Santiago de Chile, Santiago, Chile; [4]Universidad de la Republica, Montevideo, Uruguay. Contact: guido.lagos@uai.cl

In this work we show a limit result for the probability of a system being in an operational state as the size of the system grows to infinity. More specifically, we consider a sequence of *mixed coherent systems* whose components are homogeneous and non-repairable, with failure times of its components governed by a *Levy-frailty Marshall-Olkin* (LFMO) distribution — a distribution that allows simultaneous failures. We show that under measurability conditions the system failure time converges in distribution to a first-passage time of a Levy subordinator process. To illustrate, we give a parametric family of systems where the time of systemic failure converges to an exponential distribution. To the best of our knowledge, this is the first result to tackle the asymptotic behavior of the system failure time as the number of components of the system grows.

2 An Online Learning Algorithm for Capacity Sizing in Queues with Hawkes Arrivals

Xinyun Chen[1], Guiyu Hong[2], Xiuwen Wang[2], [1]Chinese University of Hong Kong, Shenzhen, Shenzhen, China;

[2]Chinese University of Hong Kong, Shenzhen, Shenzhen, China. Contact: guiyuhong@link.cuhk.edu.cn

We investigate the capacity sizing problem for a single-sever queue with Hawkes arrivals and general service time distributions. Due to the complexity of system dynamics, there is no analytic solution to this problem. We develop an online learning algorithm to numerically compute the optimal service capacity with a theoretic guarantee. In particular, we prove that our algorithm obtains regret of logarithmic order with properly chosen hyper-parameters. In the end, we apply the online learning algorithm to solve the capacity sizing problem for various single-server queues with Hawkes input. The numerical results indicate a sharp difference between GI/GI/1 and Hawkes/GI/1 queues, especially in some asymptotic regimes, indicating significant impact of autocorrelation in arrival processes to queueing control problems.

3 Maximizing Utilization in Large Systems Serving Jobs with Time-varying Resource Requirements

Yige Hong[1], Qiaomin Xie[2], Weina Wang[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of Wisconsin-Madison, Madison, WI, [3]Carnegie Mellon University, Pittsburgh, PA, Contact: yigeh@andrew.cmu.edu

Today's datacenters need to serve jobs whose resource requirements vary over time. The existence of such jobs makes it hard to fully utilize resources while not exceeding capacity constraints. The exact trade-off between utilization and capacity violation is not well-understood in the literature. In this paper, we study an infinite-server computing system where each server has a finite resource capacity, and jobs have time-varying resource requirements. Our goal is to design a job assigning policy that minimizes the number of occupied servers while keeping the cost of capacity violation within certain budget. We propose a novel framework that reduces the policy design problem under study to a problem in a single-server system through policy conversion techniques. This allows us to design an asymptotically optimal policy by solving a simple linear programming problem.

4 Sample-path Large Deviations for Unbounded Additive Functionals of Lindley Recursion

Chang-Han Rhee, Northwestern University, Chicago, IL

We prove a sample-path large deviation principle (LDP) with sub-linear speed for unbounded functionals of Lindley recursion. The LDP holds in the Skorokhod space D[0,T] equipped with the M1' topology. Our technique hinges on a suitable decomposition of the Markov chain in terms of regeneration cycles. Each regeneration cycle denotes the area accumulated during the busy period of the reflected random walk. We prove a large deviation principle for the area under the busy period of the MRW, and we show that it exhibits a heavy-tailed behavior.

Sunday, 2 PM–3:15 PM

SD55

M - Marriott 2

Recent Advances and Future Challenges in Online Decision-making

General Session

Session Chair

Debankur Mukherjee, 1</sup

Session Chair

Daan Rutten, Georgia Institute of Technology

1 Chasing Convex Bodies and Functions with Black-Box Advice

Nicolas Christianson, Tinashe Handina, Adam Wierman, California Institute of Technology, Pasadena, CA, Contact: nchristianson@caltech.edu

Modern AI/ML algorithms have the potential to improve performance over traditional algorithms for online optimization, which are designed to give worst-case guarantees. However, while AI/ML algorithms might perform well when the training data accurately reflects the deployment environment, they lack worst-case performance guarantees, e.g., under distribution shift. This hinders their use in real-world settings where safety/performance guarantees are crucial. In this talk, I will discuss recent work designing algorithms for online optimization with "black-box" advice that bridge the gap between the good average-case performance of AI/ML and the worst-case guarantees of traditional algorithms. We focus on the problem of chasing convex bodies and functions, discussing several algorithms and fundamental limits on algorithm performance in this setting.

2 Advances in Online Algorithms with Unreliable Predictions

Daan Rutten[1], Nicholas Christianson[2], Debankur Mukherjee[3], Adam Wierman[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]California Institute of Technology, Pasadena, CA, [3]ISyE Georgia Tech, Atlanta, GA, Contact: drutten@gatech.edu

We discuss recent advances and techniques in online algorithms with unreliable predictions. The online algorithm has access to a black-box oracle, such as a machine learning model, that provides untrusted and potentially inaccurate predictions of future input. The goal of the algorithm is to exploit the predictions if they are accurate, while guaranteeing performance that is not much worse than the hindsight optimal sequence of decisions, even when predictions are inaccurate. We discuss two problems: capacity scaling in data centers based on unknown future demand and the general framework of online optimization with switching costs. We prove theoretical guarantees on the competitive ratio using a potential function approach and show their optimality by lower bounds.

3 Accelerate Learning for Two-sided Bandits with Many Arms

Wanning Chen[1], Mohsen Bayati[2], Junyu Cao[3], [1]University of Washington, Seattle, WA, [2]Stanford University, Stanford, CA, [3]The University of Texas at Austin, Austin, TX

Multi-armed bandit (MAB) algorithms are used by companies instead of randomized experiments to find the best product from periodically refreshed product catalogs since they can reduce the opportunity costs efficiently. Due to a lack of knowledge of customer preferences for new products (i.e. cold start), MAB algorithms involve an initial data collection phase called the burning period. During this period, they operate like randomized experiments, incurring large burning costs that scale with the large number of products. We design an algorithm based on the low-rank matrix estimator to reduce the burning, by identifying that many products can be cast into two-sided products. The rewards of such products are modeled with a low-rank matrix, whose rows and columns represent the two sides. We show that our algorithm reduces costs with both theoretical and empirical evidence.

4 Online Learning with Hints

Manish Purohit, Google, Mountain View, CA

In this talk, I provide a brief overview of "Learning-augmented algorithms": algorithms that have access to predictions made by a machine learning oracle.
I will present an application of this framework to the classical online learning problem where the online player receives a "hint" regarding the upcoming cost vector before choosing an action for that round. Our goal is to design an algorithm that exploits good hints to obtain regret that grows only logarithmically with the number of time steps (thus circumventing well known lower bounds), while at the same time being resilient to bad hints. We develop a general framework for online learning with hints that obtains near-optimal regret bounds with respect to the quality of the hints. I shall conclude with different extensions of this framework such as reducing the number of hints utilized, and exploiting multiple hint sources.

Sunday, 2 PM–3:15 PM

SD56

M - Marriott 3

Data-driven E-commerce Inventory Management

General Session

Session Chair

Will Ma, Columbia University, Cambridge, MA

1 Integrated Conditional Estimation-optimization with Its Application in Multi-product Newsvendor Problem

Meng Qi[1], Paul Grigas[2], Zuo-Jun Max Shen[3], [1]Cornell University, Ithaca, NY, [2]UC Berkeley, Berkeley, CA, [3]University of California Berkeley, Berkeley, CA

Many real-world optimization problems, such as the multi-product Newsvendor problem, involve uncertain parameters with probability distributions that can be estimated using contextual feature information. In contrast to the standard approach of first estimating the distribution and then optimizing the objective based on the estimation, we propose an integrated conditional estimation-optimization(ICEO) framework that estimates the underlying conditional distribution of the random parameter while considering the structure of the optimization goal. We show that our ICEO approach is asymptotically consistent under moderate regularity conditions and further provide finite performance guarantees in the form of generalization bounds. We also investigate the computational difficulties and conduct numerical experiments to show the empirical success of ICEO.

2 Adaptive Algorithms for Multi-Warehouse Multi-Store Inventory System with Lost Sales

Xiuli Chao[1], Stefanus Jasin[2], Sentao Miao[3], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, [3]McGill University, Montreal, QC, Canada. Contact: sentao.miao@mcgill.ca

We consider a two-echelon inventory control problem for a Multi-Warehouse Multi-Store (MWMS) system with lost sales. We focus on a time horizon with no external replenishment, or the problem of "what to do until your (external) shipment comes in". The warehouses are stocked with inventories at the beginning of the horizon, and the stores dynamically replenish from the warehouses in each period. In this paper, we develop provably near-optimal algorithms by integrating and extending two key ideas/approaches: (i) Lagrangian relaxation of the original complex dynamic inventory control problem, and (ii) dynamic re-adjustments of both replenishment and allocation policies. Our results show that adaptive readjustments significantly improve the performance of the base algorithm both theoretically and numerically.

3 Order Selection Problems in Hiring Pipelines

Boris Epstein[1,1], Will Ma[2], [1]Columbia University, New York, NY, [2]Columbia University, Cambridge, MA

We study problems faced by firms which are running recruitment processes and must decide the order in which to send offers to candidates. The firm has a pool of candidates, from which at most k of them can be hired. There are also constraints on the total number of candidates who can receive offers. Each candidate has a probability of accepting the offer and provide a value to the firm when they accept. The goal of the firm is to maximize the sum of the values of hired candidates.

We study two different variants of the problem. In the sequential offering model, offers are sent one-by-one and at most T offers can be sent in total. In the parallel offering model, the firm can send, at each stage, as many offers as positions left in that stage. Our algorithms are static, implying bounds on the adaptivity gaps for these problems.

4 Online Multi-Item Order Fulfillment and Prophet Inequality

Ayoub Amil, Ali Makhdoumi, Yehua Wei, Duke University - Fuqua School of Business, Durham, NC, Contact: ayoub.amil@duke.edu

We study a problem in which an e-commerce platform (or online retailer) with multiple warehouses and finite inventory is faced with the choice of deciding from which warehouse each of the items in the arriving order(s) should be fulfilled. Online retailers, unlike traditional retailers, must quickly make a series of decisions, such as deciding from which facility the items will ship, by what shipping method, or whether or not multi-item orders will be split. We formulate this problem as an online decision problem in which a platform sequentially decides a shipping method to adopt to fulfill the arriving order, subject to warehouses' inventory constraints. By building connections to the *prophet inequality* and *magician problem* literature, we design an online algorithm that is both asymptotically optimal and has a strong approximation guarantee in the non-asymptotic setting.

Sunday, 2 PM–3:15 PM

SD57

M - Marriott 4

Advanced Data Analytics for Reliability and Maintenance

General Session

Session Chair

Akash Deep, University of Wisconsin Madison, Madison, WI

Session Chair

Congfang Huang, UW Madison, Madison, WI

Session Chair

Jaesung Lee, University of Wisconsin, Madison, WI

1 A Bayesian Framework of Markov Decision Process with Uncertain Transition Probabilities

YUE SHI, Yisha Xiang, Texas Tech University, Lubbock, TX

This study considers a Markov decision process model whose transition probabilities are unknown to the decision maker and need to be estimated from historical transition data. Due to limited availability of data and/or data errors, such an estimation is often subject to large statistical estimation errors, making the estimated transition probabilities significantly deviated from the true ones.

To mitigate the impact of the parameter uncertainty on optimal policies, we use a Bayesian approach to model the uncertainty in transition probabilities and propose a second-order approximation model to obtain optimal policies.

We assess the utility of the proposed method using a remanufacturing planning problem.

2 HMM-based Joint Modeling of Condition Monitoring Signals and Failure Event Data for Prognosis

Akash Deep[1], Shiyu Zhou[2], Dharmaraj Veeramani[2], Yong Chen[3], [1]University of Wisconsin Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Iowa, Iowa City, IA, Contact: adeep@wisc.edu

Accurate estimation of remaining useful life (RUL) of a unit is critical to fulfill reliability commitments. In presence of hard failures, accurate prognosis of RUL using condition monitoring (CM) signals becomes challenging. To tackle this problem, we present a prognostic framework by jointly modeling CM signals and failure event data. Development of the presented method depends on the idea that while the unit operates, it continually degrades through a series of hidden states until the unit reaches the dead state, and the CM signals are functionally related to this hidden failure process. Through this modeling, requirement of a failure threshold on CM signals is eliminated. We provide a modified EM procedure to estimate parameters, and through a comprehensive set of numerical as well as real-world experiments we demonstrate superior prognosis performance.

3 Applying Machine Learning Methods to Improve All-terminal Network Reliability

Jose Azucena[1], Haitao Liao[2], [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas, Fayetteville, AR, Contact: jch051@uark.edu

We propose a novel framework for improving network reliability using Deep Reinforcement Learning (DRL) and Deep Neural Networks (DNNs). With the help of DNNs and Stochastic Variational Inference (SVI), the DRL agents will effectively compute the all-terminal reliability for multiple network configurations during training. The Bayesian nature of the SVI+DNN model allows for quantifying the estimation uncertainty while enforcing regularization and reducing overfitting.

Sunday, 2 PM–3:15 PM

SD58

M - Marriott 5

Advanced Data Analytics and Statistical Modeling for Smart Heath

General Session

Session Chair

Bing Yao, Oklahoma State University, Stillwater, OK

Session Chair

Cheng-Bang Chen, University of Miami, Miami, FL

1 Calibration of Patient Flow Model in Hospital via Gaussian Processes Based Bayesian Optimization

You Zhou, Purdue University, West Lafayette, IN, Contact: zhou1129@purdue.edu

Smart hospital is an important cornerstone of smart healthcare. It has become a research hotspot on how to assist hospital managers to make better decisions based on history data. In this study, we investigated a state transition model over the patient flow inside the hospital and calibrated the parameters of the model against the daily census data. We employed a Gaussian Process based Bayesian Optimization approach to identify the best parameter design. We compared our methods with direct employment of Nelder-Mead and the surrogate function using Gaussian Process trained with a fixed set of sampling points. Overall, our method showed better goodness-of-fit and achieved better validation results given limited number of calls of simulator. Our method can assist hospital manager to better monitor medical needs and allocate the corresponding resources.

2 A Novel Recurrence Quantification Analysis for Cardiac Arrhythmia Detection in Multichannel ECG Signals

Yujie Wang[1], Ayush Manojkumar Lodha[2], Cheng-Bang Chen[3], [1]University of Miami, Miami, FL, [2]Indian Institute of Technology Gandhinagar, Ahmedabad, India; [3]University of Miami, Miami, FL, Contact: yxw509@miami.edu

Cardiac arrhythmias reflect various irregular conditions of the heart. It is crucial to accurately identify the arrhythmias from the electrocardiogram (ECG) signals. Prior research has shown that recurrence analysis (RA) is robust in characterizing the complex ECG; however, the dynamic recurrences within and between heterogeneous transitional states, which contain rich information, have not been thoroughly investigated. This research proposes a novel RA framework addressing this gap. We coordinate two different RAs to characterize the subtle dynamic in ECG and develop new quantifications to delineate these recurrences precisely. Experimental results show that our methodology accurately depicts the ECG and detects arrhythmias.

3 Heart Rate Variability Feature Selection Method for Mental Stress Detection

Joseph Nuamah, Oklahoma State University

Advances in wearable sensor technologies have led to various approaches for detecting mental stress using physiological signals, including heart rate variability (HRV). In a binary classification task, we combined feature selection methods with different machine learning (ML) models (SVM, XGBoost, Random Forest and LASSO) to a publicly available dataset, WESAD, to determine HRV features that best distinguish stress and non-stress states. Based on the macro-averaged F1 score, the best result of 0.80 was obtained with recursive feature extraction combined with XGBoost when the number of features was 11 out of a total of 25. We evaluated the performance of our model with data obtained from participants from a different stress response study. Results obtained is a step towards evaluating reproducibility of ML models for mental stress detection.

4 RL-Driven Information Broadcasting Policies for Early Task Initiation in Healthcare Systems for Improved Patient Flow

SeungJin Wang, Wayne State University, Troy, MI
Emergency Department (ED) patient boarding, the process of patients being held up in ED for hours on due to admission delays and reactive hospital bed management, has been a national and international crisis for years. Modern Electronic Health Record (EHR) systems have been shown to enable real-time predictions around ED patient length-of-stay and disposition decisions to facilitate proactive coordination of downstream resources to streamline patient flow from ED to the Inpatient Unit (IU) network. Given the evolving uncertainty in prediction accuracies and resource states, there is need for optimal information broadcasting policies around future demand to downstream resources. We explore reinforcement learning algorithms to best balance broadcast lead-times with information reliability

Sunday, 2 PM–3:15 PM

SD59

M - Marriott 6

Condition Monitoring, Operations and Maintenance in Power Systems

General Session

Session Chair

Farnaz Fallahi, Wayne State University, Detroit, MI

Session Chair

Murat Yildirim, Wayne State University, Detroit, MI

1 Transitioning to Sensor-driven Asset Management in a Hydropower System Domain

Farnaz Fallahi, Wayne State University, Detroit, MI, Contact: farnaz.fallahi@wayne.edu
This paper proposes a unified condition-based maintenance and operations scheduling approach for hydropower systems that models the non-linearity in power production as well as uncertainties related to water inflows and market price. The problem is formulated as a two-stage stochastic programming model to minimize the operations and maintenance cost. Our results on a comprehensive set of experiments demonstrate that the proposed approach provides significant improvements in asset availability, market revenue and maintenance costs in a large-scale hydropower system.

2 Differentially Private Decentralized Generator Maintenance and Operations for Power Networks

Paritosh Ramanan, Georgia Institute of Technology, Atlanta, GA
Decentralized methods have been popular for their computational scalability while enabling data ownership by utility stakeholders. However, decentralization also requires sharing network flow estimates over public channels raising privacy concerns. In this talk, we present a differential privacy driven, ADMM approach for decentralized, mixed integer optimization of operations and maintenance problems which preserves network flow privacy. Our solution relies on strong privacy guarantees regarding phase angles and flow. We introduce an exponential moving average based consensus mechanism to enhance convergence, coupled with a control chart based convergence criteria to improve stability. Our results demonstrate that our privacy preserving approach is robust to a range of noise levels and operational scenarios remaining on par with benchmark methods.

3 A Robust Optimization Framework for Operations and Maintenance in Multi-component Systems

Deniz Altinpulluk[1], Farnaz Fallahi[2], Mohammad Javad Feizollahi[3], Murat Yildirim[4], [1]Wayne State University, Detroit, MI, [2]Wayne State University, Birmingham, MI, [3]Georgia State University, Atlanta, GA, [4]Wayne State University, Detroit, MI, Contact: deniz.altinpulluk@gmail.com
Regular maintenance policies face reliability and profitability issues due to frequent maintenance requirements while facing significant unexpected failure risks. Recent developments in sensor technology provide asset-specific degradation information from components that can be harnessed to improve operational and maintenance effectiveness. The degradation rate of a component highly depends on the production load and conditions of other components in the system. This allows us to tame the degradation rate by reducing production load or maintaining its degraded pairs. Rates of these contributions to the total degradation rate from these dependencies are uncertain. We introduce a robust optimization model that accommodates maintenance and production decisions to minimize maintenance costs and penalties from unsatisfied demand.

4 Predicting Remaining Useful Life in Complex Systems with Multiple Failure Modes

Benjamin G. Peters, University of Texas Rio Grande Valley, Edinburg, TX, Contact: benjamin.peters01@utrgv.edu

Modern industrial systems are comprised of multiple components with complex degradation processes. To address this complexity, modern systems are equipped with several sensors for condition monitoring, a process that utilizes sensor data for predicting the system's remaining useful life (RUL). RUL prediction is challenging for complex systems due to the large volume of data collected by these sensors and because complex systems are subject to multiple failure modes. High-dimensional (HD) data analytics holds potential for enabling the development of robust prognostics frameworks for complex systems due to its ability to process the large data structures generated by these sensors. Therefore, we present an HD data analytics framework for predicting RUL in complex systems with multiple failure modes.

Sunday, 2 PM–3:15 PM

SD60

M - Marriott 7

IISE Transaction Invited Session

Panel Session

Session Chair
Jionghua Jin, University of Michigan, Ann Arbor, MI

1 **Moderator**
Jionghua Jin, University of Michigan, Ann Arbor, MI
This is a special invited Panel Session of IISE Transactions on Data Science, Quality & Reliability (IISE-DSQR). In the session, three panelist speakers will present their recently published papers in IISE-DSQR, which show a few examples of frontier research topics promoted by the IISE-DSQR journal. The discussion with the journal editor about the journal scope and review process is followed.

2 **Panelist**
Yuxin Wen, Chapman University, Santa Ana, CA

3 **Panelist**
Honghan Ye, University of Wisconsin- Madison, Woodbury, MN

4 **Panelist**
Ramin Moghaddass, University of Miami, Coral Gables, FL, Contact: ramin@miami.edu

Sunday, 2 PM–3:15 PM

SD61

M - Marriott 8

ENRE Harold Hotelling Medal for Lifetime Achievement

Award Session

Session Chair
Sandra D. Eksioglu, University of Arkansas, Fayetteville, AR

Session Chair
Alexandra M. Newman, Colorado School of Mines, Golden, CO

1 **Citation of Merit**
Richard Paul O'Neill, ARPA-E, Silver Spring, MD
This talk reviews career highlights in the academic and government sectors related to the design of energy markets.

Sunday, 2 PM–3:15 PM

SD62

M - Marriott 9

Smart Power-grid and Mobility Toward Carbon Neutrality

General Session

Session Chair
Kai Pan, Hong Kong Polytechnic University, Kowloon, Hong Kong.

Session Chair
Ziliang Jin, The Hong Kong Polytechnic University

1 **Algorithmic Privacy for Energy Systems Optimization**
Vladimir Dvorkin, Massachusetts Institute of Technology, Cambridge, MA
Decision-making in energy systems is often guided by optimization models that use sensitive, private energy optimization data (e.g., energy demands, prices, etc.). Optimization outcomes may unintentionally expose this data, thus leading to privacy breaches. We introduce differentially private energy system optimization models that make different, yet adjacent in some sense, energy datasets statistically similar in randomized optimization outcomes, thereby proving probabilistic privacy guarantees for energy

data owners. We explain how stochastic programming and differential privacy achieve algorithmic privacy in energy optimization, and we provide illustrative examples of private energy system control, forecasting and classification.

2 Auction Designs to Increase Incentive Compatibility and Reduce Self-scheduling in Electricity Markets

Conleigh Byers[1], Brent Eldridge[2], [1]ETH Zurich, Zurich, Switzerland; [2]Pacific Northwest National Laboratory, Baltimore, MD, Contact: cbyers@ethz.ch

The system operator's scheduling problem in electricity markets, called unit commitment, is a non-convex mixed-integer program. The optimal value function is non-convex, preventing the application of traditional marginal pricing theory to find prices that clear the market and incentivize market participants to follow the dispatch schedule. Units that perceive the opportunity to make a profit may be incentivized to self-commit (submitting an offer with zero fixed operating costs) or self-schedule their production (submitting an offer with zero total cost). We simulate bidder behavior to show that market power can be exercised by becoming a price taker. We investigate different pricing mechanisms over multi-period commitment windows and show that convex hull pricing can minimize producer incentives to deviate from the central dispatch decision.

3 Achieving Power Sector Carbon Neutrality in a Low-cost Renewable Era

Gang He, Stony Brook University, Stony Brook, NY

Clean power transition is at the center to achieve mid-century carbon neutrality goals. The cost of solar and wind has plummeted in the past decade, and solar and wind electricity has been achieving grid parity. Low-cost renewables offer new perspectives for energy system decarbonization that was less visioned before. In this talk, Dr. He will discuss the pathways of clean power transition and their system impacts using high-resolution models, to reflect the need for integrating variable renewable energy and phasing out coal to achieve carbon neutrality in the power sector at a low-cost renewables era.

4 Equity by Design in Electric Vehicle Charging Networks

Yen-Chu Wu, Eleftheria Kontou, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: kontou@illinois.edu

In this study, we optimize electric vehicle charging station deployment by integrating equity objectives in this facility location problem. We aim to reduce detours and improve the ability to complete long-distance trips for low-income electric vehicle travelers and multi-unit dwelling residents. We use a genetic algorithm with a column generation approach to solve the nonlinear mixed integer programming problem. We provide insights on equitable charging siting by applying this framework to the state of Illinois interstate network.

Sunday, 2 PM–3:15 PM

SD63

M - Marriott 10

Control and Optimization Solutions to Safeguard Against Cyber-physical Adversaries in Energy Grids

General Session

Session Chair

Nawaf Nazir, 1</sup

Session Chair

Soumya Kundu, 1</sup

1 A Conditional Value at Risk (CVaR) Based Mode-selection Framework to Safeguard Against Adversarial Attacks in Microgrids

Nawaf Nazir, Soumya Kundu, Pacific Northwest National Laboratory, Richland, WA, Contact: nawaf.nazir@pnnl.gov

The increasing penetration of distributed generation in the energy grids has created challenges for power system operations including safeguarding against various cyber-physical attacks. Hence, the need is to develop resilient methods, such as chance constraints, that provide guarantees on system stability and security. However, traditional methods do not consider the wide range of possible adversarial events, especially low probability high impact events. In this work, we develop a mode-selection based framework that firstly forecasts the probability of various adversarial events and then based on this chooses a mode of operation amongst a finite number of modes, in order to counter the effects of the adversarial events in a scalable approach. Finally we develop CVaR based algorithms to dispatch flexible resources and validate the results on a microgrid test case.

2 Enabling DER Participation in Frequency Regulation Markets

Adil Khurram[1], Priyank Srivastava[2], Sonia Martínez[3], Jorge Cortes[4], Jan Kleissl[3], [1]University of California, San Diego, San Diego, CA, [2]Massachusetts Institute of Technology,

Cambridge, MA, [3]University of California, San Diego, San Diego, CA, [4]University of California-San Diego, La Jolla, CA, Contact: akhurram@ucsd.edu

This work develops a hierarchical framework for aggregators to participate in the ancillary services market, where each aggregator manages a microgrid consisting of a collection of heterogeneous DERs. Meaningful abstractions of aggregators are developed using the second-order cone relaxation of the AC optimal power flow problem. These abstractions are used to identify bids for the market clearing stage as well as for the real-time disaggregation of the regulation signal in a distributed fashion. This type of formulation preserves the privacy of DERs by abstracting the operating constraints of an individual DER into cost function, capacity limits and ramp rate limits for the entire microgrid operating under the aggregator, mitigating attacks by cyber physical eavesdropping adversaries.

3 Stochastic Linearization: Review and Recent Advances

Hamid Ossareh, University of Vermont, Burlington, VT

Quasilinear Control (QLC) Theory provides a set of methods intended for the analysis and design of stochastic feedback systems with static nonlinearities such as actuator saturation. QLC leverages the method of Stochastic Linearization (SL), which linearizes the nonlinear functions by utilizing the statistical properties of the inputs to the nonlinearities. This results in an approximation that can predict the mean and variance of the signals in the loop with reasonable accuracy, which can in turn be used for the purpose of planning and controller design. In this talk, we review SL and several key QLC methods, and present recent advances in these areas, such as handling systems with multivariate nonlinearities and systems with multiplicative noise, which arise in power system applications.

4 Risk-aware Learning for Scalable Voltage Optimization in Distribution Grids

Shanny Lin, Shaohui Liu, Hao Zhu, The University of Texas at Austin, Austin, TX, Contact: shaohui.liu@utexas.edu

By capitalizing on a scalable neural network architecture and the conditional value-at-risk (CVaR), we develop a decentralized risk-aware learning framework to attain safe decision rules for distributed energy resources to support distribution grid voltage optimization. To address the sample dispersion issue, we leverage the CVaR as a regularization term on the prediction error and voltage deviation to systematically reduce the worst-case scenarios to improve the system safety. In addition, we propose a mini-batch selection algorithm to accelerate the training speed. Numerical tests using real-world data on the IEEE 123-bus test case demonstrate computation and safety improvements.

Sunday, 2 PM–3:15 PM

SD64

M - Indiana A

Learning and Data-driven Algorithms for Revenue Management

General Session

Session Chair

Negin Golrezaei, Massachusetts Institute of Technology, Lexington, MA

Session Chair

Jason Cheuk Nam Liang, MIT, MA

1 Intertemporal Pricing via Nonparametric Estimation: Integrating Reference Effects and Consumer Heterogeneity

Hansheng Jiang[1], Junyu Cao[2], Zuo-Jun Max Shen[3], [1]University of California, Berkeley, Berkeley, CA, [2]The University of Texas at Austin, Austin, TX, [3]University of California Berkeley, Berkeley, CA, Contact: hansheng_jiang@berkeley.edu

We consider intertemporal pricing in the presence of reference effects and consumer heterogeneity with arbitrary distributions. We use a nonparametric estimation method to learn consumer heterogeneity from transaction data. Further, we formulate the pricing optimization as an infinite horizon dynamic programming problem and solve it by applying a modified policy iteration algorithm. Moreover, we investigate the structure of optimal pricing policies and prove the sub-optimality of constant pricing policies even when all consumers are loss-averse according to the classical definition. Our numerical studies show that our estimation and optimization framework improves the expected revenue of retailers. We validate our model using real data from JD.com, a large E-commerce retailer, and find empirical evidence of consumer heterogeneity.

2 Decentralized Online Convex Optimization in Networked Systems

Judy Gan[1], Yiheng Lin[2], Guannan Qu[3], Yash Kanoria[1], Adam Wierman[2], [1]Columbia Business School, New York, NY, [2]California Institute of Technology, Pasadena, CA, [3]Carnegie Mellon University, Pittsburgh, PA, Contact:

ygan23@gsb.columbia.edu

We study the problem of networked online convex optimization, where a central planner must make individual node decisions online with the goal of minimizing a global cost. The global cost is a sum of three parts: convex node costs, temporal interaction costs, and spatial interaction costs. In deciding individual node's action at each time, an online algorithm has access to the exact predictions of local cost functions for the next k time steps in an r-hop neighborhood. Our work proposes a novel algorithm, Localized Predictive Control (LPC). We show that LPC achieves a competitive ratio approaching 1 exponentially fast in the lookahead steps k and locality radius r in an adversarial setting. Further, we show that the dependence on k and r in our results is near optimal by lower bounding the competitive ratio of any decentralized online algorithm.

3 Algorithmic Pricing in Competitive Markets with Consumer Reference Effects

Negin Golrezaei[1], Patrick Jaillet[2], Jason Cheuk Nam Liang[3], [1]Massachusetts Institute of Technology, Lexington, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT Operations Research Center, Cambridge, MA

Algorithmic pricing has become prevalent in online markets, where interactions between pricing algorithms have trained consumers to form price expectations (reference prices) over time. In this work, we study the interplay between algorithmic pricing and dynamic reference prices, and focus on long-term Stable Nash Equilibria (SNE), at which firms do not deviate and reference prices are invariant.

Under a cumulative-memory reference dynamic, we show SNEs always exist for markets where consumers are risk-neutral (RN) or risk-averse (RA), but does not necessarily exist for risk-seeking consumers. Focusing on the class of Online Mirror Descent algorithms, in RN markets we first show suitable step sizes allow global last-iterate convergence to an SNE. In RA markets with vanishing step sizes, we show that prices converge locally to an SNE in its last iterate.

4 Reducing Marketplace Interference Bias via Shadow Prices

Ido Bright[1], Arthur J. Delarue[2], Ilan Lobel[3], [1]Lyft, Seattle, WA, [2]Lyft, Cambridge, MA, [3]New York University, New York, NY, Contact: arthur.delarue@isye.gatech.edu

Marketplace companies rely on experimentation when making changes to their platforms, in particular using randomized controlled trials (RCT). However, marketplace interference leads to bias in standard RCT metrics. We propose a technique to reduce this bias in a setting where the platform explicitly matches supply with demand via an algorithm. Instead of comparing the total value accrued by the treatment and control groups, we instead compare each group's average shadow price in the matching linear program. In the fluid limit, our proposed technique corresponds to the correct first-order approximation of the value function of interest. Under reasonable assumptions, our estimator is less biased than the RCT estimator. Our key idea is that interference can be modeled explicitly in matching marketplaces since the platform itself mediates the spillover.

Sunday, 2 PM–3:15 PM

SD65

M - Indiana B

Energy and Sustainable Operations

General Session

Session Chair

Emre Nadar, Bilkent University, Ankara, Turkey.

1 Innovative Business Models in Ocean-bound Plastic Recycling

Opher Baron[1], Gonzalo Romero[2], ZHUOLUO ZHANG[3], Sean Zhou[4], [1]University of Toronto, Toronto, ON, Canada; [2]Rotman, University of Toronto, Toronto, ON, Canada; [3]Chinese University of Hong Kong, Hong Kong, Hong Kong; [4]Chinese University of Hong Kong, New Territories, Hong Kong. Contact: gonzalo.romero@rotman.utoronto.ca

30 million tons of plastic waste reach the ocean each year, most from developing countries. We study novel business models to address this global problem. Firms aim at profitably recycling plastic to reduce ocean pollution while positively impacting local communities. They sell (a) plastic offsets and (b) segregated plastic. We find that adopting both attains more environmental impact, gives a higher income to the collectors while enjoying a higher profit than (a) or (b) alone. However, the largest collectors' share of the local supply chain profit is attained by (b). Moreover, the largest social impact may be attained by (a). We use empirical data to calibrate our model and unveil additional insights.

2 Retreat, Defend, or Attack? Optimal Investment Decisions in Green Technology Under Competition

Osman Alp[1], Tarkan Tan[2], Maximiliano Udenio[3], [1]University of Calgary, Calgary, AB, Canada; [2]University of Zurich, Zurich, Switzerland; [3]KU Leuven, Leuven, Belgium. Contact: osman.alp@ucalgary.ca

Firms that invest in more sustainable technologies as a proactive measure against changing market dynamics are likely to gain a significant competitive advantage. We analyze a firm's optimal green investment strategy, accounting for the uncertainty in the competitors' actions and the future green market size. We develop a stylized model under three stages and characterize the optimal policy as `Retreat', `Defend', or `Attack' strategy when green market size is known, one of which is optimal based on the problem parameters. We conduct theoretical and numerical analyses regarding the optimal solution and the regret associated with making sub-optimal decisions, when the green market size is random.

3 Making Community Solar Work for the Community

Siddharth Singh[1], Owen Wu[2], [1]UCL School of Management, London, United Kingdom; [2]Indiana University, Bloomington, IN, Contact: siddharth.singh@ucl.ac.uk

Fueled by policy effortsto decarbonize the electricity grid, intermediate scale solar projects aregaining traction through community solar, an innovative business model in whichresidential customers pay an ongoing subscription fee for a share of solarcapacity. These customers are compensated for the generation of their share bythe utility, at a bill credit rate set by the regulator. This bill credit rateis typically a flat per-unit credit, independent of customer type andsubscription size. Using an analytical model that that endogenizes the adoptiondecisions of heterogeneous customers, we illustrate the importance of using anappropriate, and possibly richer, bill credit rate structure to ensure thatcommunity solar really works for the community in terms of generating anddistributing value to the community members.

4 Optimal Procurement in Remanufacturing Systems with Uncertain Used-item Condition

Emre Nadar[1], Mustafa Akan[2], Laurens G. Debo[3], Alan Scheller-Wolf[4], [1]Bilkent University, Ankara, Turkey; [2]Carnegie Mellon University, Pittsburgh, PA, [3]Dartmouth College, Hanover, NH, [4]Tepper School of Business, Pittsburgh, PA, Contact: akan@cmu.edu

We consider a single-product remanufacture-to-order system with multiple uncertain quality levels for used items. The quality level of a used item is only revealed after it is acquired and inspected; the remanufacturing cost is lower for a higher quality item. Modeling this system as a Markov decision process, we seek an optimal policy that specifies when a used item should be procured, and whether an arriving demand for the remanufactured product should be satisfied and which available item should be remanufactured to meet this demand. Taking into account the system congestion level measured as the number of available items and their quality levels, we establish the optimality of a state-dependent non-congestive acquisition policy.

Sunday, 2 PM–3:15 PM

SD66

M - Indiana C

Energy Supply Chain Optimization

General Session

Session Chair

Merve Merakli, ExxonMobil, Woodlands, TX

1 Integrated Network Optimization for Oil Production Using Mixed-integer Linear Programming

Emmanuel Ogbe[1], Jose Santiago Rodriguez[2], Francisco Trespalacios[2], Neal Adair[1], Keith Zorn[2], [1]ExxonMobil, Spring, TX, [2]ExxonMobil, Spring, TX, Contact: emmanuel.ogbe@exxonmobil.com

Maximizing oil production requires the optimization of a complex system involving intricate nonlinear relationships between wells, flowlines, and surface equipment. In this presentation, we establish a mixed-integer linear model for global optimization of an integrated oil production network. The model integrates piecewise-linear approximations for nonlinear multiphase flow behavior in wells and pipelines into a production system model whose objective is to maximize oil rate. When compared to well-established oil optimization tools, the proposed approach achieves both increased production and a significant reduction in computational time. We will discuss the mathematical model and present results for two real offshore production systems.

2 Spatially Explicit Optimization of Biofuel Supply Chains

Christos Maravelias, Eric O'Neil, Princeton University, Princeton, NJ

Producing a substantial amount of biofuel from dedicated cellulosic biomass requires a significant amount of land to be converted to growing energy crops; however, the locations best suited to plant crops are dependent on supply chain (SC) factors such as facility location, technology selection, carbon capture and storage (CCS) considerations. We introduce a spatially explicit MIP model that considers the upstream design of the landscape (crop establishment and fertilization), the SC network design (including inventory, transportation, and biorefinery location and capacity) and technology selection with CCS from a wide array of options. The uneven spatial distribution of biomass, and the differences in price and GHG impact between electricity grids motivate studying biorefinery technology tradeoffs (including CCS) and biomass SCs simultaneously.

3 Marine Circuit Inventory Routing

Rick Zhu[1], Ben Sauk[2], Ryan Ryan Gwaltney[2], Stefanos Baratsas[1], [1]ExxonMobil Technology and Engineering Company, Spring, TX, [2]ExxonMobil Technology and Engineering Company, Spring, TX

Marine Circuit Inventory Routing

We focus on a marine circuit inventory routing problem including: inventory levels and demand for multiple products at multiple ports, tank limits, vessel and port constraints, multiple relative operating costs, and a variety of objectives. We utilize several advanced mathematical programming techniques with a proprietary in-house heuristic algorithm to determine optimal sequence of port visits and product discharge rates to achieve lowest cost, with excellent computational performance.

We handle a complex inventory routing problem considering 20+ ports across several sub regions, multiple products with different priority, and varying numbers of vessels. Our optimal solution can not only consistently outperform existing routes the user derived but also identify non-intuitive opportunities.

4 Assessing Mixed-integer Optimization Models for the Design of Shale Oil Gathering Networks

Demian J. Presser[1], Renzo O. Piccoli[1], Diego Cafaro[2], Ignacio E. Grossmann[3], Yufen Shao[4], Yuanyuan Guo[5], Kevin C. Furman[6], [1]INTEC (UNL-CONICET), Santa Fe, Argentina; [2]INTEC(UNL-CONICET), Santa Fe, Argentina; [3]Carnegie Mellon University, Pittsburgh, PA, [4]ExxonMobil Upstream Research Co, Spring, TX, [5]ExxonMobil Upstream Research, Conroe, TX, [6]ExxonMobil, Houston, TX, Contact: demianup@gmail.com

The design of shale oil gathering networks comprises topological and fluid dynamics considerations. While topological decisions define connections between wellheads, junction nodes and processing facilities, complex fluid dynamics models determine the performance of the pipeline network, and the feasibility of managing production flows over time. The optimal design of gathering networks is addressed in this work with mixed-integer programming models at different levels of detail and complexity, assessing their impact on the quality of the solution. We investigate the effects of alternative topologies and correlations, and provide insights on the need of more detailed approaches, as well as the computational cost of more accurate solutions.

Sunday, 2 PM–3:15 PM

SD67

M - Indiana D

Machine Learning and Data Analytics for Revenue Management

General Session

Session Chair

Ruihao Zhu, Purdue Krannert School of Management, Chicago, IL

1 Detecting Production Planning Problems in Commercial Kitchens

Elena Belavina[1], Yu Nu[2], Karan Girotra[3], [1]Cornell University, New York, NY, [2]Cornell Tech/Cornell University, New York, NY, [3]Cornell Tech/Johnson Cornell University, New York, NY, Contact: belavina@cornell.edu

Sub-optimal inventory management decisions are the root cause of food waste. While laboratory experiments have identified several behavioral errors that drive this sub-optimality, detecting instances of such errors in real-time in a real-world food production environment remains a challenge. In this study, we develop several econometric-modeling based and deep-learning based classifiers to detect common production problems using real-world data streams. We assess the performance of different estimators in different data environments, ranging from full instrumentation—where ordering, production, consumption, and waste data are all recorded—to settings where only the food waste may be recorded. We also evaluate the importance of auxiliary data (such as cooking time, shelf life, batch size) in problem detection.

2 Deep Learning for Visual Advertising on Digital Platforms: Asymptotically Optimal Image Selection

N. Bora Keskin[1], Yuexing Li[1], Shaoxuan Liu[2], Jing-Sheng (Jeannette) Song[1], [1]Duke University, Durham, NC, [2]Shanghai Jiao Tong University, Shanghai, China. Contact: yl492@duke.edu

We consider a digital platform that aims to crop and display a large number of images to maximize customer conversions, i.e., the customer purchasing decisions. For each image, the platform chooses a cropping window and observes the resulting conversions. The platform does not know how cropped images influence conversions. We design a novel two-stage deep learning policy that dynamically learns this relationship and adjusts images to maximize conversions. We derive a theoretical performance guarantee proving the asymptotic optimality of our policy. The A/B testing results showcase that our policy increases the platform revenue by a substantial amount. The case studies based on a real-life data set also reveal that our policy exhibits good performance even if the functional relationship between images and conversion is misspecified.

3 Optimal Experimental Design for Staggered Rollouts

Ruoxuan Xiong[1], Susan Athey[2], Mohsen Bayati[2], Guido Imbens[2], [1]Emory University, Atlanta, GA, [2]Stanford University, Stanford, CA, Contact: ruoxuan.xiong@emory.edu

In this paper, we study the design of experiments that are conducted on a set of units for multiple time periods. These experiments are particularly useful to study the treatments that have causal effects on both current and future outcomes. The design problem involves selecting a treatment time for each unit to most precisely estimate the treatment effects, post experimentation. The optimization is an NP-hard integer program. We provide a near-optimal solution when the design decisions are performed all at the beginning. Next, we study sequential experiments that allow for adaptive decisions during the experiments, and early stops of the experiments. We propose a new algorithm, PGAE, that combines ideas from Bayesian statistics, dynamic programming, and sample splitting. PGAE can adaptively make treatment decisions and draw valid post-experimentation inferences.

4 Context-based Dynamic Pricing with Separable Demand Model

Chonghuan Wang[1], David Simchi-Levi[2], Jinzhi Bu[3], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Massachusetts Institute of Technology, Hong Kong, Hong Kong. Contact: chwang9@mit.edu

We consider context-based dynamic pricing with unknown demand over a selling horizon of T periods. Motivated by the empirical evidence from the real-world dataset, we consider the demand function with a separable structure of the form $f(p)+g(x)$, where p and x denote the price and features. We systematically characterize the statistical complexity of the online learning problem under different assumptions of $f(p)$ and $g(x)$. Specifically, we study three different demand models: (i) $f(p)$ is linear and $g(x)$ is non-parametric; (ii) $f(p)$ is non-parametric and $g(x)$ is linear; and (iii) $f(p)$ and $g(x)$ are non-parametric. For each model, we design an efficient algorithm with provable regret upper bound, and establish a matched lower bound except for an extreme case in model (iii). Finally, we extend to the setting where $g(x)$ is also separable, and show the regret can be further reduced.

Sunday, 2 PM–3:15 PM

SD68

M - Indiana E

Advances in Revenue Management

General Session

Session Chair

Tarek Abdallah, Northwestern University, Kellogg School of Management, Chicago, IL

1 New Approach to Dynamic Pricing

Tarek Abdallah, Northwestern University, Kellogg School of Management

We study a dynamic pricing problem when the firm is selling a single item with limited inventory. We propose a new scaling regime to study this problem where we scale the arrival rate in order to capture markets where demand is high but inventory is limited. We provide closed form asymptotic solutions for the optimal static and dynamic pricing policies in this regime.

2 Pricing Strategies for Online Dating Platforms

Titing Cui, Michael L. Hamilton, University of Pittsburgh, Pittsburgh, PA, Contact: tic54@pitt.edu

In recent years dating apps have become the most common way for new couples to meet. Many of these dating apps use subscription based pricing (SP), where subscriptions to the app are sold at a fixed price. In online dating SP may be controversial as it potentially misaligns the incentives of the platform and its users. The length of these subscriptions periods varies across platforms, but the most extreme version is contract pricing (CP), where the dating app is contracted at a one time price. We study the profit and welfare trade-offs associated with the length of the subscription period, and show that SP offers robust profit guarantees, but for some markets CP may increase both profit and welfare while correcting incentive issues.

3 Hybrid Model for Sequential and Simultaneous Choice with Search Cost

Ruxian Wang, Johns Hopkins University, Carey Business School, Kensington, MD, Contact: ruxian.wang@jhu.edu

We propose a hybrid model to study sequential and simultaneous choice behavior in the presence of search cost. After examining all products in an assortment, a rational consumer decides whether to continue searching. Switching from one assortment to another often incurs a search cost related to transportation expense or time.

4 Learning Consumer Valuation from Bundle Sales

Ningyuan Chen, Setareh Farajollahzadeh, Guan Wang, University of Toronto, Toronto, ON, Canada. Contact: ningyuan.chen@utoronto.ca

When the firm offers bundles of products at discounted prices, one cannot observe the information of the consumers' valuations for individual products from the sales data. Instead, we can only infer the valuation of the bundle. To learn the consumer valuations for individual products from such data, we formulate the inference problem to estimate the distribution of consumers' valuations from the transaction data with bundles and show the equivalence to an inference problem when the observations are censored by polyhedral regions. We develop EM algorithms to estimate the mean and variance of the high-dimensional valuation distribution and provide theoretical guarantees.

Sunday, 2 PM–3:15 PM

SD69

M - Indiana F

Next Generation Experimentation Platforms

General Session

Session Chair

Vivek Farias, MIT, Cambridge, MA

Session Chair

Andrew T. Zheng, Massachusetts Institute of Technology, Boston, MA

Session Chair

Tianyi Peng, Pasadena, CA

1 Markovian Interference in Experiments

Vivek Farias, MIT, Cambridge, MA

We consider experiments in dynamical systems where interventions on some experimental units impact other units through a limiting constraint (such as a limited inventory). Despite outsize practical importance, the best estimators for this `Markovian' interference problem are largely heuristic in nature, and their bias is not well understood. We formalize the problem of inference in such experiments as one of policy evaluation. Off-policy estimators, while unbiased, apparently incur a large penalty in variance relative to state-of-the-art heuristics. We introduce an on-policy estimator: the Differences-In-Q's (DQ) estimator. We show that the DQ estimator can in general have exponentially smaller variance than off-policy evaluation. At the same time, its bias is second order in the impact of the intervention. This yields a striking bias-variance tradeoff so that the DQ estimator effectively dominates state-of-the-art alternatives. From a theoretical perspective, we introduce three separate novel techniques that are of independent interest in the theory of Reinforcement Learning (RL). Our empirical evaluation includes a set of experiments on a city-scale ride-hailing simulator.

2 Synthetic Interventions (i.e., Synthetic A/B Testing)

Anish Agarwal, Massachusetts Institute of Technology, Newton, MA

We introduce the synthetic interventions (SI) framework which connects causal inference with tensor completion. We represent the various potential outcomes (i.e., counterfactuals) of interest through an order-3 tensor. The key theoretical results presented are: (i) Formal identification results establishing under what missingness patterns, latent confounding, and structure on the tensor is recovery of unobserved potential outcomes possible. (ii) The SI estimator to recover these unobserved potential outcomes and proving it is finite-sample consistent and asymptotically normal. We use SI on high-impact applications: (i) TaurRx Therapeutics to identify patient sub-populations where their therapy was effective. (ii) Uber Technologies on evaluating the impact of driver engagement policies without running an A/B test.

3 Provably Efficient Reinforcement Learning for Partially Observable Systems

Masatoshi Uehara, Cornell, New York, NY

We study Reinforcement Learning for partially observable systems using function approximation. We propose a new PO-bilinear framework, that is general enough to include models such as undercomplete tabular Partially Observable Markov Decision Processes (POMDPs), Linear Quadratic Gaussian (LQG), Predictive State Representations (PSRs), as well as a newly introduced model Hilbert Space Embeddings of POMDPs. Under this framework, we propose an actor-critic style algorithm that is capable to performing agnostic policy learning. Given a policy class that consists of memory based policies (i.e., policy that looks at a fixed-length window of recent observations), and a value function class that consists of functions taking both memory and future observations as inputs, our algorithm learns to compete against the best memory-based policy among the policy class.

4 Regret Bounds and Experiment Design for Estimate-then-optimize

Samuel Tan, Peter Frazier, Cornell University, Ithaca, NY, Contact: sst76@cornell.edu

In many real-world applications, the pipeline from data to decisions involve two steps: estimation and optimization. First, a user employs a machine learning model to estimate parameters for an optimization problem, and then they solve that problem using the learned parameters, as if they are correct. This approach is often termed "estimate-then-optimize." However, errors in the estimation step can lead to sub-optimal decisions, where the resulting loss in objective function value is known as regret. Our contribution is a novel bound on this regret when using estimate-then-optimize for smooth and unconstrained optimization problems and a method of using the bound to guide experiment design. In particular, when the fitted parameters are asymptotically normal, we provide a general procedure for experiment design to minimize the regret from estimate-then-optimize.

Sunday, 2 PM–3:15 PM

SD70

M - Indiana G

ML2OR Pipelines

General Session

Session Chair

Meinolf Sellmann, InsideOpt, Cortlandt Manor, NY

1 Neural Networks and Column Generation for Parallel Machine Scheduling

Amira Hijazi, Osman Ozaltin, Reha Uzsoy, North Carolina State University, Raleigh, NC, Contact: amhijazi@ncsu.edu

We present a neural network-based column generation (CG) approach for the parallel machine scheduling problem. Each iteration of CG consists of solving a restricted master problem to construct a solution where all jobs are processed and a pricing subproblem for each machine to generate a new column for a subset of jobs to be processed on that machine. We propose to use an encoder-decoder attention model based on the transformer architecture to learn the job sequencing problem on the parallel machines and thus generate columns to add to the master problem. We train this model and present computational results.

2 Tree Search Configuration: Cutting Planes and Beyond

Maria-Florina Balcan[1], Siddharth Prasad[1], Tuomas Sandholm[1], Ellen Vitercik[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Stanford University, Palo Alto, CA, Contact: vitercik@stanford.edu

Cutting-plane methods have enabled remarkable successes in integer programming over the last few decades. State-of-the-art solvers integrate a myriad of cutting-plane techniques to speed up the underlying tree search algorithm used to find optimal solutions. In this talk, we provide the first sample complexity guarantees for learning high-performing cut-selection policies tailored to the instance distribution at hand using samples. We then develop a general abstraction of tree search that captures key components such as node selection and variable selection. For this abstraction, we bound the sample complexity of learning a good policy for building the search tree.

3 Fitting General and Regression Hyperplanes in the Presence of Confounding Outliers

John W. Chinneck[1], J. Paul Brooks[2], [1]Carleton University, Ottawa, ON, Canada; [2]Virginia Commonwealth University, Richmond, VA, Contact: chinneck@sce.carleton.ca

Finding a good hyperplane fit for a large data set in many variables in a small amount of time is a challenging computational problem. A main difficulty is recognizing and removing confounding outliers before making a fit because outliers (especially clustered outliers) can severely skew many fitting methods. We present new methods for fitting hyperplanes to general datasets (to match the points) and for regression (to match the output variable values). We compare our methods to other state-of-the-art hyperplane fitting methods and show that they produce better fits in much less time. The new methods are very fast and scalable and easily handle data sets having thousands of data points in small amounts of time.

4 Capacitated Vehicle Routing with Stochastic Loading Constraints

David Winkelmann, Jakob Schulte, André Hottung, Bielefeld University, Bielefeld, Germany. Contact: david.winkelmann@uni-bielefeld.de

Using homogenous vehicles for the shipping process of packages requires allocating customers to tours with respect to constraints resulting from the characteristics of the vehicle. However, if the shape of packages is highly heterogeneous, the achievable fill rates vary and are unknown when the tours are determined. This leads to an optimisation problem under uncertainty addressing the trade-off between routing costs and penalty costs if not all packages can be loaded into the trucks as planned. We propose to model the problem as a CVRP that integrates a binary regression model to estimate the probability that the packages do not fit into a truck. Using Taylor series expansion of the exponential function allows to reduce the transformation of the linear predictor to a polynomial term, which can be directly incorporated into the Gurobi optimiser.

Sunday, 2 PM–3:15 PM

SD71

M - Arizona

Political Redistricting

General Session

Session Chair

Maral Shahmizad, Oklahoma State University, Stillwater, OK

1 A Linear-size and Integral Model for Partitioning Planar Graphs with Application in Political Redistricting

Jack Zhang[1], Hamidreza Validi[1], Austin Buchanan[2], Illya V. Hicks[1], [1]Rice University, Houston, TX, [2]Oklahoma State University, Stillwater, OK, Contact: dz27@rice.edu

In this paper, we propose a linear-size and integral formulation with size O(n) for partitioning a planar graph with n vertices into k rooted subtrees. We prove the integrality and correctness of the formulation. We employ the linear-size formulation as the base model to solve the US redistricting problem at county and tract levels respecting three basic criteria: (i) population balance, (ii) connectivity, and (iii) compactness. We conduct a set of computational experiments on the 2020 census data at county and tract levels. We also computationally compare the proposed model with an existing compact model in the literature. Our code and data are available on GitHub.

2 Political Redistricting Optimization with Recombination

Kiera W. Dobbs[1], Douglas M. King[2], Sheldon H. Jacobson[3], [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]U of Illinois at Urbana-Champaign, Urbana, IL, [3]University of Illinois, Urbana, IL

Optimization methods can promote political fairness, transparency, and public engagement in the redistricting process. Although exact methods laid the foundation for political redistricting, realistic instances continue to require heuristics. With a case study on Illinois congressional redistricting, we examine two methods for transitioning between feasible district plans within local search optimization: a more traditional Flip iteration and a recently introduced spanning tree iteration (Recombination). Although local search with Recombination is slower than with Flip, it consistently produces district plans with better objective values.

3 Political Districting to Minimize County Splits

Maral Shahmizad, Austin Buchanan, Oklahoma State University, Stillwater, OK

When partitioning a state into political districts, a common criterion is that political subdivisions (e.g., counties) should not be split across multiple districts. While this criterion is sometimes enforced quite strictly by state law and the courts, it is typically not known how much splitting is truly necessary. We consider two related questions: What is the maximum number of counties that can be kept whole? What is the minimum number of county splits necessary? To answer these questions, we use techniques from integer programming and apply them to USA redistricting instances.

4 A Benders Decomposition Approach for Solving the Majority-minority Districting Problem

Samuel Kroger, Hamidreza Validi, Tyler Perini, Illya V. Hicks, Rice University, Houston, TX, Contact: sak8@rice.edu

Section 2 of the Voting Rights Act enacts creating majority-minority districts to provide minority groups with opportunities to elect representatives of their choice. A majority-minority district is created if at least the following conditions (“Gingles prongs”) are satisfied: (i) compactness and numerosity, (ii) political cohesion, and (iii) sufficiency of white majority vote to defeat the preferred candidate of minorities. Furthermore, if the first condition is not satisfied, then there is no requirement on creating a majority-minority district. Although the second and third Gingles prongs are qualitative measures, the first prong can be captured by mathematical models and algorithms. In this talk, we present a mixed integer programming formulation and a decomposition method for solving the majority-minority districting problem at county and tract levels.

Sunday, 2 PM–3:15 PM

SD72

M - California

Business Value of Social Media Analytics

General Session

Session Chair
Sukhwa Hong, University of Hawaii at Hilo, Hilo, HI

1 Predicting Mortgage Loan Origination Delays with Text Mining

David Goldberg, San Diego State University, San Diego, CA

Mortgage loan origination, or the process of initiating new loans, is a complex process involving many steps. As a result, the process is rife with delays. We analyze internal conversation transcripts from a large mortgage firm to determine unique words and phrases predictive of delays. We show that predictive models based upon these words and phrases are capable of flagging likely delays before they occur. These results enable cost-saving managerial interventions.

2 Information Disclosure Scores on the Use of Social Media

Daeeun Daniel Choi, California State University, Northridge, Northridge, CA

Smart technology (e.g., the Internet of Things, big data, and artificial intelligence) interacts with various social media to attract consumer attention and improve companies' business values. Collecting and managing consumers' personal information has become the center of their business strategies. However, severe privacy risks threaten consumers because of the disclosed new types of personal information, although many consumers do not recognize the gravity of privacy vulnerability issues. Thus, we adopt a design science research approach to educate consumers about their information disclosure tendency. This study creates individual information disclosure scores when adopting smart technology.

3 Feeling Strong by Mourning in Online Health Communities

Eduardo Villacis-Calderon, Virginia Tech

Online health communities (OHCs) provide virtual spaces where people can exchange social support. Given the nature of conversations, OHCs can quickly become negatively valenced, in which feelings of sadness, anger, and frustration are predominant. These negative emotions can create toxic virtual spaces that people might want to avoid. However, in OHCs, people find a sense of community in which negative valenced communities can bring them together with similar others instead of alienating them. We part from the premise that not all negative experiences contribute to building stronger communities. Therefore, this research investigates virtual interactions that, although negatively valenced, contribute to building strong OHCs.

4 Automated Text Summarization for the Enhancement of Effective Communication

Sukhwa Hong, University of Hawaii at Hilo, Hilo, HI

In this study, we propose a novel abstractive automatic text summarization (ATS) method that first represents the source documents as an intermediate representation and then generates the summary sentences, which do not appear in the original documents for effective communication with the stakeholders. Furthermore, we incorporate a novel deep neural machine translation for generating summary sentences into our summarization process to generate more readable and persuasive summaries. Human assessment is often used to evaluate ATS quality, which makes the evaluation process vague and inconsistent. Therefore, we further incorporate more sophisticated evaluation criteria such as readability and more complex measures such as persuasiveness into our model that are used to determine the quality of the proposed method.

Sunday, 2 PM–3:15 PM

SD73

M - Colorado
Challenges in Preferences and Equity in Service Systems
General Session

Session Chair
Hanwei Li, Cambridge, MA

1 Course Selection Under Correlated Rankings

Zhenyu Hu, Jussi Keppo, Meixi Wu, National University of Singapore, Singapore, Singapore. Contact: meixi@u.nus.edu

When making course selections, students consider their own assessment of each course's quality and also their peers' course selections. We model each student's quality score for different classes by a factor model comprising a common factor and an idiosyncratic factor. We then analyze course bidding mechanisms, where students' priorities are correlated, and we characterize the equilibrium action profile. The model is identifiable and can be estimated using Bayesian inference. The model can also be applied to other settings, such as job applications.

2 **Managing Spatial Equity in Urban Services: Evidence from the Bike-sharing Industry**

Qihang Yang[1], Weiming Zhu[2], Victor Martinez de Albeniz[3], Jianfeng Lin[1], Zhaochen Dong[1], Jinglong Dai[1], [1]Meituan, Beijing, China; [2]HKU Business School, Hong Kong, Hong Kong; [3]IESE Business School, Barcelona, Spain. Contact: weimingz@hku.hk

Urban services such as dockless bike sharing and last-mile delivery tend to occupy public space while providing service to the targeted users. In regions where the demand for such services is high, the service level may increase, leading to public areas being used more heavily, resulting in spatial equity concerns both on consumer service and the use of public space. In this paper, using the dockless bike-sharing system as an example, we build a mixed-integer program and a reinforcement learning model to determine the optimal bike redistribution policy subject to spatial equity constraints, which are defined by imposing an upper bound on the percentage of the pedestrians that bikes can block. We then conduct a randomized field experiment with Meituan Bike to identify the potential revenue loss due to more equitable redistribution.

3 **Presenter**

Huan Cao, Greenbelt, MD

4 **Assortment Display, Price Competition, and Fairness in Online Marketplaces**

Michelle Wu, MIT Institute for Data, Systems, and Society, Cambridge, MA

Online platforms have been expanding the seller base to widen their product assortment to match the heterogeneous preferences of consumers. Nevertheless, the increasing number of sellers leads to intensified competition and results in sellers setting lower prices for the products. Thus, it is unclear whether displaying all the sellers to the entire customer base maximizes platform revenue. Motivated by the unique setting of Airbnb, we consider a game-theoretical setup in which each seller on the platform provides a single-unit product to a heterogeneous customer base and competes with one another on price. We investigate sellers' optimal pricing decisions and the platform's optimal assortment display policy, which is characterized by the partitioning of products and traffic assigned to each partition. We find that the platform should display the entire assortment to all the customers when demand is sufficiently high. Moreover, we propose a tabulation algorithm and a mixed-integer programming formulation to effectively solve for the sellers' and the platform's optimal decisions. Additionally, we incorporate constraints to guarantee a certain degree of the seller and customer fairness, on both the system and individual level, in the optimal display policy. Using data from Airbnb, we present a case study to illustrate how our model framework can be applied in practice. Finally, we extend the case in which each seller supplies a distinct product with an inventory size of one by considering scenarios in which each product has more than one unit.

Sunday, 2 PM–3:15 PM

SD74

M - Florida

Portfolio Risk and ESG

General Session

Session Chair

Steve Y. Yang, Stevens Institute of Technology, Hoboken, NJ

Session Chair

Ruixun Zhang, Peking University, Beijing, China.

1 **Quantifying the Impact of Impact Investing**

Andrew W. Lo[1], Ruixun Zhang[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Peking University, Beijing, China, China. Contact: zhangruixun@pku.edu.cn

We propose a quantitative framework for assessing the financial impact of any form of impact investing, including ESG and other non-financial criteria. We derive conditions under which impact investing detracts from, improves on, or is neutral to the performance of traditional mean-variance optimal portfolios, which depends on whether the correlations between the impact factor and unobserved excess returns are negative, positive, or zero, respectively. Using Treynor-Black portfolios to maximize the risk-adjusted returns of impact portfolios, we propose a quantitative measure for the financial reward, or cost, of impact investing compared to passive index benchmarks. We illustrate our approach with applications to biotech venture philanthropy, divesting from ``sin'' stocks, investing in ESG, and ``meme'' stock rallies such as GameStop in 2021.

2 **The Cost of ESG Investing**

Christoph Schiller, Arizona State University, Tempe, AZ

Even against increasing interest in socially responsible investing mandates, we find that implementing ESG strategies can cost nothing. Modifying optimal portfolio weights to achieve an ESG-investing tilt negligibly affects portfolio performance across a broad range of ESG measures and thresholds. This is because those ESG measures do not

provide information about future stock performance, either in relation to risk or mispricing, beyond what is provided by other observable firm characteristics. That the stock market does not reflect significant equilibrium pricing of ESG information is rationalized in a model of responsible investing wherein investors differ in which ESG-related criteria are used to weight their portfolios.

3 Financial Cost of Carbon

Zachery Halem, Lazard Climate Center, New York City, NY

This paper provides new evidence showing that carbon transition risk is becoming increasingly material and is priced both in equity and debt markets. We find that there is a widespread price-earnings discount linked to corporate carbon emissions. This discount varies, however, by sector and trends differently in Europe than in the US. We also find that a small discount emerges for corporate bonds, although it is statistically significant only for small caps. Finally, we find evidence that the pricing discount also emerges, albeit to a smaller extent, for other greenhouse gas emissions.

Sunday, 2 PM–3:15 PM

SD75

M - Illinois

Recent Advances in FinTech and Quantitative Finance

General Session

Session Chair

Ning Cai, Hong Kong University of Science and Technology, Kowloon, Hong Kong SAR, China.

1 How and When are High-frequency Stock Returns Predictable?

Jianqing Fan[1], Yacine Ait-Sahalia[2], [1]Princeton University, Princeton, NJ, [2]Princeton University, Princeton, NJ

This paper studies the predictability of ultra high-frequency stock returns and durations to relevant price, volume and transactions events, using machine learning methods. We find that predictability in high frequency returns and durations is large, systematic and pervasive over short horizons. We identify the relevant predictors constructed from trades and quotes data and examine what determines the variation in predictability across different stock's own characteristics and market environments. Next, we compute how the predictability improves with the timeliness of the data. Finally, we simulate the impact of getting an (imperfect) peek at the incoming order flow in terms of improving the predictability of the following returns and durations.

2 Foreign Exchange Market Frictions and Remedies for Companies

Haokun Du[1], Yan Zeng[2], Wenhui Zhao[3], [1]UTD, Richardson, TX, [2]SYSU, Guangzhou, China; [3]SJTU, Shanghai, China.

Frictions in foreign exchange market lead to inefficiencies in internationally operating companies. The conversion costs stemmed from centralized financial market can be remedied through decentralized tradings, as inspired by a Chinese company and other anecdotal evidence. Two mechanisms, forward contract and ad-hoc contract, are considered. Although ad-hoc contract utilizes more information and is locally optimal at any information set, it distorts incentives, having less potential in raising quantities, and leading to possible coordination issues. We argue that a "one-size-fits-all" forward contract can outperform ad-hoc contract in most relevant cases. We also discuss other possibilities.

3 Robustness of Stackelberg Mean-field Games Through an Optimization Lens

Jiacheng Zhang, UC Berkeley, IEOR department, Berkeley, CA, Contact: jiachengz@berkeley.edu

We consider a discrete-time Stackelberg mean field game (SMFG) with one leader and an infinite number of homogeneous followers. Stackelberg game has attracted recent interest modeling an asymmetric, general sum game between leaders and followers. We focus on a robust setting where the followers have bounded rationality and only aim at achieving some $\ep$-Nash equilibrium (NE) while the leader wants to maximize her objective in the worst case scenario among all $\ep$-NEs. We formulate this problem into an explicit minimax optimization problem and propose algorithms to solve the problem when the leader has a finite number of actions. Finally, we also study the sensitivity analysis when the leader only has access to some perturbed model and our results suggest that one needs to be more pessimistic in this case and solve a relaxed problem to obtain a near optimal solution.

4 Total Positivity and Option Pricing

Dan Pirjol[1], Paul Glasserman[2], [1]Stevens Institute of Technology, Hoboken, NJ, [2]Stevens Institute of Technology, New York, NY, Contact: dpirjol@stevens.edu

Option prices are not convex in maturity or volatility; however it was shown recently that in the Black-Scholes model, the price of an option is convex in the price of an at-the-money option with the same maturity. We extend this result to a more general class of models satisfying a total positivity

(TP) property.We derive several implications of the TP property, including: i) monotonicity of option price ratios C(K,T)/C(F,T) in the maturity T variable; ii) constraints on the slope of the ATM skew. Empirical tests of the TP property suggest that it holds to a good approximation close to the at-the-money region.

Sunday, 2 PM–3:15 PM

SD76

M - Michigan

Information Systems Flash Session

Flash Session

Session Chair

Ruba Aljafari, University of Pittsburgh, Pittsburgh, PA

1 Black Music Matters as Well? The Spillover Effects of #blacklivesmatter on Digital Music Consumption in the United States

Yifei Wang[1], Gorkem Ozer[2], Anandasivam Gopal[3], [1]University of Maryland, College Park, MD, [2]University of New Hampshire, Durham, NH, [3]Nanyang Technological University, Singapore, Singapore.

Social movements and music are closely intertwined. In this paper, we examine how the pattern of music consumption across popular music genres may be systematically affected by the Black Lives Matter (BLM) movement in the summer of 2020. Furthermore, we explore how changes in the music consumption associated with BLM may vary across subgroups of artists, driven by the interactive effects of artist race and gender. Using streaming data from Spotify, we observe a clear and significant effect of BLM 2020 on the diversity of music streaming across genres and artists. Our paper shows that social movements that seek to address racial equality led to meaningful changes in the music consumption patterns.

2 Online Review Censorship

Aida Sanatizadeh[1], Gordon Burtch[2], Kevin Hong[3], Yuheng Hu[4], [1]University of Illinois at Chicago, Chicago, IL, [2]Boston University, Boston, MA, [3]University of Miami, Miami, FL, [4]University of Illinois-Chicago, Chicago, IL

Ample anecdotal evidence in the media notes that many businesses seek to 'silence' negative reviews, e.g., via legal threat. Despite attention toward this issue, we are aware of no systematic analyses addressing it. We address that gap here, leveraging review data from TripAdvisor.com. We show that a 1-star decrease in rating valence is associated with an approximate 25% (0.25 pp) increase in the probability of deletion. Additionally, we examine how freedom of expression (FoE) in a country associate with characteristics of (uncensored) online reviews. Lastly, we discuss implications for online ratings platforms, consumers, and research opportunities.

3 Does Board Gender Diversity Matter in It Investment

Yen-Yao Wang, Sidi Zhao, Pei Xu, Auburn University, Auburn, AL, Contact: yenyao@auburn.edu

This paper examines the role of corporate governance on IT investment by examining whether board gender diversity would influence IT investment. To address this research question, we merged three data sources: Computer Intelligence technology database for IT investment data, Institutional Shareholder Services for board information, and Compustat for firm performance-related data. Our sample has an unbalanced panel of 10,945 firm-year observations with 1,381 firms from 2007 to 2019. Using the firm-level fixed effects and fixed effects two-stage least squares models, we provide initial evidence that increased female board representation is positively associated with IT investment.

4 Adding AI to the Shared Medical Decision Model - How Medical AI Affects Patient-clinician Relationships

Jeff Clement[1], Sofia Bapna[2], Maura Jacobi[3], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota Carlson School of Management, Minneapolis, MN, [3]United Family Medicine at Allina Health, St. Paul, MN, Contact: cleme514@umn.edu

Artificial intelligence (AI) can improve medical decision-making by providing personalized diagnosis or treatment recommendations to overcome human judgement, especially in chronic or rare conditions. There are now more than 80 medical AI tools that have received FDA approval, and research continues to enhance our understanding of how clinicians employ these systems. However, little work has been done to understand how a clinician's use of AI and their subsequent decision to disclose the use of the AI tool (or not) impacts the patient-clinician relationship. We present preliminary results of a qualitative analysis to show that disclosing use of AI can increase trust in the doctor. On the other hand, consulting an AI system could signal that the doctor is less capable and qualified. We also present initial guidelines for discussing AI tools with patients.

5 A Novel Stackelberg Game to Understand the Incentivization of Federated Learning

Chaofan Zhai, Xuan Bi, Mochen Yang, University of Minnesota, Minneapolis, MN, Contact: zhai0045@umn.edu

Federated learning (FL), as a promising paradigm for data privacy, can help organizations cooperatively train a global machine learning model without exchanging their local data. However, the situations and incentivization under which organization cooperation exists are still open to discussion. In this work, we build a novel two-stage Stackelberg model, framing the role of a leader and a follower in FL. We find organizations perform distinct strategies under the heterogeneity in terms of data size, cost-benefit ratio, and the uncertainty of model success.

6 Empathic Interaction and Knowledge Exchange in Online Communities: An Expectation-satisfaction Perspective

Tao Wang, Pek-Hooi Soh, Simon Fraser University, Vancouver, BC, Canada. Contact: wangtaow@sfu.ca

Do users in online communities gain more knowledge when they display more empathy cues such as sadness and anxiety? Adopting expectation-satisfaction theory, we examine the impact of empathic interaction on knowledge acquisition in online communities. While empathy cues may elicit other's empathy and encourage helping behaviour, they also signal seeker's high expectation and potentially high cost. We hypothesize that online inquiries with more empathy cues will likely receive fewer but better-quality responses and that the provider's empathy is the mediating mechanism that dissipates the costs and improves the reply efforts. We found support from the log data of a public online community.

7 Value of Healthcare Information Technology and Advances in Medical Sciences: Can Patients Contribute?

Ruba Aljafari[1], Franck Loic Soh Noume[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of North Carolina, Greensboro, NC, Contact: raljafari@katz.pitt.edu

Research on the value of healthcare IT (HIT) suggests that patients are key information providers/recipients who realize value or contribute to value. The main assumption is that HITs operate in environments where medical practice is based on timely findings from medical sciences. However, healthcare industries express concerns about lack of advancement in medical sciences. HIT may support medical sciences by accessing and processing rich data, but less is known about the value of research capabilities that leverage IT (e.g., analytics/artificial intelligence) and whether the patient perspective matters. We explore synergies between these capabilities and HIT from the patient perspective.

8 Flash Paper

Agnes Yang, Jason Chan, University of Minnesota, Minneapolis, MN, Contact: yang6972@umn.edu

The goal of this study is to provide the initial understanding of the role of a decentralized autonomous organization (DAO) in Decentralized Finance (DeFi), both enabled by blockchain technologies. Whereas the rise of this collective decision-making system ostensibly promises a more democratic, effective decision-making, not only decisions are de facto driven by a handful of entities but the effectiveness remains questionable. In this study, we focus on the governance of DeFi, rapidly burgeoning financial markets that aim to replace traditional finance by removing intermediaries. We utilize exogenous cyberattack on the platform which is deadlier in the crypto world where code is law.

Sunday, 2 PM–3:15 PM

SD77

M - Texas

Behavioral Queueing Science, Special Issue of Operations Research

General Session

Session Chair

Kenneth Schultz, Unaffiliated, Englewood, OH

Session Chair

Armann Ingolfsson, [1</sup]

1 Physician Discretion and Patient Pick-up: How Familiarity Encourages Multitasking in the Emergency Department

Bradley R. Staats[1], RJ Niewoehner[2], Diwas S. KC[3], [1]UNC, Chapel Hill, NC, [2]UNC Kenan-Flagler Business School, Chapel Hill, NC, [3]Emory University, Atlanta, GA, Contact: Bradley_Staats@kenan-flagler.unc.edu

What leads Emergency Department physicians to select which patients, and how many patients, they will treat? Queuing models frequently assume individual servers operate independently of other servers. In contrast, we consider how familiarity between peer physicians affects patient selection and the chosen multitasking level, a process more commonly known in the ED as patient pick-up.

2 Balancing Agent Retention and Waiting Time in Service Platforms

Marcelo Osvaldo Olivares, Andres Musalem, University of Chile, Santiago, Chile.

Online platforms have enabled service companies to access a large pool of employees with flexible working hours, operating at low levels of utilization without increasing operating costs. We conduct an empirical study in an online call-center platform to analyze how worker utilization may also effect employees attrition and show how this trade-off should be accounted for in the design of the service platform to plan capacity in order to balance responsiveness with employee retention.

3 OR Special Issue on Behavioral Queueing Science: Summary

Armann Ingolfsson, University of Alberta, Edmonton, AB, Canada. Contact: armann.ingolfsson@ualberta.ca

The intent of the special issue of Operations Reseach on behavioral queueing science is to advance the dialogue between empirical researchers, data scientists, and mathematical modelers. We outline the ways in which the papers that will be published in the special issue advance knowledge about how servers and customers behave and interact, and how such behaviors can be inferred, modelled and analyzed.

4 The Relationship Between Expected Service Times and Service Rates in State-dependent Queues

Likang Ding[1], Bora Kolfal[2], Armann Ingolfsson[2], [1]University of Alberta, Edmonton, AB, Canada; [2]University of Alberta, Edmonton, AB, Canada. Contact: likang@ualberta.ca

Queueing models are typically formulated in terms of service rates but recent empirical queueing research focuses on expected service times. We analyze service times in Markovian queueing models with state-dependent service rates. Our primary research question is to analyze the relationship between service rates and expected service times. We provide closed-form solutions to convert service rates into expected service times and vice versa. Contrary to what is sometimes assumed, in general, expected service times are not the inverse of service rates, and service times in state-dependent Markovian systems are not exponentially distributed. We find conditions under which monotonicity in service rates implies monotonicity in expected service times and vice versa. Furthermore, we characterize service time distributions in state-dependent systems.

Sunday, 2 PM–3:15 PM

SD78

M - Utah

Information Systems and the Society

General Session

Session Chair

Xue Tan, Indiana University, Bloomington, IN

1 Preference or Bias: Characterizing Political Slants Toward Equity on a Donation Platform

SIyu Shi, Ian Ho, Brian Lee, Jingchuan Pu, Pennsylvania State University, State College, PA, Contact: siyu.shi@psu.edu

Political preferences refer to the support and attachment toward specific political ideologies. Political preferences directly induce political party affiliation and could indirectly affect non-political decision-making. We study the impact of political preferences on K-12 donations. Ideally, educational donations shall be need-based, i.e., the universal value across party affiliations. In our quasi-experiments, we show a fund-raising school on average suffers from a 2.82% loss of funds due to the party change of the state governor. Such a politics-driven loss leads to an additional disadvantage for majority-minority schools by 0.34%. We also confirm that the donations from the safe states (vs. swing states) are affected by the election results significantly, deviating from the original purpose of educational donations and hurting social welfare.

2 Learning from Machines: Can AI Tools Enhance Human Learning Online?

Mi Zhou[1], Arslan Aziz[1], Xiyang Hu[2], [1]UBC Sauder School of Business, Vancouver, BC, Canada; [2]Carnegie Mellon University, Pittsburgh, PA, Contact: mi.zhou@sauder.ubc.ca

The advancement of artificial intelligence (AI) has been profoundly changing business and society in different settings. In this research, we investigate whether, and how, AI tools can improve the outcome of human skill acquisition. We choose online chess as our research context as chess is a cognitively demanding analytical task that has advanced AI engines which can provide real-time performance analysis and feedback of chess games. We conduct a randomized field experiment to empirically estimate the causal impact of having access to AI-based analysis and feedback on the extent of improvement in user performance. We find that AI-based tools can significantly improve learners' performance by effectively identifying the weaknesses in their gameplay. Our paper contributes to the literature on the efficacy and efficiency of online learning with scalable AI-based tools.

3 Uncovering Demand Distributions and Consumer Network Effects --- Evidence from Vending Machine Transactions

Mingrui Zhang[1], Yong Tan[1], Xusen Cheng[2], [1]University of Washington, Seattle, WA, [2]Renmin University of China, Beijing, China. Contact: mz74@uw.edu

Vending machines are convenient and they allow customers to gain quick access to small items in a timely and cost-saving manner. We build a consumer network to uncover the consumer learning effect of visiting vending machines multiple times. Combining the settings information with the user information, we construct estimates of the vending machines' demand distributions in different settings across twenty-one million transactions from January 2019 to May 2022.

4 Product Positioning and The Value of Learning from Competitors

Jiaying Deng[1], Yingfei Wang[2], Yong Tan[2], Zhijie Lin[3], [1]Fordham University, bromx, NY, [2]University of Washington, Seattle, WA, [3]Tsinghua University, Beijing, China.

We aim to model suppliers' decision on product variety strategy. Product variety is an important strategic tool that suppliers can use to attract customers and respond to competition. However, sharing economy is different from traditional business model, because the supplier on the markets are non-professional individuals. Thus, it is still not clear whether individual suppliers learn from competitors. Some of them may lack the ability or knowledge to conduct marketing analysis, so, the variation in paying attention to the competitor's information can help us examine the value of learning from competitors. Also, we use a network embedding approach to measure the competitive market structure on the platform. In the second stage, we model suppliers' decision regarding the product variety strategy under different competition environment using a Bayesian learning model.

Sunday, 2 PM–3:15 PM

SD79

JWM - Room 201

Business Decision Making for Innovative Outcomes

General Session

Session Chair

Junghee Lee, University of Notre Dame, Notre Dame, IN

1 Designing Knowledge Driven Innovation Contests

Lakshminarayana Nittala[1], Sanjiv Erat[2], [1]University of Dayton, Dayton, OH, [2]University of California-San Diego, La Jolla, CA

Innovation contests are studied primarily as a mechanism to obtain extreme valued solutions. In the current work we propose that the conceptualization of innovation contests needs to be expanded to also consider the long-term benefits from the knowledge/capabilities generated by the contestants' efforts. We develop a novel framework that explicitly includes the generation and utilization of knowledge by participants in an innovation contest, and we analyze the implications of this framework for the design of serial contests.

2 Preference Uncertainty and Information Asymmetry in Online Matching Platforms

Amit Basu, Sreekumar R. Bhaskaran, Rajiv Mukherjee, Southern Methodist University, Dallas, TX, Contact: sbhaskar@mail.cox.smu.edu

Online match-seekers face two related challenges across two orthogonal dimensions of uncertainty. First, due to uncertainty in their subjective preferences, match-seekers may not know what candidates would be compatible with them. And second, due to information asymmetry in online settings, candidates may misrepresent their credentials. Using a stylized model, we analyze whether an online matching platform should enhance its search services with a counseling service that helps match-seekers determine the subjective compatibility of potential matches, and also whether it should offer an authentication service that reliably verifies the objective quality of match-seekers. One of the interesting results is that counseling and authentication can be substitutes or complements even though they address two orthogonal dimensions of uncertainty.

3 Leveraging the Potential of Outsourcing and Offshoring in Complex Product Development

Ole Frauen[1], Arnd Huchzermeier[2], Jurgen Mihm[3], [1]Volkswagen AG, Braunschweig, Germany; [2]WHU - Otto Beisheim School of Management, Vallendar, Germany; [3]Insead, Fontainebleau, France. Contact: ole.frauen@volkswagen.de

Leveraging the potential of outsourcing and offshoring remains a major challenge in complex product development. It is a question about effectively decomposing and distributing work across geographical and organizational boundaries while providing high quality products. The decisions must clearly depend on the product's characteristics and the emerging collaborative network. The study is based on an extensive data set involving all development projects of one of the largest car manufacturers worldwide. We demonstrate that a precise distinction between outsourcing and offshoring, as well as the introduction of a network perspective, are crucial to evaluate the effects in more detail.

4 **Voting Rules and Decision-Making by Committee**
Tian Chan[1], Panos Markou[2], [1]Emory University's Goizueta Business School, Atlanta, GA, [2]Darden School of Business, Charlottesville, VA, Contact: markoup@darden.virginia.edu
How do voting rules affect decision-making by committee? We hand-collect data from FDA advisory committee meetings (e.g., meeting transcripts, individual members, and voting outcomes) between 1997-2020, where experts discuss the safety, efficacy, and risk-benefit profile of novel drugs and medical devices. We study whether a 2006 change in voting rules (from sequential and visible voting, to simultaneous and anonymous voting) affected the deliberation and information-gathering process and outcome of a committee meeting.

Sunday, 2 PM–3:15 PM

SD80

JWM - Room 202
Negotiation Models
General Session

Session Chair
Danielle C. Costa Morais, Universidade Federal de Pernambuco - UFPE, Recife - PE, Brazil.

Session Chair
Liping Fang, Ryerson University, Toronto, ON, Canada.

1 **E-negotiation Model to Assess Offers and Select a Supplier in Agribusiness**
Over Manuel Causil, Danielle C. Costa Morais, Universidade Federal de Pernambuco - UFPE, Recife - PE, Brazil. Contact: dcmorais@insid.org.br
The negotiation process covers the exchanging of offers and counteroffers between the negotiators. In order to aid this process of making offers and counteroffers, and evaluating tradeoffs among conflicting negotiation objects an electronic negotiation support system (e-NSS) can be used. We propose a negotiation model using an e-NSS applied in agribusiness to select a packaging supplier. Price, delivery time, and green manufacturing practices were used as negotiation objects. The negotiation process was carried out with five potential suppliers where a final compromise was achieved with a single provider.

2 **Negotiations or Auctions for B2B Transactions: Lessons Learned from Comparison Studies**
Bo Yu[1], ShiKui Wu[2], Rustam Vahidov[3], [1]Dalhousie University, Halifax, NS, Canada; [2]Lakehead University, Thunder Bay, ON, Canada; [3]Concordia University, Montreal, QC, Canada. Contact: bo.yu@dal.ca
Both negotiations and auctions are capable of dynamically producing a deal between buyers and sellers. However, the choice of the appropriate exchange mechanism for various types of transactions still needs further investigation in B2B context because firms are not only concerned with economics but also with relational consequences when trading with each other. This paper reviews the studies comparing negotiations and auctions in the last three decades. The inclusion of both substantive and subjective outcomes in the assessment of the two mechanisms helps better understand their impacts. In addition, the concept of fairness helps explain how the mechanisms induce mixed motives for both competition and equity driving auctions and negotiations.

3 **Transforming Complex Social Systems: Insights from Systems Analysis and Negotiation**
Tim McDonald, Pardee RAND Graduate School, Santa Monica, CA, Contact: tmcdonal@prgs.edu
Effective response to public problems, and achieving societal goals, typically require efficient problem solving and adapting on the part of public leaders. Sometimes however effective response requires reshaping social systems to transform them over time. The challenge for leaders in democratic societies is to meet to near-term needs and expectations while also addressing the complex, systemic origins of challenges and creating new opportunities - such as promoting health, personalized learning, or rapidly pursuing renewable energy - that are only available through system transformation. This paper examines what the literatures from two fields - systems analysis and negotiation - can contribute to understanding how to transform complex systems, and how they can improve public decision making.

4 **Negotiation Support Using the Inverse Graph Model for Conflict Resolution**
Liping Fang, Ryerson University, Toronto, ON, Canada.
By using inverse graph model for conflict resolution (GMCR), a decision maker or third party can determine the required preferences to make a particular state to be individual stable or equilibrium. A survey of the current research in the inverse GMCR is presented first. The inverse GMCR analysis is being explored in two directions: (1) ascertaining all the possible required preferences for partially or completely unknown

initial preferences; and (2) determining the preferences with the minimal adjustment of decision makers' initial preferences, such that a particular state is individual stable or equilibrium. How the inverse GMCR can be utilized for negotiation support is discussed.

Sunday, 2 PM–3:15 PM

SD81

JWM - Room 203
Amazon Supply Chain Science
General Session

Session Chair
Garrett J. van Ryzin, Amazon Corporate LLC, Brooklyn, NY

1 **A Framework for Top-down Vs. Bottom-up Forecasting**
Rishab Guha, Amazon
A common question in applied forecasting is whether it makes sense to produce forecasts at the lowest possible granularity, and aggregate up to a desired top-level forecast, or forecast the top-level directly. We provide a theoretical model, and simulation evidence which shows that, in general, a top-level forecast will be able to estimate aggregate factor dynamics that may be obscured at fine granularity. We show that aggregate forecasts can be used to automatically generate features that can improve the calibration and predictive performance of bottom-level forecasts.

2 **Inventory Management in a Multi-product Capacitated Network with Dynamic Fulfillment**
Salal Humair[1], Nanjing Jian[2], Alp Muharremoglu[1], Yan Xia[3], [1]Amazon.com, Bellevue, WA, [2]Amazon.com, Bellevue, WA, [3]Amazon.com, Bothell, WA
Amazon uses automated replenishment algorithms to purchase and distribute tens of billions of inventory units through its fulfillment network every year. Those algorithms are designed to maximize the long-term profit, by optimizing the tradeoffs between local in-stock, the usage of limited capacity resources, and the end-to-end supply chain cost. To tackle this problem at Amazon scale, we formulated it into a constrained inventory optimization under a dynamic fulfillment policy with stochastic demand. We developed a distributed Lagrangian decomposition framework to solve the problem for each product independently, and a novel procedure to optimize the service-level threshold at each warehouse under the dynamic fulfillment policy. The model has been launched in North America and Europe, showing significant improvement in Amazon's long-term profit.

3 **Optimizing Large-scale Fulfillment Networks by Column Generation and Time-space Graphs**
Yufei Wang, Vinicius L. Lima, Weihong Hu, Prashant R. Nittoor, Luciana S. Buriol, Amazon, Bellevue, WA
Amazon operates a fulfillment network of an unprecedented scale with thousands of locations and shipping lanes that transport millions of packages daily from warehouses worldwide to individual customer homes. It is critical to keep the network in the most efficient state to minimize operation cost and maximize delivery speed. The optimization problem in this work involves how to change the network in a weekly basis, considering removal/addition of shipping lanes, departure times to adjust, and shipment routing. We present an integer programming model based on a time-space graph that captures both the topological and temporal aspects of the fulfillment network. As a solution approach, we modify the network topology heuristically and, for each configuration, we solve the network flow plan with a specialized column generation to scale the problem of such magnitude.

Sunday, 2 PM–3:15 PM

SD82

JWM - Room 204
DEI in Research and Funding Opportunities
Panel Session

Session Chair
Diana Gineth Ramirez-Rios, Rensselaer Polytechnic Institute, Troy, NY

Session Chair
Jeremy Watts, University of Tennnessee, Knoxville, TN

Session Chair
Wilkistar A. Otieno, University of Wisconsin-Milwaukee, Milwaukee, WI

Session Chair
Clara Novoa, Texas State University, San Marcos, TX

1 **Moderator**
Diana Gineth Ramirez-Rios, University at Buffalo, Buffalo, NY, Contact: dgramire@buffalo.edu

Have you ever thought about different ways to get DEI funding or get your research work support DEI in a more tangible manner? This panel puts together a group of academic experts in DEI research that share their experiences and offer advice on how to become more active in DEI. This panel will discuss funding as well as publication efforts towards DEI and provide unique ways to think about DEI in your research.

2 Panelist

Michael P. Johnson, University of Massachusetts Boston, Boston, MA, Contact: michael.johnson@umb.edu

3 Panelist

Christopher Dalton Parker, American University, Washington

4 Panelist

Sriram Narayanan, 1</sup

5 Panelist

Ravi Subramanian, Georgia Institute of Technology, Atlanta, GA

Sunday, 2 PM–3:15 PM

SD83

JWM - Room 205

spORts I

General Session

Session Chair

Aaron Bradley Hoskins, California State University, Fresno, Fresno, CA

1 Knuckleball Spin Rates Analysis

Aaron Bradley Hoskins, California State University, Fresno, Fresno, CA

This study investigates the reported spin rates of knuckleballs in the Statcast database. It analyzes pitches identified as knuckleballs to determine if the reported spin rates are consistent with the pitch being a true knuckleball or if the pitch is likely to be a different type of pitch.

2 Analysis of Pitcher Performance of Those Following Slow Pitchers

Parker Hill, Aaron Bradley Hoskins, California State University, Fresno, Fresno, CA, Contact: ph0011@mail.fresnostate.edu

The goal of this research is to assess the effects of slow pitchers in the MLB on the pitchers and batters that follow them. In particular, this project aims to quantify the likeliness of various scenarios including strike-outs, balls, homeruns, and other variations of play scenarios as a result of the change from slow to average/faster pitcher. The data used in this paper included all of the pitching logs for the 17 pitchers that had no pitches above 90 mph and the pitching results of those that followed immediately after them in their respective games during the 2021 baseball season.

3 Performance Enhancing Drugs in the Olympics, Russia's Role and Effective Sanctions

Raymond Stefani, California State University, Long Beach, Lake Forest, CA, Contact: Raystefani@aol.com

Performance enhancing drug use in the Ancient and Modern Olympics is reviewed. Thomas Hicks was helped by strychnine and brandy to win the 1904 Olympic marathon, although he nearly died. The first drug disqualification was in 1968 for a drunken shooter in the modern pentathlon. 100m winner Ben Johnson was famously disqualified in 1988 for steroid use, triggering drug testing in 1992 for athletics and in 1996 for swimming, immediately causing worse winning performances in both sports, indicating the extent of drug use. Russia and its former republics are responsible for 60% of Olympic medals stripped for drug use; however, most actions taken against Russia were generally not sanctions at all. A number of strong sanctions are suggested to require compliance with anti-drug standards and to put an end to psychological abuse as was seen for Kamila Valieva, once wartime sanctions end.

4 The Evolution of Seeding Systems and the Impact of Imbalanced Groups in FIFA Men's World Cup Tournaments 1954-2018

Michael A. Lapre, Vanderbilt University, Nashville, TN

We empirically assess competitive imbalance in FIFA World Cup tournaments. Using least squares, we determine ratings for all teams. For each team, we average the ratings of the opponents in the group to calculate group opponents rating. We find that even a modest decrease in group opponents rating by just a single goal can increase a team's probability of reaching the quarterfinal by 51%. None of the five seeding systems used by FIFA during 1954-2018 were effective in eliminating this unfair effect of group opponents rating. We close with several policy recommendations to restore competitive balance at the World Cup.

Sunday, 2 PM–3:15 PM

SD84

JWM - Room 206
Bayesian Optimization
General Session

Session Chair
Peter Frazier, Cornell University, Ithaca, NY

Session Chair
Raul Astudillo, Cornell University, Ithaca, NY

1 Multi-step Budgeted Bayesian Optimization with Unknown Evaluation Costs

Daniel Jiang[1], Raul Astudillo[2], Max Balandat[1], Eytan Bakshy[3], Peter Frazier[2], [1]Meta Core Data Science, Menlo Park, CA, [2]Cornell University, Ithaca, NY, [3]Meta Core Data Science, New York City, NY, Contact: drjiang@fb.com

Most Bayesian optimization algorithms ignore how evaluation costs, which are often unknown, may change over the optimization domain. An unknown cost function with a budget constraint introduces a new dimension to the exploration-exploitation trade-off, where learning about the cost incurs the cost itself. We propose a new dynamic programming-based acquisition function for this problem setting.

2 Bayesian Optimization for Non-Stationary Functions

Mohit Malu[1], Giulia Pedrielli[2], Gautam Dasarathy[3], Andreas Spanias[1], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Scottsdale, AZ, [3]Arizona State University, Tempe, AZ, Contact: mmalu@asu.edu

Bayesian Optimization with Gaussian Process prior typically assumes stationarity of the underlying function over the search space, but many real-world applications require optimizing non-stationary function. Non-stationary function can be considered as a set of stationary functions over the input space divided into multiple partitions with one class of stationary function in each partition. Often in control system setting we have access to class information along with the function evaluation. In this work, we propose a novel optimization technique Class-BO (Class Bayesian Optimization) for the non-stationary functions. We compare the empirical performance of Class-BO and show that it outperforms other non-stationary methods.

3 Achieving Metric Diversity for Sample-efficient Search of Multiobjective Optimization Problems

Eric Hans Lee, SigOpt, CA

Performing multi-objective optimization of important scientific applications such as materials design is becoming an increasingly important research topic. This is due largely to the high costs of said applications, and the resulting need for sample-efficient, multimetric optimization methods that efficiently explore the Pareto frontier to expose a promising set of design solutions. We propose moving away from using explicit optimization to identify the Pareto frontier and instead suggest searching for a diverse set of outcomes that satisfy user-specified performance criteria. This presents decision makers with a robust pool of promising designs and helps them better understand the space of good solutions. To achieve this outcome, we present the Likelihood of Metric Satisfaction acquisition function and demonstrate its viability on various problems.

Sunday, 2 PM–3:15 PM

SD85

JWM - Room 207
Teaching and Learning Flash Session
Flash Session

Session Chair
William P. Millhiser, Baruch College, City University of New York, New York, NY

1 Ease of Text Analytics with Visual Programming

Dursun Delen, Oklahoma State Unviersity, Tulsa, OK, Contact: dursun.delen@okstate.edu

Text analytics is the nontrivial process of converting textual data into actionable insight. The underlying framework leverages natural language processing (NLP), computational linguistic (CL), pattern recognition, and both supervised and unsupervised machine learning methods. This presentation will focus on the ease of developing text analytics projects using visual programming environment, KNIME Analytics Platform. Two of the most popular text analytics applications, namely sentiment analysis and topic detection, will be used as exemplary cases.

2 The Brain-based Learning and Teaching Relationship Map

Luis J. Novoa, Baback Vaziri, James Madison University, Harrisonburg, VA, Contact: vaziribx@jmu.edu

The Brain-based Learning and Teaching (BBLT) map relates brain-based teaching techniques that highlight the benefits of neuroplasticity with well-known teaching principles.

We identify several of these brain-based techniques and hypothesize positive and negative feedback relationships among various constructs. The identified relationships in the map allow structure to test different ways to improve teaching experiences using an active, collaborative, and experiential approach, which we consider critical nowadays in the OR/MS and business analytics education field.

3 The Future of OR/MS Education: The NSF Visioning Report

Alexandra Medina-Borja, US National Science Foundation, Alexandria, VA, Contact: amedinab@nsf.gov

What is the future of operations research and management sciences' education? In 2020, the US National Science Foundation (NSF) released a visioning report "STEM Education for the Future." At the same time, NSF funded the National Academies of Science, Engineering and Medicine to call a national and urgent conversation about the future of STEM education. Both were planned well before 2020, but the recommendations for the future were extraordinarily valid when the pandemic stroke. This presentation will discuss what is the meaning of the recommendations for the future of operations research and management science undergraduate and graduate education. The presenter will open the floor for a discussion on what are the challenges and opportunities for the formation of OR professionals.

4 Analysis of the Incorporation of Current Trends in Supply Chain Management Within Curricula

Matthew J. Drake[1], Paul H. Pittman[2], [1]Duquesne University, Pittsburgh, PA, [2]Indiana University Southeast, New Albany, IN, Contact: drake987@duq.edu

The field of supply chain management is constantly changing in response to innovation and societal developments. Curricula in supply chain management programs must update to stay current. Each year the Association for Supply Chain Management (ASCM) publishes a list of the top trends in supply chain management. We discuss results of a survey examining the extent to which these trends are being covered in supply chain management programs. We also provide suggestions for programs that wish to incorporate these trends into their curricula as well as for researchers seeking to develop effective new teaching materials.

5 Flash Paper

Sinan Tas, University of Wisconsin-Madison, Madison, WI, Contact: tas@wisc.edu

Gamification is a tool that can increase attention and promote learning. In this talk, we will talk about how this tool can be applied in a classroom setting to bolster diversity and inclusion. We will provide a multi-year study and discuss how certain components of gamification can contribute to the engagement of students from diverse backgrounds and help support an inclusive learning environment.

6 Predictive Analytics and Decision Modeling in the BBA Core Curriculum

William P. Millhiser, Amita Singh, Baruch College City University of NY, New York, NY, Contact: william.millhiser@baruch.cuny.edu

The Zicklin School of Business at Baruch College, the largest AACSB-accredited business school in North America, replaced calculus in the BBA required core curriculum with "Foundations of Predictive Analytics and Decision Modeling." The intended outcomes for this change are to enhance students' quantitative reasoning skills, to better prepare students for upper level classes, and to update the curriculum for relevancy to the current job market. This presentation describes the new course, reasons for the change, the impact on CUNY's community colleges, and what we've learned in the first two years of implementation.

Sunday, 2 PM–3:15 PM

SD86

JWM - Room 208

AAS Best Student Presentation Competition 2/3

Award Session

Session Chair

Keji Wei, Sabre, Grapevine, TX

1 Award Presenter

Xuan Jiang, UCB

Evaluating a potential air corridor is an essential step in the planning and organization of urban air mobility operations. Metrics typically used for this purpose are evaluated by simulation and optimization, which can be time and resource consuming. We propose to explore metrics to evaluate urban air corridor design that (1) are based on traffic data, and (2) provide temporal and spatial (i.e. multi-objective) purpose-specific insights, without the need for simulation. The metrics will account for different stakeholder interests, such as, safety from legacy traffic and environmental impacts, in the evaluation of the corridor designs. For this study, the corridor is described as a rectangular cuboid composed of several smaller cuboids based on the vertical and lateral distance thresholds derived from FAA regulations. Aircraft time within a cuboid, the number of aircraft within the cuboid within a certain period and location slices of the corridor are used to evaluate the proposed air corridors. The paper also discusses methods for choosing the best corridors from a given set as well as the best corridor for a given region. The methodology is demonstrated with a case study based on air traffic data within 150 miles of Edwards Air Force Base in Los Angeles, California. Experiments show that the proposed metrics can help stakeholders gain both spatial and temporal insights without the need for simulation.

3 Identification and Prediction of Disruptions in Airline Networks

Xiyitao Zhu, University of Illinois Urbana-Champaign, Urbana, IL

Air transportation disruptions can lead to demand-capacity imbalances, resulting in flight delays and cancellations due to traffic management actions. To facilitate better system recovery and enable near-real time decision support for prescriptive management actions, it is crucial to better understand system disruptions as well as predict their evolution. We first formalize the notion of disruption-recovery trajectories (DRTs) by representing key network delay and cancellation performance metrics as transitions between discrete states. Based on the DRT framework, we then develop two distinct prediction models: The first model seeks to predict the trend of key performance metrics, the second identifies whether or not the system will recover in a few hours. We report prediction results for four major US airlines, and elaborate on next steps.

4 Airline Dynamic Offer Creation Using a Markov Chain Choice Model

Kevin Wang, MIT, Cambridge, MA

We present a novel approach to the pricing and assortment optimization of airline ancillary offers using the Markov chain choice model (MCCM). A potential breakthrough in bundle price optimization, the MCCM decomposes the complex problem into a finite number of univariate optimization problems. We show how MCCM-based pricing adapts to the customer context, either increasing revenue by incentivizing customer buy-up to bundle offers or recommending a la carte pricing, when the customer cannot afford bundles or only finds few products relevant. We quantify the revenue benefit of dynamic offer creation by comparing MCCM bundle pricing and offer set selection against an a la carte baseline, both with and without targeted offer sets and prices.

Sunday, 2 PM–3:15 PM

SD87

JWM - Room 209

Airline Operations and Manpower Planning

General Session

Session Chair

Stacey Mumbower, Embry-Riddle Aeronautical University

1 Human Power Planning at Airlines

Burak Cankaya[1], Bulent Erenay[2], Eyyub Yunus Kibis[3], Aaron Glassman[4], [1]Embry Riddle Aeronautical University, Daytona Beach, FL, [2]Ohio University, Columbus, OH, [3]Montclair State University, Montclair, NJ, [4]Embry-Riddle Aeronautical University, Virginia Beach, VA, Contact: bcankaya@erau.edu

Human power planning for pilots is one of the major bottlenecks in all airline processes. It takes time to shape crew-fleet assignments. There are many stochastic decisions that disrupt long-term planning. In this research, we are addressing 20 years of planning by considering the stochastic nature of the problem using statistics and AI.

2 Crew Teaming in Airline Pairing Optimization

Waldemar Kocjan, Jeppesen, Goeteborg, Sweden. Contact: waldemar.kocjan@jeppesen.com

Airline crew planning is a process performed in consecutive stages. First manpower planning, estimates the crew necessary to perform planned operations. Then crew pairing phase creates a set of anonymous trips, series of flights starting and ending at a specific base. Finally, the rostering stage assigns these trips to the real crew. Creating trips in the pairing phase is subject to different requirements. Crew teaming is a requirement to keep a crew together between certain flights, during a working day or during a whole trip. Fulfilling such requirement is very important for operational stability of a schedule, however it is very difficult due to different rules and costs for different crew positions. The trade-off between cost of the solution and degree of teaming is a big challenge. This presentation shows how teaming is encourage inside the Jeppesen Crew Pairing product.

3 Strict Seniority Crew Rostering with Global Constraints - How to Measure Solution Quality?

Henrik Wallenius, Jeppesen, Gothenburg, Sweden.

In strict seniority rostering, crew bids are satisfied in strict seniority order, i.e. the bids of a senior crew are infinitely more important than all bids of junior crew. Typically this problem is solved sequentially in seniority order and while the strict seniority aspect is guaranteed, the solution is often infeasible in reality as it violates global business requirements. The Jeppesen Strict Seniority Rostering optimizer is able to obtain a solution that will satisfy global constraints. However, when global aspects are considered, seniority inversions might occur, where junior crew are given assignments that should have been assigned to a senior crew. Measuring the quality of such solution is ambiguous and in this talk we will present an alternative way of evaluating strict seniority solutions that satisfy global constraints.

4 Condition-Based Maintenance Planning of an Aircraft Fleet Under Partial Observability: a Reinforcement Learning Approach

Iordanis Tseremoglou, Bruno F. Santos, Delft University of Technology, Delft, Netherlands. Contact: b.f.santos@tudelft.nl

In this work, we present a two-stage framework for scheduling the maintenance of a commercial aircraft fleet, each aircraft having multiple monitored systems. In the first stage, we formulate the maintenance decision-making process for each monitored system as a Partially Observable Markov Decision Process, considering a partially observable prediction of the system deterioration. In the second stage, a Reinforcement Learning agent is proposed to schedule non-routine, routine, and prognostics-based tasks for a fleet of aircraft. Results indicate that 96.4% of the monitored systems were maintained on time.

Sunday, 3:30 PM–4:30 PM

SK01

CC - Sagamore 1

Keynote: Global Health Security and Healthcare Supply Chains: Perspectives and Opportunities for Operations Research

Keynote Session

Session Chair

Enver Yucesan, INSEAD, Singapore, NA, Singapore.

1 Global Health Security and Healthcare Supply Chains: Perspectives and Opportunities for Operations Research

Prashant Yadav, INSEAD, Fontainebleau, France.

As has become abundantly obvious in the last two years, infectious diseases have the potential to endanger lives, disrupt economies, travel, trade, and have a significant impact on our mental health. The need for robust prevention, preparedness, and response mechanisms is also widely recognized and accepted. However, achieving global health security also requires coordinated actions across countries, regions, and other forms of administrative geographical units. Operations research plays a key role in many parts of global health security such as modelling and simulation of disease outbreaks, analytical models of different policy responses, and design and operation of supply chains for medical counter measures. While all aspects of global health security depend on global coordination, the supply chains for global health technologies such as vaccines, diagnostics, and therapeutics require special kinds of coordination across multiple manufacturers, purchasers, payers, and delivery partners. This talk will focus on the evolution of the field of global health supply chains, which had it origins in global health security, but over time focused more on health systems building. It will highlight areas where health care supply chain research has contributed at the forefronts of policy making regarding global pandemic response and preparedness. It will also present opportunities for OR/OM researchers to contribute more effectively to achieve direct policy impact in this area.

Sunday, 3:30 PM–4:30 PM

SK02

CC - Sagamore 2

Keynote: Modeling Systemic Risk in Supply-Demand Networks

Keynote Session

Session Chair

Jie Xu, George Mason University, Fairfax, VA

1 Modeling Systemic Risk in Supply-Demand Networks

David D. Yao, Columbia University, New York, NY

Recent events (the pandemic, geo-political conflicts, climate change, etc) call for studies on systemic risk in supply-demand networks (SDNs). An SDN is a network with nodes (or "agents") representing resources with processing and/or storage capabilities and arcs representing their supply-demand relations. Systemic risks in the SDN arise from its interconnectedness, such that disruption (or ``shock'') at one node may quickly propagate to other nodes and possibly lead to a system-wide disaster. There are similarities to systemic risk in the financial system, but also fundamental differences. We will discuss how stochastic networks can play an essential role in modeling and analyzing systemic risk in the SDN, along with certain risk-hedging tools and other technologies such as digital twins and reinforcement learning.

Sunday, 3:30 PM–4:30 PM

SK06

CC - Sagamore 6
Keynote: 2022 Edelman Reprise - Analytics Saves Lives during the Covid Crisis in Chile
Keynote Session

1 **Analytics Saves Lives during the Covid Crisis in Chile**
Leonardo J. Basso[1], Marcelo Olivares[2], Denis Saure[3], Charles Thraves[4], Gabriel Weintraub[5], [1]Instituto Sistemas Complejos de Ingeniería, Santiago, Chile; [2]Universidad de Chile, Santiago, Chile; [3]Proyecto Fondecyt 1211407 Etapa 2021, Santiago, Chile; [4]University of Chile, Santiago, Chile; [5]Stanford Graduate School of Business, Stanford, CA
During the Covid-19 crisis, the Chilean Ministry of Health and the Ministry of Sciences, Technology, Knowledge and Innovation partnered with the Instituto Sistemas Complejos de Ingenier´ıa (ISCI) and thetelecommunications company ENTEL, to develop innovative methodologies and tools that placed operations research and analytics at the forefront of the battle against the pandemic. These innovations have beenused in key decision aspects that helped shape a comprehensive strategy against the virus, including tools that: (i) shed light on the actual effects of lockdowns in different municipalities and over time; (ii) helpedallocate limited intensive care capacity; (iii) significantly increased the testing capacity and provided on-theground strategies for active screening of asymptomatic cases; and (iv) implemented a nationwide serologysurveillance program that significantly influenced Chile's decision regarding vaccine booster doses and that also provided information of global relevance. Important challenges during the execution of the projectincluded the coordination of large teams of engineers, data scientists, and health care professionals in the field; how to effectively communicate information to the population; and the handling and use of sensitivedata. The initiatives enjoyed ample press coverage and, by providing scientific evidence supporting the decision-making behind the Chilean strategy against the pandemic, they helped provide transparency andobjectivity to decision-makers and the general population. According to conservative estimates, the number of lives saved by all of the initiatives together is close to 3,000, equivalent to more than 5% of the total deathtoll in Chile during the pandemic. The saved resources associated with testing, ICU beds, and working days amount to more than 300 million USD.

Sunday, 3:30 PM–4:30 PM

SK07

CC - Sagamore 7
Keynote: IFORS Distinguished Lecture - The Amazon Fulfillment Network: Topology and Capacity Planning
Keynote Session

Session Chair
Stefan Nickel, Karlsruhe Insitute of Technology, Karlsruhe, Germany.

1 **The Amazon Fulfillment Network: Topology and Capacity Planning**
Luciana Buriol, Amazon, Bellevue, WA
The Amazon fulfillment network is comprised of Amazon buildings and transportation lanes among them. In this talk, I will focus on the network with nodes representing Amazon Fulfillment Centers, Sortation Centers, and the Delivery Stations, where the links are the truck and air lanes among them. The lanes of this network are highly dynamic: their capacity can be changed a few days in advance, and they can also be deprecated or launched with short notice. On the other hand, large buildings are planned years ahead. Designing and expanding this network, as well as adjusting the nodes and links capacities for everyday operation demands an orchestration of complex OR systems. In this talk, I will describe this process.

Sunday, 5 PM–6:15 PM

SE01

CC - Room 101
Optimization for Data Mining and Machine Learning
General Session

Session Chair
Young Woong Park, Iowa State University, Ames, IA

1 **Optimality-Based Clustering**
Taewoo Lee[1], Zahed Shahmoradi[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]UTHealth, Houston, TX, Contact: taewoo.lee@pitt.edu

We propose a new clustering approach, called optimality-based clustering, that clusters data points based on their latent decision-making preferences. We assume that each data point is a decision generated by a decision-maker who (approximately) solves an optimization problem and cluster the data points by identifying a common objective function of the optimization problems for each cluster such that the worst-case optimality error is minimized. We propose three different clustering models and test them in the diet recommendation application.

2 Product-based Approximate Linear Programs for Network Revenue Management

Rui Zhang[1], Saied Samiedaluie[2], Dan Zhang[3], [1]Leeds School of Business University of Colorado Boulder, Boulder, CO, [2]University of Alberta, Edmonton, AB, Canada; [3]University of Colorado, Boulder, CO, Contact: rui.zhang@colorado.edu

The approximate linear programming (ALP) approach has received significant attention in the network revenue management literature. A popular approximation is separable piecewise linear (SPL) approximation. In this paper, we propose a *product-based* SPL approximation. We show that the resulting ALP admits compact reformulations, like its resource-based counterpart. Further, the new approximation allows us to derive a set of valid inequalities to speed up the computation, and select "better" optimal solutions. In a set of 192 instances, bid-price policies based on the new approximation generate higher expected revenues than resource-based policies, with an average revenue lift of 0.72% and a maximum revenue lift of 5.3%. The policy is competitive with the strongest known heuristic. In addition, the new approximation is 1.42 times faster than the resource-based one.

3 A Principled Methodology for Challenging the Single Ground Truth Assumption

Romena Yasmin, Adolfo Raphael Escobedo, Arizona State University, Tempe, AZ, Contact: ryasmin@asu.edu

This talk introduces the Split Consensus Ranking Aggregation problem, which is founded on the assumption that multiple heterogeneous subpopulations may be present within a set of input preference rankings, each with its own underlying collective tendency. Specifically, it presents an exact mixed-integer linear programming model based on the *Kemeny* distance measure and a clustering-based heuristic algorithm for finding such split consensuses quickly. To test the proposed methodology, random instances are generated based on a modified version of the Mallows ⍰-distribution. In addition, a crowdsourcing study is featured to demonstrate the usefulness of the tools in identifying groups with contradictory opinions on everyday topics.

4 Distributionally Robust Chance-constrained Quadratic Support Vector Machines Under Moment Uncertainty

Fengming Lin, Shu-Cherng Fang, Xiaolei Fang, North Carolina State University, Raleigh, NC, Contact: flin6@ncsu.edu

Support vector machines (SVMs) are powerful in supervised classification. Basic SVMs are dealing with the situation where the exact values of data are known. When the training is plagued with uncertainty, only the moments known for the distributions, this work proposes a distributionally chance-constrained (DRC) quadratic SVM to ensure the small probability of misclassification. While such a DRC model turns out to be intractable, this work equivalently reformulates it as a semidefinite program and further yields a second-order cone program that are tractable to be solved by off-the-shelf software. Computational experiments on synthetic and real-world datasets show that the proposed classifiers are better equipped to handle data uncertainty and outperform state-of-the-art in many cases, so as on a real battery failure prediction with highly imbalanced data.

Sunday, 5 PM–6:15 PM

SE02

CC - Room 102

Analytics for Policing and Urban Public Service Operations, Session I

General Session

Session Chair

Yao Xie, ISyE Georgia Tech, Atlanta, GA

Session Chair

He Wang, Georgia Tech, Atlanta, GA

1 Conjecturing for Forensic Body Fluid Identification

Paul Brooks, David Edwards, Craig Larson, Nico Van Cleemput, Fatemeh Valizadeh, Virginia Commonwealth University, Richmond, VA

Current methods for forensic body fluid identification suffer from poor precision and inefficient use of sample material. We develop a method for identification based on measurements of the microbiome using next-generation sequencing. A conjecturing method is used to discover nonlinear and boolean relationships in the microbiome data. We evaluate approaches for leveraging conjectures to enhance multi-class classification methods.

2 A Hybrid Simulation Approach for Dynamic and Equitable Police Patrol Deployment

Prabin Lamichhane[1], Yuan Zhou[1], Victoria C. P. Chen[2], Chen Kan[3], Bahar Nasirian[1], [1]University of Texas at Arlington, Arlington, TX, [2]The University of Texas at Arlington, Arlington, TX, [3]University of Texas-Arlington, Arlington, TX

Policing is complex, involving officers, criminals, politicians, citizens, and stressful, emotional situations. Within the past decade, the predictive policing movement has sought to predict crime, but existing data are highly biased. The proposed project steps away from purely data-driven predictive learning and instead employs stochastic simulation models to overcome bias in representing the dynamic policing system. For this project, we have built a hybrid agent-based and discrete-event simulation model of police patrolling operations of the Arlington Police Department, Texas to explore how proactive police patrol deployment can balance patrol officers' workloads, decrease their stress, and reduce crime.

3 Causal Inference for Fairness in Policing and Crime Prevention

Jonathan Y. Zhou[1], Zheng Dong[2], Qiuping Yu[3], Yao Xie[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, [3]Georgia Institute of Technology, Atlanta, GA, Contact: jyz@gatech.edu

We study how scheduling and dispatching policies impact policing effectiveness and fairness using event-level police patrol and 911-call data between 2013-2017 from the Atlanta Police Department. We first empirically identify two major factors — police's scheduling policy and the geographic division of the police patrolling units — that lead to significant disparities in police response time to 911 calls across different neighborhoods. We then propose strategies to mitigate the disparities while also improving overall policing outcomes using a framework that combines causal inference and optimization.

Sunday, 5 PM–6:15 PM

SE03

CC - Room 103

Empirical Applications of Big Data, Machine Learning, and System Dynamic Modeling

General Session

Session Chair

Mengyang Pan, Swufe, Chengdu, China.

1 A Deep Autoencoder-based Scalable Reinforcement Learning Framework for Hidden Degradation State Estimation

Erotokritos Skordilis[1], Ramin Moghaddass[2], Md Tanzin Farhat[3], [1]University of Miami, Herbert Business School, Department of Business Technology, Miami, FL, [2]University of Miami, Coral Gables, FL, [3]Dept. of Industrial Engineering, University of Miami, Miami, FL

The increased complexity and inherent uncertainty of modern sensor-intensive systems present a great challenge for capturing latent system dynamics that are necessary for control and decision-making. In this work, we present a two-step approach for latent degradation state and remaining useful life (RUL) estimation. In the first step, we use a variational autoencoder (VAE) to learn a distribution over the latent state-space that characterizes the system under observation. Then, a scalable model-based reinforcement learning framework is utilized to train an agent for identifying the true values of the hidden states, as well as the RUL at specific times using the VAE decoder as the environment. Numerical experiments using the NASA CMAPSS data were conducted to prove the validity of the proposed method.

2 The Heterogeneous Impacts of China's High-speed Rail on People's Mobility

Xinyu Wang, Southwestern University Of Finance And Economics, Chengdu, China. Contact: w.xinyu0313@gmail.com

More than 100 HSR branches have been built, forming a complicated HSR network in China. Network science and empirical models are combined for research to improve the insufficient measurement of dummy variables of the existence of HSR. The heterogeneous mechanisms of HSR affecting regional economy through people's mobility are studied. Empirical results show that HSR has positive impacts on people's mobility only in the secondary and tertiary industries, thereby promoting the regional economy. HSR has a significant impact on regional economy through people's mobility in financial, health, public administration industries regardless of HSR cities. The influential mechanisms are partly heterogeneous in developed and developing HSR cities. People's mobility in construction and education industries is the only significant result for developing HSR cities.

Sunday, 5 PM–6:15 PM

SE04

CC - Room 104

Data Nuggets Methods for Mining Big Data

General Session

Session Chair

Javier Cabrera, Rutgers University, Piscataway, NJ

1 A New Projection Pursuit Index for Big Data

Yajie Duan[1], Javier Cabrera[2], [1]Rutgers University, Piscataway, NJ, [2]Rutgers University, Piscataway, NJ

Visualization of extremely large datasets in static or dynamic form is a huge challenge. A new visualization method for big-data is proposed based on Projection Pursuit, Guided Tour and Data Nuggets methods, that will help display interesting hidden structures such as clusters, outliers and other nonlinear structures in big-data. Different Projection Pursuit (PP) indices have been developed to detect structures of multivariate data but there are computational problems for big-data. A new PP index is developed to be computable for big-data, with the help of a data compression method called "Data Nuggets" that reduces large datasets while maintaining the original structure. Static and dynamic graphical tools for big-data can be developed based on the proposed PP index to detect nonlinear structures.

2 Sensitivity of the Deming Model to the Choice of Variance Ratio - An Application for Mining Computational Chemistry Data

Kanaka Tatikola, Janssen R & D, Raritan, NJ, Contact: KTATIKOL@its.jnj.com

Data mining methods are becoming popular in molecular binding computational chemistry. The accurate prediction of binding affinity differences between proteins and small molecules via relative binding free energy calculations has become more popular recently. In this talk, we describe statistical methodology for modeling the relationship of experimental and calculated binding affinities taking into account the ratios of standard deviations in experiment and calculation. The work extends beyond the case of binding free energies to other affinity or property prediction methods. From the technical side we introduce a diagnostics graph to evaluate the sensitivity of Deming�s regression model to the choice of variance ratio.

3 Deep Unrolled Models for the Inverse Problems in Brain Source Imaging

Feng Liu, Stevens Institute of Technology, Jersey City, NJ

Electroencephalography (EEG)/Magnetoencephalography (MEG) source imaging aims to seek an estimation of underlying activated brain sources to explain the observed EEG/MEG recording. Traditionally, the design of regularization terms is based on preliminary assumptions on the spatio-temporal structure in the source space. In this paper, we propose a novel paradigm to solve the ESI problem by using Unrolled Optimization Neural Network (UONN) (1) to improve the efficiency compared to traditional iterative algorithms; (2) to establish a data-driven way to model the source solution structure instead of using hand-crafted regularizations; (3) to learn the hyperparameter automatically in a data-driven manner.

Sunday, 5 PM–6:15 PM

SE05

CC - Room 105

Integer Programming for Machine Learning: Exact and Approximation Algorithms

General Session

Session Chair

Yongchun Li, Virginia Tech, Blacksburg, VA

1 Quant-BnB: A Scalable Branch-and-bound Method for Optimal Decision Trees with Continuous Features

Haoyue Wang, Rahul Mazumder, Xiang Meng, Massachusetts Institute of Technology, Cambridge, MA, Contact: haoyuew@mit.edu

Decision trees are one of the most popular methods in the machine learning toolbox. In this paper, we consider the problem of learning optimal decision trees, a combinatorial optimization problem that is challenging to solve at scale. To achieve computational scalability, most existing approaches focus on classification tasks with binary features. In this paper, we present a new branch-and-bound (BnB) method to obtain optimal decision trees. Different from existing customized approaches, we consider both regression and classification tasks with continuous features. We split the search space based on the quantiles of the feature distribution---leading to upper and lower bounds for the underlying optimization problem along the BnB iterations. Our proposed algorithm Quant-BnB shows significant speedups compared to existing approaches for shallow optimal trees.

2 Time-varying Markov Random Fields: Efficient Algorithms and Provable Guarantees

Andres Gomez[1], Salar Fattahi[2], [1]University of Southern California, Los Angeles, CA, [2]University of Michigan, Ann Arbor, MI

In this talk we study inference problems with Markov Random Fields, a class of graphical models used often to learn spatio-temporal processes. We consider problems with sparsity: instead of standard Maximum Likelihood techniques, which approximate sparsity with the convex L1 norm, we propose an alternative method that explicitly incorporates the L0 norm while maintaining computational tractability. The resulting method not only provides better statistical guarantees than state-of-the-art methods, but also scales to much larger instances.

3 Guassian Graphical Models: A Scalable Framework Based on Combinatorial Optimization

Kayhan Behdin, Wenyu Chen, Rahul Mazumder, Massachusetts Institute of Technology, Cambridge, MA, Contact: behdink@mit.edu

We consider Gaussian Graphical Models, where the goal is to estimate the precision matrix of a multivariate Normal distribution. We propose a new estimator based on pseudo-likelihood when the precision matrix is sparse. However, our estimator uses l0 regularization, unlike most current algorithms which are based on convex optimization. We show our estimator can be written as a Mixed Integer Program (MIP). We provide statistical guarantees for our estimator and discuss how the use of l0 penalty improves the behavior. We provide an optimization framework including heuristic methods to obtain good solutions to the MIP, as well as a specialized nonlinear branch-and-bound method to obtain optimal solutions to our estimator. Our numerical experiments show that our estimator is computationally scalable to 10,000 variables while leading to better statistical performance.

Sunday, 5 PM–6:15 PM

SE07

CC - Room 107

The Interplay between Learning, Optimization, and Statistics

General Session

Session Chair

Lijun Ding, 1</sup

1 Unique Sparse Decomposition of Low Rank Matrices

Dian Jin[1], Xin Bing[2], Yuqian Zhang[1], [1]Rutgers University, Piscataway, NJ, [2]Cornell University, Ithaca, NY, Contact: dj370@soe.rutgers.edu

The problem of finding the unique low dimensional decomposition of a given matrix has been a fundamental and recurrent problem in many areas. In this paper, we study the problem of seeking a unique decomposition of a low-rank matrix Y that admits a sparse representation. Specifically, we consider Y=AX where the matrix $A\in \R^{p\times r}$ has full column rank, with $r < \min\{n,p\}$, and the matrix $X\in \R^{r\times n}$ is element-wise sparse. We prove that this low rank, sparse decomposition of Y can be uniquely identified, up to some intrinsic signed permutation. Our geometric analysis for its nonconvex optimization landscape shows that any strict local solution is close to the ground truth, and can be recovered by a simple data-driven initialization followed with any second-order descent algorithm. Our theoretical findings are corroborated by numerical experiments.

2 Accelerated Minimax Algorithms Have Merging Paths

TaeHo Yoon, Ernest Ryu, Seoul National University, Seoul, Korea, Republic of. Contact: tetrzim@snu.ac.kr

Recently, several new accelerated methods in minimax optimization and fixed point iterations have been discovered. Interestingly, their acceleration rely on the mechanism of anchoring, which retracts the iterates toward the initial point, and is distinct from Nesterov’s momentum-based acceleration. We introduce these accelerated algorithms and show that they exhibit what we call the merging path (MP) property; the trajectories of these algorithms merge quickly. Using this novel MP property, we establish point convergence of existing accelerated minimax algorithms and present new state-of-the-art algorithms for the strongly-convex-strongly-concave setup and for the prox-grad setup.

3 Exact Optimal Accelerated Complexity for Fixed-point Iterations

Jisun Park[1], Ernest Ryu[2], [1]Seoul National University, Seoul, Korea, Republic of; [2]Seoul National University, Department of Mathematical Sciences, Seoul, Korea, Republic of. Contact: colleenp0515@snu.ac.kr

Despite the broad use of fixed-point iterations throughout applied mathematics, the optimal convergence rate of general fixed-point problems with nonexpansive nonlinear operators has not been established. This work presents an acceleration mechanism for fixed-point iterations with nonexpansive operators, contractive operators, and nonexpansive operators satisfying a H¨older-type growth condition. We then provide matching complexity lower bounds to establish the exact optimality of the acceleration mechanisms in the nonexpansive and contractive setups. Finally, we provide experiments with CT imaging, optimal transport, and decentralized optimization to demonstrate the practical effectiveness of the acceleration mechanism.

4 Flat Minima Generalize for Low-rank Matrix Recovery

Lijun Ding, University of Washington, Seattle, WA

Empirical evidence suggests that for a variety of overparameterized nonlinear models, most notably in neural network training, the growth of the loss around a minimizer strongly impacts its performance. Flat minima—those around which the loss grows slowly—appear to generalize well. This work takes a step towards understanding this phenomenon by focusing on the simplest class of overparameterized nonlinear models: those arising in low-rank matrix recovery. We analyze overparameterized matrix and bilinear sensing, robust PCA, covariance matrix estimation, and single hidden layer neural networks with quadratic activation functions. In all cases, we show that flat minima, measured by the trace of the Hessian, exactly recover the ground truth under standard statistical assumptions.

Sunday, 5 PM–6:15 PM

SE09

CC - Room 109

Quality, Reliability and Statistics with Big Data

Contributed Session

Session Chair

Di Bo, University of Tennessee, Knoxville, Knoxville, TN

1 Suspicious Machine Screening in Serial-parallel Multistage Manufacturing Process with a Nominal Quality Feature: A Production Log Data-based Approach

Seung-Hyun Choi[1], Dong-Hee Lee[2], Young-Mok Bae[1], Young-Chan Oh[3], Jong-Bum Park[3], Kwang-Jae Kim[1], [1]POSTECH, Pohang, Korea, Republic of; [2]Sungkyunkwan University, Suwon, Korea, Republic of; [3]SK hynix, Cheongju, Korea, Republic of. Contact: seunghyun.choi@postech.ac.kr

Serial-parallel multistage manufacturing process (SP-MMP) has multiple consecutive process stages, and each stage has several alternative machines. Faulty machines negatively influence product quality; thus, identification of faulty machines is a critical task for quality enhancement. Suspicious machines, which are suspected to be faulty machines, are screened before machine diagnosis to enhance the efficiency of faulty machine identification. This study proposes a method to screen suspicious machines using production log data in SP-MMP with nominal quality features. The proposed method estimates whether a machine incurs low-quality products by itself or by its interaction with other machines. The performance of the proposed method is validated through case studies on a simulated SP-MMP and a real semiconductor manufacturing process.

2 Active Quickest Detection in Linear Regression Model

Qunzhi Xu[1], Yajun Mei[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: xuqunzhi@gatech.edu

Active quickest detection problem has received extensive attentions in modern big data age, partly due to the resource constraints either at the data acquisition level or at the communication level. Often it is required that the decision maker actively selects partial samples from the underlying raw data so as to detect the change as quickly as possible. In this talk, we consider the active quickest detection in linear regression model Y_t=X_t□+□$_t$,where the p-dimensional coefficient □ might changes from 0 to an unknown sparse vector □* at some unknown time □. Here Y_t is observed q-dimensional vector ($q \leq p$) and X_t is the $q \times p$ design matrix. We focus on how to detect the change-time □ efficiently based on the observed data (Yt,Xt) and we will share some of our preliminary results.

3 Cusum for Sequential Change Diagnosis

Austin Warner, Georgios Fellouris, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: awarner5@illinois.edu

A sequence of independent random elements is accessed sequentially and at some unknown time there is an abrupt change in its distribution. We aim to quickly detect the change and to accurately identify the post-change distribution among a finite set of alternatives. A standard change detection algorithm that raises an alarm as soon as a CuSum procedure that corresponds to one of the post-change alternatives raises an alarm is shown to control the worst-case conditional probability of false isolation under some conditions, and minimize Lorden's criterion for the detection delay to a first-order asymptotic approximation as both the worst-case probability of false isolation and the false alarm rate go to zero at certain relative rates. These properties are satisfied under some conditions which are satisfied in a special case of the multichannel problem.

4 Feature Subspace Selection for High-dimensional Experiments of Material Development Process

DI BO, Hoon Hwangbo, Stephanie TerMaath, University of Tennessee, Knoxville, Knoxville, TN, Contact: dbo@vols.utk.edu

This research proposes a novel feature selection approach capable of identifying significant feature interactions in a high-dimensional feature space. Identifying feature interactions is a hard task as it involves evaluations of a large number of potential interactions that can be defined. The proposed method generates a random subset of features with low dimensionality limiting the maximum order of interactions, evaluates its significance, and ensembles only those found significant to model a response. When applied to high-dimensional data collected from a material development process, the proposed method improves prediction and provides useful physical insights about material behaviors.

Sunday, 5 PM–6:15 PM

SE10

CC - Room 110

Analytics and AI

Contributed Session

Session Chair

William Jordan Peck, Penn State Applied Research Lab, State College, PA

1 An Inverse Optimization Approach to Causal Inference

Elijah Pivo[1], Dimitris Bertsimas[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: epivo@mit.edu

In causal inference we typically quantify the average causal effect of applying a treatment to some unit. For example, we may wish to estimate the average causal effect of smoking on life expectancy or of a training program on wage. Current practice is to use flexible machine learning methods like neural networks or random forests to model the relationships between treatment and outcome under the doubly robust framework. In this work, we consider the case where the outcome is a decision and propose using optimization problems to model the relationship between treatment and outcome. We compare the performance of machine learning methods and optimization models for quantifying average causal effects in several examples.

2 Comparing Interpretability and Explainability for Feature Selection

Luca Mingardi, Interpretable AI, Cambridge, MA, Contact: luca@interpretable.ai

A common approach for feature selection is to examine the variable importance score of a machine learning model to understand which are the relevant features for making a prediction. Given the significance of feature selection, it is crucial for the calculated importance scores to reflect reality. Black-box models provide state-of-the art predictive performance, but rely on variable importance to offer insight into their behavior. We investigate the performance of variable importance as a feature selection by comparing the ability of CART, Optimal Trees, XGBoost and SHAP to identify the relevant features across a number of experiments. The results show that black-box models fail to distinguish between relevant and irrelevant features, while interpretable methods identify irrelevant ones, proving to be a better feature selection tool.

3 Deep Learning-based Adversarial Attacks for Time Series Data

Juheon Kwak, Soomin Lee, Dongil Kim, Chungnam National University, Daejeon, Korea, Republic of. Contact: juhun2005@cnu.ac.kr

Time series data are frequently utilized in various fields, such as music analysis, sensor networks, and weather forecasting, etc. There have been various attempts to analyze and predict time series data by using deep learning. Recently, another research area arising is the adversarial attack that generates adversarial examples to cause a malfunction in a machine learning model. In this paper, we propose a new attack method for time series data based on deep learning. The proposed model can make adversarial examples of time series, and the new examples can fool existing detection models. The experimental results guarantee the further research efforts to improve the fooling performance of the proposed method, and to develop a defense model against this attack model.

4 Automatic Manufacturing Feature Extraction and Detection

William J. Peck, The Pennsylvania State University, State College, PA, Contact: wjp16@psu.edu

A major preoccupation of Industry 4.0 is the inclusion of automation to continually transform and revolutionize manufacturing. For a given industrial good, extracting manufacturing features is often done manually with little to no help or oversight from computers. A feature point mapping method is chosen as a methodology to allow for automatic manufacturing feature extraction and detection for industrial goods. Given a series of manufacturing feature reference images, the six principal views and the isometric view of the part, our algorithm is able to extract and detect manufacturing features that are contained within the industrial good. Shifting away from human detection to computer detection for manufacturing features is an important step towards the realization of information intensive manufacturing systems defined by Industry 4.0.

Sunday, 5 PM–6:15 PM

SE11

CC - Room 111

AI on Healthcare and its Analytics

General Session

Session Chair

Anqi Xu, 1</sup

1 How Diffused Emotions Affect User Contribution in Online Cancer Communities

Anqi Xu, Jennifer Xu, Haijing Hao, Bentley University, Waltham, MA, Contact: axu@bentley.edu

Online cancer communities (OCCs) provide cancer patients platforms to learn about the illness, provide and receive support, and network with others in similar situations. The majority of content in OCCs are user-generated, thus, it is essential to encourage user participation and keep the functionality of the community. When providing support or networking with other users in the community, cancer patients' emotions are also expressed in their replies to others' posts. Will these expressed emotions diffuse and affect other users', especially the post author's future engagement in the community? To answer this question, we apply machine learning techniques to identify eight categories of emotion (based on Plutchik's wheel of emotions) and employ empirical analysis to examine the effects of these emotion categories on users' future participation.

2 Consumers' Perception to AI-based Home Care System: An Empirical Study

Bijun Wang[1], Onur Asan[2], Mo Mansouri[3], [1]Stevens Institute of Technology, Hoboken, NJ, [2]Univeristy of Wisconsin-Madison, Madison, WI, [3]Stevens Institute of Technology, Hoboken, NJ, Contact: bwang27@stevens.edu

Consumer health applications and device powered by AI is a burgeoning industry in recent years. Nevertheless consumer needs and attitudes are not fully explored in the service. This study developed a research model consisting of contextual and acceptable values to explain the intention of chronic patients when using AI-based medical applications. To conduct this study, we performed an online survey in United states. More than 200 respondents provided usable data; these data were analyzed by structural equation modeling to test the proposed hypothesis. Hope this study will benefit patients, healthcare providers, and AI providers and facilitate the implementation of AI in the healthcare system.

3 Utilizing Digital Twins to Develop Semi-supervisedonline Control Model for Self-monitoring and Management of Patients with Type 2 Diabetes Mellitus

Syed Hasib Akhter Faruqui[1], Shiyu Li[2], Yan Du[2], Brittany Dennis[2], Chengdong Li[2], Jing Wang[3], Adel Alaeddini[4], [1]Northwestern University, Chicago, IL, [2]University of Texas Health Science Center at San Antonio School of Nursing, San Antonio, TX, [3]Florida State University, Tallahassee, FL, [4]University of Texas at San Antonio, San Antonio, TX

Patients with T2DM need to maintain strict glycemic control and dietary regimen to avoid the risk of hypoglycemia, hyperglycemia, and consequential complications. To help patients with T2DM maintain a healthy life, we propose using an online control model. To do so, we first developed a predictive digital twin to represent the characteristics of T2DM patients following a specific diet and exercise regimens using a deep learning model. This can facilitate the means to monitor, learn, and parameterize the control model to improve the quality of a patient's lifestyle. Next, we developed an online control algorithm utilizing particle swarm optimization to examine the impact of various behavioral changes on the next day's glucose level. Finally, the constraints of the control model are determined using the patients' digital twins' characteristics data and diet type.

Sunday, 5 PM–6:15 PM

SE12

CC - Room 113

AI Applications at Mayo Clinic

General Session

Session Chair

Esma S. Gel, University of Nebraska-Lincoln, Lincoln, NE

1 Implementation of an AI-based Triage Algorithm for Multidisciplinary Treatment of Complex Dizziness

Santiago Romero-Brufau, Mayo Clinic, Rochester, MN

Dizziness affects 15-20% of adults, and recurrent and chronic dizziness can be highly debilitating, but up to 85% of cases receive inappropriate diagnosis and treatment. Management of the various causes of dizziness spans several health care specialties. Ensuring consistent and appropriate triage with efficient use of clinician time remains a challenge globally. We developed a decision-tree-based automated triage system using a combination of machine learning methods and expert-based adjustment and implemented it as part of the clinical triage workflow for new patients at Mayo Clinic. The system queries patients for symptoms and history, and presents its recommended set of appointments to the clinician and scheduling staff. The system reduced clinician workload by 70% and achieved an overall accuracy of 87% with significant clinician satisfaction, all of which was maintained two years after implementation.

2 Harnessing Artificial Intelligence in Developing a Tool to Decrease the Cost and Improve Efficiency of Clinical Trials

Thomas Kingsley, Mayo Clinic, Rochester, MN, Contact: kingsley.thomas@mayo.edu

A clinical trial often costs millions of dollars and years complete. A significant reason is the challenge in identifying patients for study enrollment. The clinical research coordinator often spends 50% or more of their time manually chart reviewing data sources to identify patients. Natural language processing (NLP) algorithms can be trained to extract concepts used in study enrollment from unstructured text data. However, the challenge with training NLP models is their scalability and generalizability across a range of research disciplines. This can be solved by developing a combination of structured data querying and highly sensitive but non specific NLP models as a starting cohort for research coordinators. The selection of patients in real time using a rank order list allows for NLP model updating iteratively and improved classification performance over time.

3 Sharing in Caring: Analyzing Shared Medical Appointments Through an Operations Lens

Enver Yucesan, Sundara Natarajan Panchanatham, INSEAD, Singapore, Singapore. Contact: enver.yucesan@insead.edu

Shared medical appointments (SMA) are doctor-patient visits in which groups of patients are seen by one or more healthcare professionals in a concurrent session with the objective of enhancing patient experience, eliminating redundant work, improving medical compliance and reducing cost for certain treatments. From an operations perspective, providers face several key challenges in the effective organization of SMAs, which includes finding the optimal group size, devising robust scheduling mechanisms, determining the optimal capacity allocation, and incentivizing more patients to opt for SMA. In this work, we analyze the key operational trade-offs involved in SMAs as a service system and provide guidelines that enable providers to identify optimal settings (capacity/payment/group size) for several system configurations.

4 Intelligent Teletriage and Personalized Routing at a Neurosurgery Department

Esma S. Gel[1], Derya Kilinc[2], Aysegul Demirtas[3], [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Mayo Clinic, Rochester, MN, [3]Intel, Chandler, AZ, Contact: esma.gel@unl.edu

We consider the intake process of new low back pain (LBP) patients at a neurosurgery clinic to improve access delays through personalized routing strategies. Using clinical notes, we devise a decision-tree based intelligent teletriage tool that can be used by non-medically trained agents to predict the surgical class of a patient. We establish that the accuracy of the teletriage tool is in the order of 80% using out-of-sample testing on real-life data sets. We then show that when used in combination with the intelligent triage tool, priority based routing strategies can result in 90% reduction in access delays for the higher priority surgical patients who should be seen urgently. We comment on the potential for the use of needs-based personalized routing strategies with intelligent teletriage to reduce access delays, improve patient outcomes and provider satisfaction.

Sunday, 5 PM–6:15 PM

SE14

CC - Room 115

Large-scale Data Analytics for Transportation Systems (Planning + Operation)

Joint Session

Session Chair

Sean Z. Qian, Carnegie Mellon University, Pittsburgh, PA

Session Chair

Wei Ma, The Hong Kong Polytechnic University, Kowloon

1 Recsys Model to Infer Missing Transportation Mobility Data

Yiran Zhang, Xuegang Ban, University of Washington, Seattle, WA

The explosion of big data has fueled tremendous transportation studies such as CAV and shared mobility with the rapid proliferation of diverse passive and mobile sensing in recent years. However, the increasing reliance on big data also raises risks due to the inherent bias issues. To explore and identify the data bias issues, this study focuses on the bias of the data generation process (DGP) from the passively collected smartphone app-based data. A two-step model is built up to learn the DGP considering the sampling and data collection of the smartphone users. Data bias is then discussed and identified at each step, covering demographic, temporal, and spatial biases.

2 Deep Model for Traffic Prediction with Low-rank Mode and Minimal Transfer for Nonrecurrent Events

Weiran Yao, Sean Z. Qian, Carnegie Mellon University, Pittsburgh, PA

We use low-rank approximation method to connect traffic simulation and the data-driven approach. We first calibrate a dynamic traffic assignment model using dynamic origin-destination estimation to enable generalization to unobserved, nonrecurrent events. We use the calibrated model to generate typical nonrecurrent traffic data and fit the Koopman operator on the simulated data to extract both nonrecurrent and recurrent traffic modes. The model is finetuned on real-world data samples end-to-end through a gradient approach. We conducted experiments on both a toy dataset (4x4 grid network) and a real-world dataset (TSMO system 1). Experiment results demonstrate that our low-rank approximation approach could consistently adapt to unseen traffic scenarios, to which the traditional data-driven approach cannot generalize.

3 Data-driven Multi-horizon Prediction of Ridesharing Spatiotemporal Demand Pattern

Mark Hernandez[1], Fatemeh Nazari[2], Mohamadhossein Noruzoliaee[2], [1]University of Texas Rio Grande Valley, Edinburg, TX, [2]University of Texas Rio Grande Valley, Edinburg, TX, Contact: fatemeh.nazari@utrgv.edu

Technological advances in providing near ubiquitous mobility in the past decade have led to introducing on-demand shared mobility, in particular, ridesharing services. The accurate prediction of rider demand over space and time is a crucial input to improving the ridesharing system efficiency, for instance, by preemptively relocating vacant vehicles and thus slashing the rider waiting time. Focusing on the multi-horizon origin-destination (OD) demand of these services, this research presents a graph-based deep learning approach for both solo (e.g., Uber) and pooled (e.g., UberPool) ridesharing services while also investigating the impacts of COVID-19 pandemic, weather conditions, and socio-demographic attributes. A case study in a large metropolitan area in the United States is presented to demonstrate the performance of the presented model.

4 Traffic-Twitter Transformer: A Natural Language Processing-joined Framework for Network-wide Traffic Forecasting

Yinhai Wang[1], Meng-Ju Tsai[2], [1]University of Washington, [2]University of Washington, Seattle, WA

With accurate and timely traffic forecasting, the impacted traffic conditions can be predicted inadvance to guide agencies and residents to respond to changes in traffic patterns appropriately.However, existing works on traffic forecasting mainly relied on historical traffic patternsconfining to short-term prediction, under 1 hour, for instance. To better manage futureroadway capacity and accommodate social and human impacts, it is crucial to propose a flexibleand comprehensive framework to predict physical-aware long-term traffic conditions for publicusers and transportation agencies. In this paper, the gap of robust long-term traffic forecastingwas bridged by taking social media features into consideration. A correlation study and a linearregression model were first implemented to evaluate the significance of the correlationbetween two time-series data, traffic intensity and Twitter data intensity. Two time-series datawere then fed into our proposed social-aware framework, Traffic-Twitter Transformer, whichintegrated Nature Language representations into time-series records for long-term trafficprediction. Experimental results in the Great Seattle Area showed that our proposed modeloutperformed baseline models in all evaluation matrices. This NLP-joined social-awareframework can become a valuable implement of network-wide traffic prediction andmanagement for traffic agencies.

Sunday, 5 PM–6:15 PM

SE15

CC - Room 120

Advances in Health Care Operations

General Session

Session Chair

Joel Goh, NUS Business School, Singapore, Singapore.

1 The Impact of Historical Workload on Nurse's Perceived Workload in Intensive Care Unit

Carri Chan[1], Yi Chen[2], Jing Dong[3], [1]Columbia Business

School, New York, NY, [2]Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [3]Columbia University, New York, NY

Workload balancing in service system is critical for both workers' welfare and the quality of delivered service. In this work, we examine the importance of balancing workload temporally in healthcare system. Using a dataset of more than 1000 patients over a year that records detailed nurse-patient matching and workload measures, we use an instrumental variable approach and a sample selection model to empirically quantify the effect of historical workload on nurse's perceived workload in current shift. We find that a higher historical workload can lead nurse to perceive a higher workload. Such an observation brings a nontrivial tradeoff between maintaining the continuity of care and mitigating nurses' occupational burnout as well.

2 Could Budget-neutral Incentives Increase Organ Donor Designation?

Diwakar Gupta[1], Paola Martin[2], [1]University of Texas, Austin, TX, [2]University of Texas at Austin, Austin, TX, Contact: diwakar.gupta@mccombs.utexas.edu

Organ Procurement Organizations (OPOs) decide which deceased-donor referrals to pursue for organ recovery, driven mostly by clinical reasons. In addition, a key operational factor is whether the referral was timely. In a preliminary analysis, data from an OPO showed that, after accounting for clinical variables, a referral was 58% more likely to be designated a donor if it was timely. This talk explores ways in which OPOs could incentivize hospitals to increase the proportion of timely referrals in a budget-neutral way.

3 How and in What Ways Does Colocation of Services Matter? Empirical Evidence from a Large Healthcare Setting

Vishal Ahuja[1], Carlos Alvarez[2], Bradley R. Staats[3], [1]Southern Methodist University, Dallas, TX, [2]Texas Tech University, Dallas, TX, [3]University of North Carolina at Chapel Hill, Chapel Hill, NC

Location choice - especially colocation - is a key facet of operational decision-making. Thus, it is critical to understand not only whether colocation makes a difference but also under what circumstances it is most beneficial, and the mechanisms through which those benefits are realized. We consider colocation in the context of healthcare services, as primary care serves as a gateway to address mental health concerns and referrals to specialists. We ask the following three questions: Does colocation of mental and physical health resources improve patient outcomes? How do sicker patients benefit more from colocation? How does team familiarity between providers moderate colocation-outcomes relationship?

4 Providing Wait Time Information to ED Patients: Effects on Satisfaction and Reneging

Danqi Luo[1], Mohsen Bayati[2], Erica Plambeck[2], [1]UCSD Rady School of Management, San Diego, CA, [2]Stanford University, Stanford, CA, Contact: d1luo@ucsd.edu

The effect of communicating delay information to patients on their satisfaction and their likelihood to leave the ED before being treated (reneging) is investigated in a field experiment in an Emergency Department (ED). When the delay information is provided, the odds of having a higher wait satisfaction increase by 81 percent, and the odds of reneging reduce by 14 percent. The announced delay serves as a reference point against which the patients compare their actual delay. As per Prospect Theory, patients are loss-averse, hence the risk of reneging is substantially lower when they wait shorter than the displayed delay than when they wait longer: $33% lower versus $151% higher. Furthermore, we discovered that although statistically significant, the influence of actual wait time on patient satisfaction and the likelihood of reneging is negligible.

Sunday, 5 PM–6:15 PM

SE16

CC - Room 121

Actionable Analytics and Sequential Decision Making in Healthcare

General Session

Session Chair

Yonatan Mintz, University of Wisconsin Madison, Madison, WI

1 A Two-timescale Model for Routing Policy Optimization with Application in Community Corrections

Xiaoquan Gao[1], Pengyi Shi[2], Nan Kong[3], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, [3]Purdue University, West Lafayette, IN, Contact: gao568@purdue.edu

In the United States, the overuse of incarceration combined with a lack of social and community assistance for criminals results in a vicious cycle between incarceration and recidivism. We study incarceration diversion decisions with community corrections as an alternative to jailing to alleviate the prominent issue of jail overcrowding. We formulate an MDP model to optimize incarceration diversions for individuals of different risks. To tackle the curse-of-dimensionality caused by non-memorylessness, we develop a novel two-timescale approximation, which is embedded in an actor-critic policy gradient algorithm. We provide structured insights for diversion decisions and capacity allocation in the criminal justice system.

2 An Approximate Algorithm for Optimizing Repeated Decisions in Infectious Disease Control

Suyanpeng Zhang, Sze-chuan Suen, University of Southern California, Los Angeles, CA, Contact: suyanpen@usc.edu

The Covid-19 outbreak emphasizes the necessity of studying policies to prevent or control the transmission of infectious diseases. However, one needs to solve the dimensionality problem to tractably evaluate dynamic policies for infectious disease modeling under a discrete Markov decision process (MDP) framework. We develop an optimization algorithm for finding non-fixed grid regions for approximate MDP solutions for informing infectious disease control policies over time.

3 Thompson Sampling Techniques for Nonstationary Bandits

Jinxin Tao, Yonatan Mintz, Amy Cochran, University of Wisconsin Madison, Madison, WI, Contact: jtao34@wisc.edu

Nonstationary bandit settings, where the parameters of each arm are unknown to the decision maker but may change over time according to a set of known dynamics are common in many applications in personalized healthcare and micro randomized trials, and can be modeled as a reducing or gaining unknown efficacy (ROGUE) bandits. However, if decision makers want to estimate the effect size of bandit treatments, they require that each action be pulled a minimum number of times, thus precluding the use of UCB style policies. Here we present a novel Thompson Sampling algorithm we call ROGUE-TS to optimize this setting and show that this algorithm achieves logarithmic in time expected regret and provides the desired statistical properties. We present computational results that show that ROGUE-TS improves over state of the art algorithms in terms of cumulative regret and average reward.

4 Personalized Financial Incentives for Weight Loss

Qiaomei Li, Yonatan Mintz, Corrine Voils, Kara Louise Gavin, University of Wisconsin Madison, Madison, WI, Contact: qli449@wisc.edu

Financial weight loss incentives administered by a mobile app have been found to help patients lose weight. However, the efficacy of these interventions is dependent on patient adherence. Thus clinicians must find the appropriate incentives to administer to patients to ensure they adhere to the intervention and influence long term behavioral change. In this talk, we develop a personalized model for the patients' decision-making process in these interventions and use it to construct personalized incentives. To validate our model we perform a computational study using data from a randomized control trial. We find our method outperforms existing machine learning methods in terms of weight loss prediction at the end of the intervention using a short time-span of data and that our approach helps improve the efficacy of the intervention program with limited resources.

Sunday, 5 PM–6:15 PM

SE17

CC - Room 122

Optimization Models for Problems in Healthcare Delivery Systems

General Session

Session Chair

Ankit Bansal, West Virginia University, Morgantown, WV

1 A Two-stage Stochastic Program for Right-shoring Pharmaceutical Supply Chains

Martha Lucia Sabogal De La Pava[1], Emily L. Tucker[2], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC

In disruptive events, highly geographically concentrated pharmaceutical supply chains increase the risk of global drug shortage. Countries with low production capacity are at the highest risk. Right-shoring strategies help decision-makers balance the cost, benefits, and risks of onshoring and offshoring manufacturing plants. We present a two-stage stochastic location-distribution model that considers a joint shoring approach through international alliances. We analyze how the risk of ban export during disruptive scenarios and the drugs exports of the possible partners affect both the expected cost assumed by investors when locating a manufacturing plant and the risk of shortage in multiple countries.

2 Optimizing Channels Placement in 3D Printed Masks for High Dose Rate Brachytherapy (HDR-BT)

Nasim Mirzavand Boroujeni[1], Jean-Philippe P. Richard[2], David Sterling[1], Chris Wilke[1], [1]University of Minnesota, minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, Contact: mirza048@umn.edu

High dose rate brachytherapy (HDR-BT) is used for skin cancer treatment when surgery cannot remove all cancer cells.
Positioning needles close to the skin can be challenging in practice.
Advances in 3D printing, however, offer promise to mitigate this issue.
We introduce three optimization models for determining the position of channels inside of 3D printed masks for the treatment of skin cancers using HDR-BT.
We propose solution methods for these models that we evaluate on actual patients data.
Solution times are sufficiently fast to be useful in practice. Further, when compared to plans obtained for masks created without the use of optimization, we observe that our plans tend to be more homogeneous and to have better dosimetric indices.

3 A Multi-objective Optimization Approach for Family Medicine Residency Scheduling

Bjorn Berg[1], Nick Lawrence[2], Derek Hersch[1], Patricia Adam[1], [1]University of Minnesota, Minneapolis, MN, [2]Booz Allen Hamilton, Falls Church, VA, Contact: bberg@umn.edu

Family medicine residency training programs include both experiential and didactic education activities including inpatient hospital service time, specialty rotational training, outpatient clinic responsibilities, and other educational programming. The *Clinic First* curricular model aims to better balance the priority of residents' clinic requirements with the other educational goals. In this talk we develop a modeling framework for resident rotation scheduling which directly incorporates the Clinic First curricular approach and the operational requirements of the residency program clinic. The optimization model presented incorporates a multi-objective approach in designing family medicine resident rotation schedules. Numerical results are presented based on historic rotation schedule data from a residency program clinic.

4 Mixed-integer Linear Programming Formulations for the Robust Surgery Scheduling Problem

Ankit Bansal[1], Jean-Philippe P. Richard[2], Bjorn Berg[2], Yu-Li Huang[3], [1]West Virginia University, Morgantown, WV, [2]University of Minnesota, Minneapolis, MN, [3]Mayo Clinic, Rochester, MN

An exact mixed-integer linear program for the two-stage robust optimization surgery-to-OR allocation problem is presented. We show that the second stage problem can be formulated as a linear program through graphical interpretation. The resulting linear program of the second stage problem is then dualized and integrated into the first-stage problem to yield a monolithic MILP. Multiple reformulations of the resulting MILP are presented . Data from an academic medical center is used to compare the computational performance of these formations and its solution quality with the only known exact approach in the literature.

Sunday, 5 PM–6:15 PM

SE18

CC - Room 123

Medical Decision Making Research by Bonder Scholars

General Session

Session Chair

Pooyan Kazemian, Case Western Reserve University, Cleveland, OH

1 Managing Multiple Chronic Conditions

Luke DeRoos, Mariel Sofia Lavieri, University of Michigan, Ann Arbor, MI, Contact: lkbruski@umich.edu

Age-related macular degeneration (AMD) is a chronic eye disease, and the most common cause of blindness in people over 55. Treating advanced AMD typically requires frequent, expensive injections into a patient's eye. Additionally, having AMD in one eye significantly increases the likelihood of having it in the other eye. We present a dynamic programming framework designed to simultaneously schedule treatment for both eyes. We show how following our framework can reduce patient and provider costs without compromising long-term patient vision. We also demonstrate how our framework can be expanded to consider multiple chronic conditions beyond AMD.

2 Improving Tuberculosis Treatment Adherence Support: The Case for Differentiated Care

Justin J. Boutilier[1], Jonas Oddur Jonasson[2], Erez Yoeli[3], [1]University of Wisconsin - Madison, Fitchburg, WI, [2]MIT Sloan School of Management, Somerville, MA, [3]MIT Sloan School of Management, Cambridge, MA

Lack of patient adherence to treatment protocols is a main barrier to reducing the global disease burden of tuberculosis (TB). We study the operational design of a treatment adherence support (TAS) platform that requires patients to verify their treatment adherence on a daily basis. Our results indicate that, compared with a benchmark policy, the TAS platform could reach the same number of at-risk patients with 6%-40% less capacity, or reach 2%-20% more at-risk patients with the same capacity, by using various ML-based prioritization policies that leverage patient engagement data. Personal sponsor outreach to all patients is likely to be very costly, so targeted TAS may substantially improve the cost-effectiveness of TAS programs.

3 Design and Analysis of Interpretable Policies for Hypertension Treatment Planning

Gian-Gabriel P. Garcia[1], Lauren N. Steimle[1], Wesley J. Marrero[2], Jeremy B. Sussman[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]Thayer School of Engineering at Dartmouth, Hanover, NH, [3]Michigan Medicine, Ann Arbor, MI, Contact: giangarcia@gatech.edu

In medical decision-making, Markov decision processes (MDPs) are useful for optimal treatment planning. Yet, optimal policies may lack interpretable structure. Interpretability is especially critical in hypertension treatment, where complicated clinical guidelines have drawn substantial controversy from practitioners. In this research, we design and analyze MDP-based interpretable policies for treatment planning which leverage the natural interpretability of monotonicity, i.e., the intensity of the prescribed action increases with the severity of the state. We apply our method to hypertension treatment planning and show that it outperforms current guidelines in terms of quality-adjusted life-years and cardiovascular events saved, with only a small loss compared to the optimal policy.

Sunday, 5 PM–6:15 PM

SE20

CC - Room 125

Social Justice Integration into Decision Making

General Session

Session Chair

Destenie S. Nock, Carnegie Mellon University, Pittsburgh, PA

Session Chair

Zana Cranmer, Bentley University, Waltham, MA

1 Presenter

Khalid K. Osman, Stanford University, Stanford, CA, Contact: osmank@stanford.edu

Access to clean, reliable water services is a growing concern in both developing and developed contexts. In the US, certain communities are still devoid of an effective and well-functioning water supply infrastructure. With limited budgets, typically, the "loudest voices" are prioritized, creating inequities as it is well documented that civic engagement and residential trust are lowest among poor and disadvantaged communities. This study aims to understand how existing social equity theories (e.g., utilitarianism, egalitarianism) can be quantified to improve water access in disadvantaged communities. Utilizing genetic algorithms, water utility budget allocation models that are optimized based on mathematical formulations of existing social equity theories are developed. Such models seek to reduce existing inequities in the provision of water services.

2 Capturing Carbon but Not Its Co-pollutants: Carbon Capture in the Electricity System and the Challenge of Just Decarbonization

Paola Furlanetto, University of Massachussets, Boston

Carbon Capture (CC) for use or sequestration is an interesting technology for decarbonization. While its cost- and carbon-effectiveness are under debate, current technologies remove CO_2 not co-pollutants. CO_2 affects the entire planet, but co-pollutants are harmful to those directly exposed with particular consequences for people of color and low-income. This work combines power systems modeling, integrated assessment modeling, and socioeconomic data to evaluate the role of CC distributional equity considering technological uncertainties and policy design. We hypothesize that CC is neither an ideal nor evil technology: its justice implications vary according to demographics, grid characteristics, and generator's types, and ultimately will depend on smart policy implementation that includes equity concerns.

3 Unveiling Hidden Energy Poverty and Its Impact on Energy Transitions

Shuchen Cong[1], Destenie S. Nock[1], Yueming (Lucy) Qiu[2], Bo Xing[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of Maryland, College Park, MD, [3]Salt River Project, Phoenix, AZ, Contact: dnock@andrew.cmu.edu

Here we will discuss how to integrate energy poverty analysis into decision making and planning in the residential sector. Income-based energy poverty metrics ignore people's behavior patterns, particularly reducing energy consumption to limit financial stress. Our relative energy poverty metric, the energy equity gap, is defined as the difference in the air conditioning turn on points between low and high-income groups. In our study region, we estimate the energy equity gap to be between 4.7-7.5°F (2.6-4.2°C). Within a sample of 4577 households, we found 86 energy-poor and 214 energy-insecure households. This energy limiting behavior means energy policy makers need to consider the energy deficits in their residential planning.

Sunday, 5 PM–6:15 PM

SE21

CC - Room 126

Novel Applications of Decision Analysis

General Session

Session Chair

Onesun Steve Yoo, University College London, London, United Kingdom.

1 Search in the Dark: The Normal Case

Manel Baucells, Darden School of Business, Playa Vista, CA

The standard search problem rewards the decision maker with the highest sampled value, minus the sampling cost. If the sampling distribution is unknown, then a Bayesian decision maker faces a complex balance between learning and optionality. We tackle the stopping problem of sampling from a normal distribution with unknown mean and unknown variance using a conjugate prior, a riddle that has remained open for half a century. We find that reservation prices---prevalent in search theory---are no longer optimal. Structurally, the optimal stopping region may be empty, or comprise one or two bounded intervals. We also introduce the so-called internal cost function, which provides a computationally practical way to identify the optimal stopping rule for any given prior, sampling history, and remaining samples, and that can also be applied to the case of known variance.

2 Decision Analysis as Data Analytics

Jeffrey M. Keisler, University of Massachusetts-Boston, Boston, MA, Contact: jeff.keisler@umb.edu

Data analytics gathers, synthesizes aggregate and manipulates data, to then identify, summarize relationships and patterns with an eye toward application. Instead of gathering raw data, decision analysis instead gathers more structured inputs from various sources and from these calculates artificial data, e.g., endpoint values, decision tree probabilities, and utility function parameters. After this, decision analysis follows a process that resembles a special instance of data analytics. Casting decision analysis in this way can enrich the incorporation of data analytics methods within decision analysis and decision analysis methods within data analytics.

3 Scale Dependence & Preference Reversals with Multicriteria Methods

Andrea Hupman[1], Ali E. Abbas[2], [1]University of Missouri - St. Louis, Saint Louis, MO, [2]University of Southern California, Los Angeles, CA

This talk examines the effects of constructed scales used to evaluate criteria, and monotonic perturbations of those scales, on the ranking of decision alternatives when using multicriteria decision methods. Within real-life applications, we illustrate how monotonic transformations of rating scales can change the preference ordering. We use simulation to characterize the sensitivity of ranking reversals in general classes of decisions. We present analytic results, analogous to those of stochastic dominance, for the conditions necessary to preserve the ranking of alternatives after a scale transformation. The results show that the ranking of decision alternatives is sensitive to the constructed scale, except in limited cases. The results provide insights for practitioners and highlight the implications of using arbitrarily constructed measurement scales.

4 Improving Large Scale Procurement Practices Using Natural Language Processing and Machine Learning

Onesun Steve Yoo[1], Xingyi Li[2], Viviana Culmone[1], Bert De Reyck[3], [1]UCL School Of Management, University College London, London, United Kingdom; [2]UCL, London, United Kingdom; [3]UCL School of Management, London, United Kingdom. Contact: onesun.yoo@ucl.ac.uk

A primary challenge faced by manufacturers aiming to improve their procurement practice is that the vast amounts of purchase orders records in their system are in the form of unstructured text data. We present our work with a publicly listed food manufacturer in the UK to tackle this issue. We used natural language processing and machine learning to classify the suppliers and products into hierarchical categories. We also developed an accompanying decision support tool that helps identify the inefficiencies in their procurement spend and provides request for quote (RFQ) targets. Methodologically, our work is the first to provide an accurate 5-level hierarchical classification problem. Practically, our solution is the first to provide an accurate assessment of the current state of a large-scale procurement practice using a “soup” of unstructured text data.

Sunday, 5 PM–6:15 PM

SE22

CC - Room 127
Homeland Security
General Session

Session Chair
Paul Jomon, 1</sup

1 Differential Game Cybersecurity Model Featuring Attackers, Defenders, and Government Intervention

Leo MacDonald, Jomon A. Paul, Kennesaw State University, Kennesaw, GA, Contact: lmacdon4@kennesaw.edu

We develop a dynamic differential cybersecurity game model between an attacker and defender (firm). The attacker can have multiple methods of attack (controls) each with separate probabilities of success and resultant payoffs. The firm meanwhile impacts the probability of successful attack by allocating resources to both prevention and containment strategies that reduce the probability of a successful attack or the resultant losses (attacker payoffs) respectively. We further consider the actions of a third player, namely government (via it's associated agencies), that can use its resources to detect attacker threats and provide information/guidance to a firm to increase the successful defense/containment strategies. We then solve for the equilibrium strategies for each player in the game.

2 A Model of Fortification: A Bayesian Persuasion Approach

Abhra Roy, Jomon A. Paul, Kennesaw State University, Kennesaw, GA, Contact: aroy1@kennesaw.edu

We analyze a model of fortification involving a firm, a government and an attacker. The attacker aims to disrupt the firm's operations. The government can provide intelligence. With these setup we analyze conditions under which the government can persuade the attacker to refrain and the firm to bolster its defenses.

3 Domestic Extremism Prevention in the United States: A Policy Framework

Jomon A. Paul, Aniruddha Bagchi, Kennesaw State University, Kennesaw, GA, Contact: jpaul17@kennesaw.edu

Absence of a domestic extremism prevention architecture represents a major strategic-policy vulnerability in efforts to counter terrorism within the United States. We focus on policies that mitigate this problem. We evaluate how radicalization occurs due to social media, political polarization, attitudes towards immigration, state of economy, religious freedom, among others.

4 Effectiveness of Covid-19 Policies: A Configurational Approach Through Fsqca

Xinfang Wang[1], Jomon A. Paul[2], Aniruddha Bagchi[2], [1]Georgia Southern University, Statesboro, GA, [2]Kennesaw State University, Kennesaw, GA

This study evaluates the impact of state COVID-19 policies such as closures, quarantine, business restrictions on deaths, hospitalizations, and the economy. We employ fuzzy set qualitative comparative analysis (fsQCA) to determine the most impactful configurations of public policies for mitigating COVID-19 hospitalizations and deaths.

Sunday, 5 PM–6:15 PM

SE23

CC - Room 128
Decision Analysis
Contributed Session

Session Chair
Aristomenis Tsopelakos, University of Illinois at Urbana Champaign, Urbana, IL

1 Agree to Disagree: Expert Disagreement as a Dynamic Decision Making Problem

Hesam Mahmoudi[1], Navid Ghaffarzadegan[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Falls Church, VA, Contact: hesam@vt.edu

The known causes of expert disagreement have one thing in common: they are static. While we do not refute any of these causes, we seek to offer an alternative dynamic explanation of how the decision making and learning can cause within- and between-cohort disagreements. We build upon the experiential learning theory to investigate how conditional feedback and sensitivity to skill interact to create path dependent and diverging opinions among learning agents. When customers have agency over choosing among experts, their choices contribute to path dependency, yet improves the total practice outcome. This improvement is due to endogenous specialization rather than diverse opinions contributing to innovation in open-ended situations. In contrast, top-down interventions to create consensus end in damaging the total outcome, even though they indeed reduce disagreement.

2 Applications of Data-driven Production Optimization for Heavy Processing Industries

Nianjun Zhou[1], Binny Samuel[2], Pavankumar Murali[3], [1]IBM, Chappaqua, NY, [2]IBM, Detroit, MI, [3]IBM, Yorktown, NY

This talk focuses on real-time recommendations for the operations of manufacturing processes based on production optimization. The solution provides the predicted and optimized production in a future horizon without and with adopting our recommendation. We develop regression models based on the carefully selected control variables and real-time sensors as the current states of operation with the deep learning technique. We choose either non-linear or Mixed-integer linear programming optimization based on the process complexity and response requirement. We apply our data-driven solution to different heavy industrial applications, such as cement and paper production.

3 Maximizing the Expected Value of Experimentation for Rank Aggregation of Top-k Pairwise Comparisons

Courtney J. Burris[1], Himangshu Kumar Paul[2], Alexander Nikolaev[1], [1]University at Buffalo, Buffalo, NY, [2]University at Buffalo, Amherst, NY, Contact: cburris2@buffalo.edu

In many applications, the top-K commonly most preferred items can be identified by procuring annotators' pairwise preferences of these items. However, soliciting and aggregating this information for ranking can be costly. We present an active sampling algorithm that, at any stage of this inference problem, selects the most informative next pairwise comparison to solicit, based on maximizing the expected value of experimentation. The algorithm's logic and efficiency are demonstrated on both synthetic and real-world datasets.

4 Sequential Anomaly Detection with Sampling Constraints

Aristomenis Tsopelakos[1], Georgios Fellouris[2], [1]University of Illinois at Urbana Champaign, Urbana, IL, [2]University of Illinois at Urbana Champaign, Urbana, IL, Contact: tsopela2@illinois.edu

We consider the problem of sequential anomaly detection, where we observe multiple data sources in real-time, not all of them simultaneously, and we try to identify which of them exhibit outlying statistical behavior. We design detection procedures that consist of a sampling rule that suggests which sources to sample, a stopping rule which determines when to stop, and a decision rule which indicates which sources to identify as anomalous. A lower and an upper bound are assumed on the number of anomalous sources. The probabilities of at least one false alarm and at least one missed detection are controlled below tolerance levels. The number of sources observed at each instance is limited due to sampling constraints. Under this problem setup, we provide two families of sampling rules: the probabilistic and the ordering family, and we show that they are asymptotically optimal.

Sunday, 5 PM–6:15 PM

SE24

CC - Wabash 1
AMPL /
Technology Tutorial

1 Advances in Model-Based Optimization with AMPL

Robert Fourer, AMPL Optimization, Indianapolis, IN, Contact: 4er@ampl.com

Optimization has been fundamental to OR and Analytics for as long as there have been computers, yet we are still finding ways to make optimization software more natural to use, faster to run, and easier to integrate with application systems. This presentation offers a quick tour of ways that AMPL's modeling framework has been enhanced to support optimization in today's challenging applications. Topics include:
 Expressing objectives and constraints more directly and understandably
 Exchanging data and results more directly and efficiently, with spreadsheets and with database systems
 Building better interfaces to applications using snapshots, callbacks, and other new features of AMPL's APIs for popular programming languages
 Deploying optimization in cloud environments and containersTo complement these feature advances, the presentation concludes by describing ways that AMPL is making model-based optimization more accessible, through the new Community Edition, a rewritten NEOS Server client, and free Model Colaboratory examples for teaching and learning optimization.

Sunday, 5 PM–6:15 PM

SE25

CC - Wabash 2
Integration of Prediction and Optimization with Applications in Operations Management
Tutorial Session

Session Chair

Mabel Chou, National University of Singapore, SG, SG, Singapore.

1 **Integration of Prediction and Optimization with Applications in Operations Management**

Meng Qi[1], Zuo-Jun Max Shen[2], [1]Cornell University, Ithaca, NY, [2]University of California Berkeley, Berkeley, CA

Big data provides new opportunities to tackle one of the main difficulties in decision-making systems - uncertain behavior following an unknown probability distribution. Standard data-driven approaches usually consist of two steps. The first step involves predicting or estimating the uncertainty behavior using data. Then the second step requires finding decisions that opti-mize an objective function that depends on the output of the first step. Instead of the classical two-step predict-then-optimize (PTO) procedure, this tutorial examines data-driven solutions that integrate these two steps. We first introduce the problem formulation as a contextual sto-chastic optimization. In this formulation, the objective function depends on the unknown uncer-tainty and the distribution of the uncertainty is associated with some contextual information. Massive data is often available to solve this problem, including historical observations of the uncertainty and contextual information. Therefore, machine learning tools have become an im-portant technique to achieve integrated data-driven solutions. Yet, it is noteworthy that the goal of the integrated data-driven solution is very different from traditional predictive tasks for ma-chine learning. Moreover, different integrated data-driven methods have shown applicability and effectiveness in many real-world decision-making situations, such as inventory manage-ment, COVID-19 pandemic, and power system. To demonstrate the practicality and the real-world impact, we review current achievements of integrated methods in different real-world applications in operations management.

Sunday, 5 PM–6:15 PM

SE26

CC - Wabash 3

Location Analysis in Architectural and Urban Planning

General Session

Session Chair

Hiroko Watanabe, The University of Tokyo, Tokyo, Japan.

Session Chair

Yudai Honma, The University of Tokyo, Meguro-Ku, Japan.

1 **Cost-benefit Analysis of Degree of Renovation and Construction Costs in Architecture Conservation for Conversion to Profit-making Facilities**

Kaori Isawa[1], Hiroko Watanabe[1], Yudai Honma[2], [1]The University of Tokyo, Tokyo, Japan; [2]The University of Tokyo, Meguro-Ku, Japan.

In Japan, whose mainstream urban development is scrap and build, historic architectures are often demolished, and architecture conservation tends to be difficult. Thus this study aims to explore sustainable architecture conservation mathematically. In this study, we propose a mathematical model to solve the optimal degree of renovation in architecture conservation for Conversion to profit-making facilities. We expect this model to become tools to help decision-making for owners have historical architectures.

2 **Maximum Likelihood Estimation of the Optimal Area Assignment by Delivery Planning Simulation**

Junya Maruyama[1], Yudai Honma[2], Daisuke Hasegawa[3], Soma Toki[4], Naoshi Shiono[5], [1]The University of Tokyo, Tokyo, Japan; [2]The University of Tokyo, Tokyo, Japan; [3]The University of Tokyo, Tokyo, Japan; [4]Tokyo Gas Co., Ltd., Tokyo, Japan; [5]Kanagawa Institute of Technology, Atsugi, Japan. Contact: juntama0826@g.ecc.u-tokyo.ac.jp

In this study, we constructed a maximum likelihood estimation model of the optimal area assignment by delivery planning. The model intended to combine the advantages of two delivery planning methods: the efficiency of the software-based method and the flexibility of the area-in-charge method. We solve a large number of delivery planning problems for each stochastic demand pattern using computers and then assign an optimal delivery area that is globally consistent with this data. We focused on whether the optimal route for each demand pattern was included in the same area, and found the assigned area that maximized the probability. This model was created for daily use by solving the optimization of the circulation problem in advance by computer, and turning it into an area map that is easy to understand.

3 **Spatial Interaction Model for Career-path Selections by High School Graduates**

Suzune Nishiyama[1], Yudai Honma[2], [1]The University of Tokyo, Tokyo, Japan; [2]The University of Tokyo, Meguro-Ku, Japan. Contact: nishiyama-suzune713@g.ecc.u-tokyo.ac.jp

In Japan, both the birthrate declining and the population aging are the critical issues, and they are often discussed in conjunction with the excessive concentration in the metropolitan area. Especially, career-path selections by high school graduates significantly affect population distribution nationwide because they often involve moving across the county. This study, therefore, analyzes the structure of their migrations based on the spatial interaction model. As their major choice is either job hunting or proceeding to higher education, we focus on the differences in decision-making between them. This study will contribute to the evidence-based policy-making from educational and urban planning aspects.

4 Spatial Clustering of Sightseeing Spats Based on Real Tourist Trajectory Data

Yuya Nemoto[1], Hiroyuki Hasada[1], Yudai Honma[2], [1]The University of Tokyo, Bunkyo-Ku, Japan; [2]The University of Tokyo, Meguro-Ku, Japan. Contact: nemoto-yuya0324@g.ecc.u-tokyo.ac.jp

With the spread of smartphones and SNS, it has become easier to find attractive sightseeing spots during trips. Therefore, even foreign tourists do not necessarily have to follow a predetermined route, and they can enjoy any place in any order. In this study, we try to clarify the hidden structure behind such free traveling. By proposing a new clustering method for sightseeing movements, we categorize tourist spots and analyze their connections. The method is applied to the actual tourist trajectory data collected on a state scale over several years. This study contributes to load balancing and proposes better tourist spots.

Sunday, 5 PM–6:15 PM

SE27

CC - Room 138

Supply Chain Management with Disruptive Technologies

General Session

Session Chair

Cuihong Li, University of Connecticut, Storrs, CT

Session Chair

Tao Lu, [1]</sup

1 Predictive 3D Printing with IoT

Jing-Sheng Jeannette Song[1], Yue Zhang[2], [1]Duke University, Durham, NC, [2]Pennsylvania State University, University Park, PA, Contact: yue.zhang@psu.edu

We consider the context of a 3D printer supplying a critical part installed in multiple machines embedded with sensors and interconnected via IoT. While it is tempting to perceive that the marriage of 3D printing and IoT would make on-demand printing a reality, our results indicate that the true benefit of the marriage is to enable predictive printing. It is optimal for the 3D printer to print-to-stock predictively in advance of demand, triggered by a system-lifetime-status dependent threshold. Whether it is optimal to print-on-advance-demand to achieve minimum inventory depends crucially on the printing speed. We further quantify the impact of IoT on system cost and inventory by separately assessing the impact of advance demand information from embedded sensors and that of IoT's real-time information fusion from sensor interconnections.

2 Should I Make use of Reservations? The use of Booking Systems for Public Services

Benjamin LEGROS[1], Jan C. Fransoo[2], [1]EM Normandie, PARIS, France; [2]Tilburg University, Tilburg, Netherlands. Contact: jan.fransoo@tilburguniversity.edu

Scarce public resources such as parking facilities or museums increasingly make use of booking systems with reservation slots, with a purpose to provide both better service and a better utilization of the limited resource. Endogenizing the service fee and the duration of the time slot in an Erlang loss queuing game, we identify conditions under which it is beneficial to deploy a booking system, and when it would be better to simply let customers arrive at random.

3 Forewarned is Forearmed? In-transit Monitoring, Contingent Sourcing and Supplier Competition

Tao Lu[1], Brian Tomlin[2], [1]University of Connecticut, Storrs, CT, [2]Tuck School of Business, Hanover, NH, Contact: tao.lu@uconn.edu

Shipment monitoring technologies enable supply chain managers to detect yield-threatening disturbances during transportation of perishable and fragile products and take contingency actions if needed. We examine the implications of in-transit monitoring and contingent sourcing on a buyer purchasing from two competing suppliers. One supplier has a long transportation lead time that is prone to yield loss in transit; the other has a short lead time that is not prone to yield loss. We show that the buyer may or may not benefit from contingent sourcing with in-transit monitoring, as the possibility of contingent sourcing may soften the competition between suppliers. We further discuss the cases when the monitoring technology is imperfect and when a detected disturbance can be corrected (with a certain probability).

4 **Blockchain and Its Applications in the Supply Chain**

Yusen Xia, Georgia State University, Atlanta, GA

In this presentation, we will discuss the blockchain application into supply chains. through several model settings. In particular, various benefits and downfalls are reviewed facing uncertainties of either upstream or downstream or both along the channel.

Sunday, 5 PM–6:15 PM

SE28

CC - Room 139

Revenue Management and Online Platform Analytics

General Session

Session Chair

Ozalp Ozer, Amazon, Richardson, TX

Session Chair

Can Kucukgul, The University of Texas at Dallas, Richardson, TX

1 **Optimal Feedback in Contests**

Sina Moghadas Khorasani[1], Jeffrey Ely[2], George Georgiadis[3], Luis Rayo[4], [1]University of California San Diego, Rady School of Management, La Jolla, CA, [2]Northwestern University, Evanston, IL, [3]Northwestern University, Kellogg School of Management, Chicago, IL, [4]Northwestern University, Kellogg School of Management, Evanston, IL, Contact: skhorasani@ucsd.edu

We obtain optimal dynamic contests for environments where the designer monitors effort through coarse, binary signals and aims to elicit maximum effort, ideally in the least amount of time possible. The designer has a vast set of contests to choose from, featuring termination and prize allocation rules together with real-time feedback for the contestants. Every effort-maximizing contest has a history-dependent termination rule, a feedback policy that keeps agents fully apprised of their own success, and a prize allocation rule that grants them, in expectation, a time-invariant share of the prize if they succeed. Any contest that achieves this effort in the shortest possible time must in addition be what we call second chance: once a pre-specified number of successes arrive, the contest enters a countdown phase where contestants are given one last chance to succeed.

2 **Pay with Your Data: Designing Optimal Data-sharing Mechanisms for Artificial Intelligence Services**

Seetharama Chandrasekhar Manchiraju[1], Sameer Mehta[2], Milind Dawande[3], Ganesh Janakiraman[4], [1]University of Texas-Dallas, Richardson, TX, [2]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands; [3]The University of Texas at Dallas, Richardson, TX, [4]University of Texas- Dallas, Richardson, TX, Contact: chandumanchi@gmail.com

Technology companies such as Google, Amazon, and Microsoft offer the speech-to-text Machine Learning (ML) service. In interesting pricing mechanisms found in practice for this service, companies provide a discount to customers for sharing their data to improve the ML models used for the service. In this paper, we analyze two pricing mechanisms used by major technology companies and derive an optimal mechanism over a class of mechanisms inspired by these two mechanisms. We compare the revenue obtained, the improvement in the service, and the consumer surplus across these mechanisms.

3 **Empirical Investigation of Side Effects of Adaptive Pricing**

Ozalp Ozer[1], Inki Sul[2], A. Serdar Simsek[3], [1]Amazon, Richardson, TX, [2]University of Texas at Dallas, Richardson, TX, [3]University of Texas-Dallas, Richardson, TX, Contact: inki.sul@utdallas.edu

We assess the impact of a retailer's frequent price adjustments on customers' long term expenditure. From the observational dataset we obtained from our partner luxury fashion retailer, we study the spillover effects of observing different prices of a product on a customer's overall future expenditure pattern within the retailer. Using propensity score matching and causal learning method, we find negative effects of frequent price changes on long-term expenditure of customers who observed them. By quantifying the long-term effect of price fluctuation on sales, we provide product-level optimal price change budget, i.e., the amount of price change allowed within a certain time period. Using this result, we find conditions in which how adaptive pricing retailer can price lower than competitors and still maintain overall revenue in the long run using simulation.

Sunday, 5 PM–6:15 PM

SE29

CC - Room 140

Patient-centered Healthcare Modeling

General Session

Session Chair

Hossein Piri, University of British Columbia-Sauder School of Business, Vancouver, BC, Canada.

1 Individualized Dynamic Patient Monitoring Under Alarm Fatigue

Hossein Piri[1], Tim Huh[1], Steven Shechter[1], Darren Hudson[2], [1]Sauder School of Business-University of British Columbia, Vancouver, BC, Canada; [2]University of Alberta-Department of Critical Care Medicine, Edmonton, AB, Canada. Contact: hossein.piri@sauder.ubc.ca

Hospitals are rife with alarms, many of which are false. This leads to alarm fatigue, in which clinicians become desensitized and may inadvertently ignore real threats. We develop a partially observable Markov decision process model for recommending dynamic, patient-specific alarms in which we incorporate a cry-wolf feedback loop of repeated false alarms. Our model takes into account patient heterogeneity in safety limits for vital signs and learns a patient's safety limits by performing Bayesian updates during a patient's hospital stay. We develop structural results of the optimal policy and perform a numerical case study based on clinical data from an intensive care unit. We find that compared with current approaches of setting patients' alarms, our dynamic patient-centered model significantly reduces the risk of patient harm.

2 Data-driven Predictive Models for Identifying Risk Factors Leading to Opiate Abuse

Jinha Lee[1], Arthur Yeh[2], Zenan Sun[3], Qizhen Lan[3], Hyojung Kang[4], [1]Bowling Green State University, Bowling Green, OH, [2]Bowling Green State University, Bowling Green, OH, [3]Bowling Green State University, Bowling Green, OH, [4]University of Illinois at Urbana-Champaign, Champaign, IL, Contact: jinhal@bgsu.edu

Although slightly decreasing from 2017 to 2018, opioid-related overdose remains a leading cause of injury-related mortality in the US, with nearly 70% of drug overdoses involving opioids. Chronic opioid therapy guidelines recommend identifying patients with increased risk of problematic opioid use, but the clinical assessment of risks often does not occur on a timely basis. Thus, relying on clinical judgment alone may be inadequate for clinicians to choose the proper course of action for patients with chronic pain. This research aims to provide the knowledge and tools necessary for opiate addiction in Ohio. In particular, this study aims to harness the potential of big-data analytics to identify the patient-level factors associated with opioid dependency and subsequently develop a model to predict the likelihood of opioid addiction.

3 A Patient-centered Solution to the Physician Preferred Item Problem

Renato E. de Matta, University of Iowa, Iowa City, IA, Contact: renato-dematta@uiowa.edu

When making decision for a patient about using an implantable medical device, the physician balances the technology, clinical judgment, and medical evidence to produce good patient outcomes. While the purchase of a broader assortment of the device would accommodate the Physician Preferred Items (PPIs), hospitals have become selective in stocking the PPIs as revenues have been constrained and Medicare reimbursements have decreased. We shall find the tradeoff between cost savings from discounts offered by a device manufacturer and reduced patient utility if the patient does not receive the PPI. We formulate the problem with uncertain demand as a two-stage stochastic program with recourse decisions. With industry data, we show that stocking each PPI coupled with the physician's flexibility to use a lesser preferred device can produce good patient outcomes at lower cost.

4 Unlocking Cost Savings Hidden in Hospital Tier Contracts

Willow Yang[1], James Campbell[2], Mitchell Millstein[2], [1]Sam Houston Sate University, Huntsville, TX, [2]University of Missouri - St. Louis, Saint Louis, MO, Contact: willowyang@shsu.edu

Medical supply costs account for up to 40% of a hospital's expenses and continue to grow. We present a new and practice-oriented approach to combatting high medical supply costs by exploiting cost-saving opportunities hidden in complex hospital procurement contracts. We formulate a MILP model to validate and optimize procurement decisions while taking into account real-world complexities, including complicated tier pricing schemes, physician preference items (PPIs), and asymmetric product substitutability. The application of our approach to regional and nationwide health systems shows significant cost-saving opportunities in hospital procurement and the ability to quantity the impact of PPIs. PPIs have been highly criticized for inflating medical supply costs. We show only a few may be "critical" for reducing costs and require the focus of management resources.

Sunday, 5 PM–6:15 PM

SE30

CC - Room 141
Risk and Uncertainty Mitigation in Supply Chains
General Session

Session Chair
Mert Hakan Hekimoglu, Rensselaer Polytechnic Institute, Troy, NY

1 Fighting Imperfect Produce: Grocery Retailing Strategies and the Battle Against Food Waste

Haoran Yu, Burak Kazaz, Fasheng Xu, Syracuse University, Syracuse, NY, Contact: hyu143@syr.edu

We examine a retailer's food ordering process where a random proportion of the order is imperfect. We build a MNL model to determine how to sell fresh and imperfect produce. We consider three prevailing strategies: Discarding, bunching and differentiating. We determine optimal quantity and price under each strategy. We identify the optimal strategy under various factors, including consumers' valuation of imperfect produce, price sensitivity, and retailer's limited shelf space.

2 Portfolio Approach to Cash Flow Variability

Nikolay Osadchiy[1], William Schmidt[2], Jing Wu[3], [1]Emory University, Atlanta, GA, [2]Cornell University, Ithaca, NY, [3]Chinese University of Hong Kong, Hong Kong, Hong Kong.

Firms with high cash flow variability are more likely to experience cash flow shortfalls that disrupt budget plans, capital expenditures, and research and development investments. We document how cash flow variability changes within firms and over a supply chain network, and find that the variability of inbound cash flows is on average greater than variability of demand, and variability of outbound cash flows is greater than variability of production. We then show that an operational hedge (customer portfolio management) can be a viable alternative to financial hedging to smooth cash flow variability.

3 VinTech: Robo-Advising Using Wine Analytics

Mert Hakan Hekimoglu[1], Burak Kazaz[2], [1]Rensselaer Polytechnic Institute, Troy, NY, [2]Syracuse University, Syracuse, NY, Contact: hekimm@rpi.edu

This paper examines a comprehensive path regarding how analytics can be employed for automated trading of wine. We coin this as VinTech. The paper highlights the essential components of data analytics necessary for robo-advising. We first develop a pricing algorithm to represent the realistic value of a wine. Using this algorithm, we then compare the price evolution of underpriced wines to overpriced wines. Last, our robo-advising algorithm constructs wine portfolios for different investment goals and risk preferences. We demonstrate the performance of our algorithm using out-of-sample testing. This paper aims to convert an opaque market into a transparent and efficient investment market.

Sunday, 5 PM–6:15 PM

SE31

CC - Room 142
Economics of Retail Distribution Services
General Session

Session Chair
Stanley Lim, Michigan State University, East Lansing, MI

1 The Point of No Return? Restrictive Changes to Lenient Return Policies and Resulting Consumer Reactions

James Duane Abbey[1], Huseyn Abdulla[2], Michael Ketzenberg[3], [1]Texas A&M University, College Station, TX, [2]Mays Business School, Texas A&M University, College Station, TX, [3]Texas A&M University, College Station, TX

Retailers face a challenging trade-off in maintaining versus restricting long-established lenient return policies. Lenient return policies have become an important part of retailers' value proposition. Yet, lenient return policies increase volume of product returns, which hurts profitability. Motivated by observing an increase in restrictive changes to long-established lenient return policies, we investigate consumer reactions to such changes and their managerial implications. Through a series of randomized online experiments with diverse consumer samples, we find that restrictive changes decrease consumer trust in retailers and lead to lowered favorable behavioral intentions. We also find that providing managerial transparency, in the form of communicating the rationale for restrictive changes, can attenuate the negative consumer reactions.

2 Inventory and Supply Chain Management with Auto-delivery Subscription

Junfei Lei, University of Washington, Seattle, WA

Auto-delivery subscription is widely employed in supply chains whereby a supplier delivers products to buyers based on the buyer's choice of shipping quantity. The buyer enjoys a discount for the auto-delivery orders and other benefits, including free subscription and cancellation. Since those benefits seem to all accrue to the buyer at the supplier's expense, it is an intriguing question about the rationale for

the supplier's decision to offer auto-delivery and its impact on the profitability of both parties. We first develop a model consisting of a supplier and a single buyer, whereby the supplier offers a discount for the auto-delivery orders and the buyer chooses the auto-delivery quantity with the flexibility of canceling the subscription. Later, we extend the model to a setting with multiple buyers, whereby the supplier sets a public discount for all the buyers.

3 The Value of Home Delivery Subscription Services: Evidence from an Omnichannel Retailer

Stanley Lim[1], Sungho Park[2,3], Elliot Rabinovich[2], Rui Sousa[4], [1]Michigan State University, East Lansing, MI, [2]Arizona State University, Tempe, AZ, [3]Seoul National University, Seoul, Korea, Republic of; [4]Catholic University-Portugal, Porto, Portugal. Contact: slim@msu.edu

We examine the value of delivery subscription programs in an omnichannel context. Using order transactions data from an an omnichannel retailer before and after the introduction of a subscription program, we find that subscribers increase their online product spending after joining the program. However, the online product sales contribution is offset by changes in consumers' behaviors intended to extract economic benefits from joining the program, with negative impacts on fulfillment operations. We discuss the implications of these findings for the design of subscription programs and fulfillment operations.

4 Modeling Drivers' Choices in a Crowdsourced Delivery System

Hyunsuk Baek[1], Stanley Lim[2], Elliot Rabinovich[3], Lina Wang[4], Rui Yin[3], [1]Arizona State University, Tempe, AZ, [2]Michigan State University, East Lansing, MI, [3]Arizona State University, Tempe, AZ, [4]Georgia Southern University, Statesboro, GA, Contact: hbaek9@asu.edu

We model the choices crowdsourced drivers make when selecting order bundles for last-mile delivery. We apply the model empirically to the operations of a crowdsourced delivery platform during a four-month period to identify how crowdsourced drivers build their delivery workloads as a function of (cumulative) pay, delivery locations of the bundles, and distances between the bundles for density. We then show the insights on improvements to the assembly of bundles.

Sunday, 5 PM–6:15 PM

SE32

CC - Room 143

Sustainability Considerations in Supply Chains

General Session

Session Chair

Olga Perdikaki, University of South Carolina, Columbia, SC

Session Chair

Aditya Balaram, University of South Carolina

1 A Comparison of the Fast-fashion and Traditional Approaches to Apparel Retail: Profits and Environmental Impact

Aditya Balaram, Mark Ferguson, Olga Perdikaki, University of South Carolina, Columbia, SC, Contact: aditya.balaram@grad.moore.sc.edu

Apparel retailers have typically followed either the traditional (long lead times and more durable products) or fast-fashion approach (shorter lead times and less durable products). We compare these two approaches in terms of profitability and environmental impact, identifying win-win (more profitable and lower environmental impact) outcomes for both approaches. We also provide prescriptions to policy makers on which phase of a product's life-cycle to focus their sustainability efforts on.

2 Environmental Regulation Design: Motivating Firms' Clean Technology Investments with Penalties and Consumer Subsidies

Mina Mohammadi[1], H. Sebastian Heese[2], Tim Kraft[3], [1]North Carolina State University, Raleigh, NC, [2]NC State University, Raleigh, NC, [3]NC State - Poole College of Management, Raleigh, NC, Contact: mmohamm6@ncsu.edu

We study a regulator's choice of firm penalty and consumer subsidy for motivating firms to invest in clean technologies. Using an asymmetric duopoly, we examine the effect of competition and development uncertainty on a regulator's optimal decisions. We find that once the penalty and/or subsidy are sufficient to induce firms' investments, the use of a subsidy is always beneficial to the environment, firms, and consumers. Conversely, although penalizing firms for selling harmful products always benefits the environment, whether the penalty increases or decreases firm profitability and consumer welfare depend on the level of competition between the firms. Our findings provide insight into a regulator's policy decisions for motivating firms' environmental investments and how these decisions should be adapted based on the level of competition within an industry.

3 **Role of Traceability and Government Inspections on Deterring Adulteration in Competing Farming Supply Chains**

Weihua Zhou[1], Jinxin Yang[1], Zhong Chen[2], Retsef Levi[3], [1]Zhejiang University, Hangzhou, China; [2]East China Normal University, Shanghai, China; [3]MIT, Cambridge, MA, Contact: jinxin21@mit.edu

Food adulteration poses a serious threat to public health. This paper theoretically and empirically examines whether supply chain traceability can help the government effectively deter adulteration when a traceable supply chain and an untraceable supply chain compete in the market. Our results show that supply chain traceability may inadvertently induce the farmer to adulterate when the traceable supply chain has a competitive advantage over the untraceable one.

Sunday, 5 PM–6:15 PM

SE33

CC - Room 144

Research in Sustainable Operations and Supply Chain Management

General Session

Session Chair

Jason Nguyen, Ivey Business School, Western University, London, ON, Canada.

1 **Pride or Guilt? Impacts of Consumers' Socially Influenced Recycling Behaviors on Closed-loop Supply Chains**

Wenjie Huang[1], Chung-Li Tseng[1], Jason Nguyen[2], Samuel Nathan Kirshner[1], Wenlin Chen[3], [1]UNSW Business School, Sydney, Australia; [2]Ivey Business School, Western University, London, ON, Canada; [3]University of Electronic Science and Technology of China, Chengdu, China. Contact: wenjie.huang1@unsw.edu.au

The Operations Management (OM) and Environmental Psychology literature have examined consumer recycling behavior to address the growing sustainability crisis. Although Environmental Psychology research establishes that social influence substantially impacts recycling behavior, it has been mostly overlooked in OM research. In contrast, Environmental Psychology literature often ignores firms' operational decisions, which also significantly affects consumers' recycling decisions. This article examines how consumers' recycling behaviors are influenced by both the socially influenced emotions of pride and guilt and the firm's optimal decisions. This helps establish a better understanding of the motivations driving consumers' recycling behaviors, which is essential to unlocking the full potential of remanufacturing.

4 **Cosmetic Quality Standard and Its Impact on Food Waste**

Pascale Crama[1], Yangfang (Helen) Zhou[2], Manman Wang[3], [1]Singapore Management University, Singapore, Singapore; [2]Lee Kong Chian School of Business, Singapore Management University, Singapore, Singapore; [3]University of Science and Technology of China, He Fei, China. Contact: helenzhou@smu.edu.sg

A significant amount of fresh produce is wasted in the upstream of food supply chain due to the high cosmetic standard---regarding the appearance of the produce---which are set by retailers. We examine the economic incentives for retailers to adopt such high standards and their impact on food loss. A high minimum cosmetic standard of the produce enables the produce to be sold at a premium, which decreases the proportion of the produce that satisfies such standards. We show how the retailer's decision of cosmetic standard as well as food loss are affected by rejection rate due to high cosmetic standards and consumers' willing-to-pay for cosmetic-pleasing products.

Sunday, 5 PM–6:15 PM

SE34

CC - Room 145

Supply Chains and Sustainability

Contributed Session

Session Chair

Sarah Damberg, EBS University

1 **How Controversies in Supply Chain Help to Achieve Better Sustainability Practices? The Moderating Effect of R&D and Advertising**

Amir Naderpour, Gregory V. Frazier, University of Texas-Arlington, Arlington, TX, Contact: amir.naderpour@mavs.uta.edu

We focus on the effect of sustainable supply chain management (SSCM) controversies on implementing environmental, social, and governance sustainability practices. We study the relationship between SSCM controversies and different dimensions of sustainability practices, and the influence of investments in R&D and advertising on this relationship. Using a longitudinal sample of 610 firms observed from 2009 to 2019 and collected from three archival sources (Sustainalytics, ASSET4, COMPUSTAT) we posit that the relationship between SSCM controversies and sustainability practices would be influenced by the levels of the firm's investments in value-creating (e.g., R&D) and value-appropriating (e.g., advertising) resources.

2 Co_2 Conversion to Fuels Supply Chain Network Optimization

Rui Zhou[1], Mingzhou Jin[2], [1]University of Tennessee, Knoxville, knoxville, TN, [2]University of Tennessee-Knoxville, Knoxville, TN, Contact: rzhou7@vols.utk.edu

CO_2 conversion to fuels has great potential in CO_2 reduction, carbon-based resources alternative, and renewable energy storage. We evaluate the economic performance of three CO_2 conversion pathways and develop a mix-integer linear programming model to incorporate spatial and techno-economical data for the renewable fuels supply chain network optimization. The model is applied to the aviation jet fuel consumption in the major U.S. airports.

3 Who Cares More? An Empirical Study of US Companies on Negative News and Sustainable Supply Chain Management

Sarah Damberg[1], Julia Hartmann[2], [1]EBS Universität für Wirtschaft und Recht, Oestrich, Germany; [2]EBS Universität für Wirtschaft und Recht, Wiesbaden, Germany.

Negative news gains more and more attention in our world and are paramount in current times. Consequences of negative news have to be handled by decision makers, even if the news controversies origin is based among the supply chain. In the current literature we see that negative news influence companies SSCM practices and affects their management. Thus, we know little about the different companies' characteristics. In this research, we empirically ascertain characteristics of a company by using panel regression in form of a split-sample analysis. Among other things, we find that B2C companies react more to negative news by implementing SSCM prcatices than B2B companies do. With our research we contribute to the sparse literature in this research field and provide interesting information for decision makers.

Sunday, 5 PM–6:15 PM

SE35

CC - Sagamore 1

Advances in Algorithms for Nonsmooth Optimization

General Session

Session Chair

Jiaming Liang, Georgia Institute of Technology, Atlanta, GA

1 A Single Cut Proximal Bundle Method for Stochastic Convex Composite Optimization

Jiaming Liang[1], Vincent Guigues[2], Renato D C Monteiro[3], [1]Yale University, New Haven, CT, [2]Fundação Getulio Vargas, Rio de Janeiro, Brazil; [3]ISyE Georgia Tech, Atlanta, GA

We present a stochastic composite proximal bundle (SCPB) method for solving convex composite stochastic optimization problems. Our approach is based on a novel one-cut model instead of the conventional cutting-plane model. The SCPB method includes the stochastic subgradient method as a special instance. To the best of our knowledge, this is the first proximal bundle method for stochastic programming able to deal with continuous distributions. To better illustrate the SCPB method, we study its performance on two-stage stochastic programming problems.

2 Scalable, Projection-Free Optimization Methods

Benjamin Grimmer, Johns Hopkins University, Baltimore, MD

We will discuss a newly developed approach to constrained optimization replacing orthogonal projections with much cheaper radial ones. This machinery only requires one-dimension line-searches while applying to a wide family of nonconvex functions and constraints. This construction gives rise to a duality relating optimization problems to radially dual problems. From this, we develop new projection-free first-order methods that avoid any Lipschitz continuity assumptions while benefiting from smoothness and growth conditions in the objective function. Moreover, we identify benefits from smoothness and strong convexity of constraint sets.

3 Survey Descent: A Multipoint Generalization of Gradient Descent for Nonsmooth Optimization

X.Y. Han, Adrian S. Lewis, Cornell University, Ithaca, NY, Contact: xh332@cornell.edu

For strongly convex objectives that are smooth, the classical theory of gradient descent ensures linear convergence relative to the number of gradient evaluations. An analogous nonsmooth theory is challenging: even when the objective is smooth at every iterate, the corresponding local models are unstable, and traditional remedies need unpredictably many cutting planes. We instead propose a multipoint generalization of the gradient descent iteration for local optimization. While designed with general objectives in mind, we are motivated by a "max-of-smooth" model that captures the subdifferential dimension at optimality. We prove linear convergence when the objective is itself max-of-smooth, and experiments suggest a more general phenomenon.

4 Optimal Methods for Convex Risk Averse Distributed Optimization

Zhe Zhang[1], George Lan[2], [1]Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: zzhang724@gatech.edu

We study convex risk-averse optimization over a network. The problem generalizes the well-studied risk-neutral distributed optimization, but its communication and computation complexities are unknown. We propose two distributed algorithms, namely the distributed risk-averse optimization (DRAO) method and the distributed risk-averse optimization with sliding (DRAO-S) method, with tight complexities. The DRAO method achieves the optimal communication complexity, but it needs to assume a certain saddle point subproblem to be easily solvable. The DRAO-S method removes the strong assumption by introducing a novel saddle point sliding subroutine. Its computation complexity, characterized by the number of projection steps and gradient evaluations, is optimal. Matching lower communication complexity bounds for both DRAO and DRAO-S are also presented.

Sunday, 5 PM–6:15 PM

SE36

CC - Sagamore 2

OPT/Optimization Under Uncertainty Flash Session II

Flash Session

Session Chair

Hyoeun Lee, UIUC, Champaign, IL

1 Does Enforcing Fairness Mitigate Biases Caused by Sub-population Shift?

Subha Maity[1], Debarghya Mukherjee[1], Mikhail Yurochkin[2], Yuekai Sun[1], [1]University of Michigan, Ann Arbor, MI, [2]IBM Research, Cambridge, MA, Contact: smaity@umich.edu

Many instances of algorithmic bias are caused by subpopulation shifts. For example, ML models often perform worse on demographic groups that are underrepresented in the training data. In this paper, we study whether enforcing algorithmic fairness during training improves the performance of the trained model in the target domain. On one hand, we conceive scenarios in which enforcing fairness does not improve performance in the target domain. On the other hand, we derive necessary and sufficient conditions under which enforcing algorithmic fairness leads to the Bayes model in the target domain. We also illustrate the practical implications of our theoretical results in simulations and on real data.

2 Optimal Transport Problems for Capacities

David Saunders, University of Waterloo, Waterloo, ON, Canada. Contact: dsaunders@uwaterloo.ca

We consider the problem of finding a capacity on a product space that minimizes the Choquet integral of a cost function among all joint capacities with given marginals. The problem can be reformulated as a linear optimization problem, for which an explicit solution exists. Relations to other optimization problems and applications in finance and economics will be discussed.

3 A Stochastic Conjugate Subgradient Method for Large-scale Convex Optimization Problems

Di Zhang, University of Southern California, Los Angeles, CA

We present a stochastic extension of Wolfe's non-smooth conjugate subgradient algorithm which was originally designed to solve large-scale convex optimization problems using approximations that go beyond standard first order methods. The convergence of the algorithm is outlined, together with compelling computational evidence of the effectiveness using a variety of data sets associated with applications of Kernelized SVM.

4 Dynamic Assortment Planning: Online Demand Learning with Limited Inventory

Omid Arhami[1], Shirin Aslani[2], Masoud Talebian[3], [1]University of Georgia, Athens, GA, [2]Sharif University of Technology, Tehran, Iran, Islamic Republic of; [3]Columbia University, New York, NY, Contact: Omid.Arhami@uga.edu

We explore a simultaneous dynamic assortment planning and inventory allocation problem spanning multiple replenishment periods, in which the store learns demand online and actively based on sales data. To optimize revenue, the store must make two decisions jointly: product assortment and inventory allocation quota. The demand censoring induced by stock-outs and substitution is addressed by our algorithm, which continuously recognizes and filters out the truncated demand data. In various cases, numerical results show that our algorithm has a sublinear regret. Our findings also reveal that an inventory constraint has a major impact on a retailer's both learning and profit.

5 **A Dimension-insensitive Algorithm for Stochastic Zeroth-order Optimization**

Hongcheng Liu, Yu Yang, University of Florida, Gainesville, FL

We consider convex, stochastic zeroth-order optimization (S-ZOO). For this problem, we propose a sparsity-inducing stochastic gradient-free (SI-SGF) algorithm, which provably yields a dimension-free (up to a logarithmic term) query complexity in both convex and strongly convex cases. Such insensitivity to the dimensionality growth is proven, perhaps for the first time, to be achievable when neither gradient sparsity nor gradient compressibility is satisfied.

6 **Insights on the Theory of Robust Games**

Giovanni P. Crespi[1], Davide Radi[2], Matteo Rocca[3], [1]Università Cattaneo LIUC, Castellanza, Italy; [2]Università di Pisa, Pisa, Italy; [3]Universita' degli studi dell'Insubria, Varese, Italy. Contact: pcrespi@liuc.it

We consider aversion to payoff uncertainty in static games. Assuming the robust-optimization approach to uncertainty, we obtain a distribution-free model to handle ambiguity. We introduce opportunity cost of uncertainty and we prove relations between robust-optimization equilibria and \epsilon-Nash equilibria of the nominal counterpart game. Under some regularity conditions, robust-optimization equilibria converge towards a Nash equilibrium of the nominal counterpart game, when the level of uncertainty vanishes. Application to Cournot duopoly is also discussed.

7 **Mitigating the Impacts of Uncertain Geomagnetic Disturbances on Electric Grids**

Minseok Ryu[1], Harsha Nagarajan[2], Russell Bent[3], [1]Argonne National Lab, Tempe, AZ, [2]Los Alamos National Laboratory, Los Alamos, NM, [3]Los Alamos National Laboratory, Los Alamos, NM, Contact: harsha@lanl.gov

Geomagnetic disturbances increase the magnitude of the electric field on the Earth's surface (E-field) and drive geomagnetically-induced currents (GICs) along the transmission lines in electric grids. GICs can pose severe risks, like current distortions, transformer saturation and increased reactive power losses, leading to system unreliability. Further, GIC modeling is challenging because E-field's magnitude and direction are uncertain and non-stationary. In this work, we model uncertain E-fields using the distributionally robust optimization approach (DRO) that determines optimal transmission grid operations such that the worst-case expectation of the cost is minimized. We develop an accelerated CCG algorithm by exploiting a special structure of the support set and present extensive numerical experiments based on GIC-specific test systems.

Sunday, 5 PM–6:15 PM

SE37

CC - Sagamore 6

Leveraging Structure of Uncertainty in Dynamic Optimization

General Session

Session Chair

Eojin Han, Southern Methodist University, Dallas, TX

1 **Dynamic Capacity Management for Deferred Surgeries**

Eojin Han[1], Kartikey Sharma[2], Kristian Singh[3], Omid Nohadani[4], [1]Southern Methodist University, Dallas, TX, [2]Zuse Institute Berlin, Berlin, Germany; [3]Benefits Science Technologies, Arlington, TX, [4]Benefits Science Technologies, Arlington, MA, Contact: eojinh@smu.edu

The COVID-19 pandemic has necessitated widespread deferrals of elective surgeries, which non only increase the cost from deterioration of patients' conditions but also decrease the revenue. However, the endogeneity of the uncertainty to hospital operations renders existing capacity management approaches inapplicable. To this end, we develop a robust optimization framework for the dynamic surgical capacity management problem. Uncertain parameters and their endogenous nature are modeled via multilinear functions, and the concept of tree of uncertainty products is proposed to for tractable approximations under various decision rules. Our Implementation for more than 15,000 hernia patients in the United States demonstrates sizable improvements over alternative methods by up to 10% with multiple practical insights on optimal expansion strategy.

2 **A Decision Rule Approach for Two-stage Data-driven Distributionally Robust Optimization Problems with Random Recourse**

Xiangyi Fan[1], Grani Adiwena Hanasusanto[2], [1]The University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, Austin, TX, Contact: fxy@utexas.edu

We study two-stage stochastic optimization problems with random recourse, where the adaptive decisions are multiplied with the uncertain parameters. To mitigate the computational intractability of infinite-dimensional optimization, we propose a scalable approximation scheme via piecewise decision rules. We then develop a data-driven distributionally robust framework with two layers of robustness to address distributionally uncertainty. The optimization problem can be reformulated as an exact copositive program, which admits tractable approximations in semidefinite programming. We design a decomposition algorithm where smaller-size semidefinite programs can be solved in parallel, which further reduces the runtime. Lastly, we establish the performance guarantees of the proposed scheme and demonstrate its effectiveness through numerical examples.

3 Presenter

Karthik Natarajan[1], Louis Chen[2], Divya Padmanabhan[3], Chee Chin Lim[4], [1]Singapore University of Technology and Design, Singapore, Singapore; [2]Naval Postgraduate School, california, CA, [3]IIT Goa, Goa, India; [4]National University of Singapore, Singapore, Singapore.

In this paper, we introduce a correlation robust model for the influence maximization problem. We evaluate a seed set's expected influence under all possible correlations - specifically, the one that presents the worst-case. We show that any seed set's worst-case expected influence can be efficiently computed, and though optimizing the worst-case (over seed sets) is NP-hard, a (1 − 1/e) approximation algorithm can be obtained. We provide structural insights from the model and contrast it with the independent cascade model. We discuss how the proposed model can be extended to optimize other objectives by controlling for conservatism using a mixture of the independent and the worst-case distribution or by incorporating risk criterion in choosing the seed set. Finally we provide insights from numerical experiments to illustrate the usefulness of the model.

4 Supermodularity in Two-stage Distributionally Robust Optimization

Daniel Zhuoyu LONG[1], Jin Qi[2], Aiqi ZHANG[3], [1]The Chinese University of Hong Kong, Hong Kong, Hong Kong; [2]Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [3]University of Toronto, Toronto, ON, Canada. Contact: jinqi@ust.hk

We solve a class of two-stage distributionally robust optimization problems which have the property of supermodularity. We exploit the explicit worst-case expectation of supermodular functions and derive the worst-case distribution for the robust counterpart. This enables us to develop an efficient method to obtain an exact optimal solution. We also show that the optimal segregated affine decision rule returns the same optimal value in our setting. Further, we provide a necessary and sufficient condition for checking whether any given two-stage optimization problem has the supermodularity property. We apply this framework to several classic problems, including the multi-item newsvendor problem, the facility location design problem, the lot-sizing problem on a network, the appointment scheduling problem and the assemble-to-order problem.

Sunday, 5 PM–6:15 PM

SE38

CC - Sagamore 7

Modeling for Stochastic Programming

General Session

Session Chair

Alan J. King, IBM Research, Yorktown Heights, NY

1 An End-to-end Automated AI System for Reinforcement Learning

Long Vu[1], Todd Mummert[1], Radu Marinescu[2], Dharmashankar Subramanian[1], Peter KIRCHNER[1], Paulito Palmes[2], Nhan Pham[1], Tejaswini Pedapati[1], [1]IBM TJ Watson Research Center, Yorktown Heights, NY, [2]IBM Research, Dublin, Ireland.

Deep Reinforcement Learning (RL) has emerged as a promising technique for solving sequential decision-making problems under uncertainty in many real-world applications. However, it is known to be highly sensitive to internal hyperparameters and requires significant expert manual effort for tuning an intractably large number of configurations. We present an Automated AI system for RL, combining both open source and proprietary algorithms in a unified framework and enabling rapid algorithm selection and hyperparameter optimization, thus allowing non-experts to benefit from SOTA RL solutions. Our system supports online and offline RL algorithms, achieving optimal solutions for a large set of benchmark RL environments. The system also provides hosted service on IBM API Hub where users can make REST API requests to train RL agents.

2 Continuous Deep Reinforcement Learning for Non-stationary Stochastic Inventory Optimization

Henri Dehaybe[1], Daniele Catanzaro[2], Philippe Chevalier[3], [1]Universite Catholique de Louvain, Louvain-la-Neuve, Belgium; [2]Universite Catholique de Louvain, Mons, Belgium; [3]UCLouvain, Louvain La Neuve, Belgium. Contact: henri.dehaybe@uclouvain.be

The deep Reinforcement Learning (RL) approach to Inventory Control has recently been the subject of increasing research interest as it holds the promise of autonomously learning complex replenishment policies. Yet, prior publications face a major scalability issue due to the need of discretizing the action-space of the problems. We propose to use continuous deep RL to address this issue by approximating continuous policies to backorder and lost sales versions of the single-item lot sizing problem in the most general setting of non-stationary stochastic demand and fixed order cost. We show that, after an appropriate training in randomly generated environments, our approach can interpolate near-optimal dynamic policies in real-time on instances with a rolling-horizon given a previously unseen demand forecast, without the need to periodically resolve the problem.

3 Behaviorally-enriched Learning Mechanism for Road Network Restoration After Disasters

Maryam Babaee, Namrata Saha, Shabnam Rezapour, Florida International University, Miami, FL, Contact: mbaba005@fiu.edu

This study proposes a reinforcement learning-based mechanism for scheduling the restoration of disrupted road infrastructure. Considering post-disruption evolutions in the routing behavior of travelers, the objective of the mechanism is to maximize the traffic acceleration. The mechanism is tested on the road network of Sioux Falls in South Dakota for several tornado scenarios that are developed based on the historical report of the National Oceanic and Atmospheric Administration.

4 Solution Path Algorithm for Distributionally Robust Support Vector Machine

Guangrui Tang, Neng Fan, University of Arizona, Tucson, AZ

Distributionally robust optimization minimizes the worst-case expected loss function under an ambiguity set. This theory inspired new interpretations of regularization in machine learning. In this talk, we derived a support vector machine model with squared loss function based on distributionally robust optimization theory. The regularization term is Lasso penalty. A solution path algorithm is proposed to speed up the tuning of the regularization hyperparameter in this model. We implement numerical experiments to validate the performance of the new model and the computational efficiency of the solution path algorithm.

Sunday, 5 PM–6:15 PM

SE39

CC - Room 201

Optimization under Uncertainty: Theory and Applications (iv)

General Session

Session Chair

Ehsan Mahyari, The University of Alabama, Tuscaloosa, AL

1 Stochastic Mixed Model Sequencing with Failures

Ibrahim Ozan Yilmazlar, Mary Beth Kurz, Hamed Rahimian, Clemson University, Clemson, SC, Contact: iyilmaz@g.clemson.edu

In the automotive industry, the sequence of vehicles to be produced is determined ahead of the production day. However, there are some failed vehicles that cannot be produced due to some reasons such as material shortage and paint failure. These vehicles are pulled out of the sequence and the vehicles in the succeeding positions are moved forward which potentially results in an increased work overload. In this study, we predict the failure probability of each model based on the historical data and we develop a sample average approximation model to generate robust mixed-model sequences. To solve the model, we design a customized Benders' decomposition algorithm and exploit several computational enhancement techniques. Numerical results show the computational efficiency of our algorithm over off-the-shelf solvers.

2 How to Safely Move from Periodic Maintenance to Predictive Maintenance

Ragnar Eggertsson[1], Rob Basten[2], Geert-Jan Van Houtum[2], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Eindhoven University of Technology, Eindhoven, Netherlands. Contact: r.h.eggertsson@tue.nl

Periodic maintenance is a traditional form of maintenance that is performed after operating a capital good for a predetermined amount of time, irrespective of the capital good's health. In contrast, predictive maintenance is a modern maintenance paradigm that performs maintenance based on the capital good's health, such as maintaining when the capital good's health indicates failure is imminent.
We study how to go from periodic to predictive maintenance for identical critical systems. The degradation process of the critical systems must be learned to implement predictive maintenance. To achieve this, we suggest a method combining safe reinforcement learning with deliberate exploration to learn the degradation process while keeping losses due to failures to a minimum.

3 Optimizing Unmanned Aerial Vehicle Delivery on Last-mile Logistics Under Stochastic Environment

Ali Tolooie, Ashesh Kumar Sinha, Kansas State University, Manhattan, KS, Contact: alit@ksu.edu

We propose a two-stage stochastic mixed-integer programming model to design a reliable and efficient supply chain network using logistics infrastructure. The proposed network includes charging stations to extend the delivery coverage of drones. We handle stochasticity in the problem by developing Markov decision process models that evaluate tradeoffs between the number of batteries and drones in the last-mile logistics system. To overcome difficulties computationally, we propose novel decomposition-based approaches for each problem to provide an exact analysis for our logistics network. In terms of the accuracy of the decomposition technique in our model, we consider the impact of the charging rate, flight rate, and demand arrival rate of each subsystem.

4 Electric Vehicle Fleet Charging Management at a Depot with Multi-connector Chargers

Ehsan Mahyari, Nickolas Freeman, The University of Alabama, Tuscaloosa, AL, Contact: emahyari@crimson.ua.edu

We consider the electric vehicle (EV) fleet charging problem from the standpoint of a Charging as a Service (CaaS) company. Agencies that operate EV fleets can rely on a CaaS company to provide a complete charging solution including services spanning the design of the charging depot to the operation of the charging process to meet an agreed upon service level offered for a contracted rate, thus, the profitability of the CaaS company is dictated by how efficiently they provide the service. Although lower power price periods are more attractive, uncertainties in arrival times and charge needs, and time-varying electricity costs result in a trade-off between charging costs and service levels. Our approach utilizes an Approximate Dynamic Programming approach to minimize the total charging costs of a depot composed of non-homogeneous chargers with multi-connector support.

Sunday, 5 PM–6:15 PM

SE40

CC - Room 202

Novel Algorithms for Faster Optimization and Machine Learning

General Session

Session Chair

Hassan Mortagy, Georgia Institute of Technology, Atlanta, GA

1 Conditional Gradients for the Approximately Vanishing Ideal

Sebastian Pokutta, Elias Wirth, Zuse Institute Berlin (ZIB), Berlin, Germany.

The vanishing ideal of a set of points X is the set of polynomials that evaluate to 0 over all points x in X and admits an efficient representation by a finite set of polynomials called generators. To accommodate the noise in the data set, we introduce the Conditional Gradients Approximately Vanishing Ideal algorithm (CGAVI) for the construction of the set of generators of the approximately vanishing ideal. The constructed set of generators captures polynomial structures in data and gives rise to a feature map that can, for example, be used in combination with a linear classifier for supervised learning. In CGAVI, we construct the set of generators by solving specific instances of (constrained) convex optimization problems with the Pairwise Frank-Wolfe algorithm (PFW).
(joint work with Elias Wirth)

2 A Superlinearly Convergent Subgradient Method for Sharp Semismooth Problems

Vasilis Charisopoulos[1], Damek Davis[2], [1]Cornell University, Ithaca, NY, [2]Cornell University, ITHACA, NY, Contact: vc333@cornell.edu

Subgradient methods comprise a fundamental class of nonsmooth optimization algorithms. Classical results show that certain subgradient methods converge sublinearly for general Lipschitz convex functions and converge linearly for convex functions that grow sharply away from solutions. Recent work has moreover extended these results to certain nonconvex problems.
In this talk, we ask: is it possible to design a superlinearly convergent subgradient method? We provide a positive answer to this question for a broad class of sharp semismooth functions.

3 Reusing Combinatorial Structure: Faster Iterative Projections over Submodular Base Polytopes

Hassan Mortagy[1], Jai Moondra[1], Swati Gupta[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: hmortagy@gatech.edu

Optimization algorithms such as mirror descent enjoy near-optimal convergence rates but suffer from a computational bottleneck of computing projections in each iteration. On the other hand, conditional gradient variants solve a linear optimization but result in suboptimal rates. Motivated by this trade-off in runtime v/s convergence rates, we consider iterative projections of close-by points over submodular base polytopes. We develop a toolkit to speed up the computation of projections using both discrete and continuous perspectives. We strengthen the away-step Frank-Wolfe (AFW) algorithm using this toolkit. For the special case of cardinality based polytopes, we improve the runtime of computing projections by a factor of Ω(n/log n). Our results show orders of magnitude in speed-ups in computational experiments. This is joint work with Jai Moondra and Swati Gupta.

4 Bayesian Optimization with Expensive Kernel Evaluations

Jiayue Wan, Cornell University, Ithaca, NY, Contact: jw2529@cornell.edu

Bayesian optimization is an efficient method for global optimization of expensive-to-evaluate black-box functions. Traditional Bayesian optimization methods use surrogate models such as Gaussian processes whose kernels can be cheaply computed the Euclidean distance between two input points. We consider problems where kernel evaluations are also expensive, which arise in areas such as peptide optimization and chemical design. To solve such problems, we design a novel Bayesian optimization algorithm that leverages cheap features when optimizing the acquisition function. We demonstrate the use case of our approach in various scenarios.

Sunday, 5 PM–6:15 PM

SE41

CC - Room 203

Market Design for Power System Uncertainties

General Session

Session Chair

Cheng Guo, 1</sup

1 Evaluating the Resiliency of Decarbonized Power-Gas Infrastructure

Saurabh Amin[1], Rahman Khorramfar[1], Dharik Sanchan Mallapragada[2], [1]MIT, Cambridge, MA, [2]MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, Contact: amins@mit.edu

Electricity and natural gas are two main energy vectors whose interdependency is expected to grow by mid-century. This interdependency necessitates careful planning to ensure a sustainable and reliable future energy system in the face of numerous uncertainties and extreme events. As such, long-term planning of energy systems has to guarantee efficient and reliable operation of critical infrastructure, and account for timely recovery from disruption. We consider generation and transmission expansion problem of joint power-gas systems and explore both tradeoff and complementarities between decarbonization targets and resiliency through strategic investment and recovery plans.

2 Investment Planning of Multi-region Power Systems with Uncertainty Using Stabilised Benders Decomposition with Adaptive Oracles

Hongyu Zhang[1], Asgeir Tomasgard[1], Ken McKinnon[2], Nicolò Mazzi[3], Rodrigo Garcia Nava[4], [1]Norwegian University of Science and Technology, Trondheim, Norway; [2]The University of Edinburgh, Edinburgh, United Kingdom; [3]aHead-research, Roma, Italy; [4]The University of Edinburgh, Edinburgh, United Kingdom. Contact: hongyu.zhang@ntnu.no

Benders decomposition with adaptive oracles has reduced computational effort significantly by iteratively building inexact cutting planes and valid upper and lower bounds. Adaptive Benders and standard Benders may suffer serious oscillation when solving a multi-region planning problem. Therefore, we propose to stabilise adaptive Benders with level set method to overcome the oscillation. We compare stabilised adaptive Benders with the unstabilised versions of adaptive Benders and standard Benders on a multi-region long-term power system investment planning problem with short-term and long-term uncertainty. The computational results show that for a 1.00% convergence tolerance, the proposed stabilised method is up to 17.5 times faster than standard Benders decomposition and 5.6 times faster than adaptive Benders decomposition without stabilisation.

3 A Statistical Model for the Unit Commitment Problem Under the Presence of Renewable Energy

Carlos Olivos[1,2], Jorge F. Valenzuela[1], [1]Auburn University, Auburn, AL, [2]Universidad Catolica del Norte, Antofagasta, Chile. Contact: cro0010@auburn.edu

The high penetration of renewable energy sources requires complex decision modeling methods that consider high levels of uncertainty. In the Unit Commitment Problem, this issue is usually solved using the two-stage stochastic programming method with a scenario-based approach. Scenarios are sampled and used as realizations of the random variables, thus increasing the computational complexity. We propose a statistical model that does not require scenarios and models the expected dispatch and commitment cost from the probability distribution function of the random residual demand. The expected cost is linearized using a piece-wise approximation, resulting in a Mixed Integer Linear Program. We present experiments up to 400 units and a comparison to a scenario-based approach.

Sunday, 5 PM–6:15 PM

SE42

CC - Room 204

Optimization Problems in Transportation Electrification and Decarbonization

General Session

Session Chair

Juliette Ugirumurera, 1</sup

Session Chair

Zhaocai Liu, 1</sup

1 Developing Hydrogen-fueling Infrastructure for Heavy-duty Transportation

Katherine Hurst, National Renewable Energy Laboratory, Golden, CO, Contact: katherine.hurst@nrel.gov

The use of hydrogen is a promising route to mitigate the greenhouse emissions associated with heavy-duty transportation. Here, we consider the current status for light-duty and heavy-duty hydrogen fueling capabilities and their projected growth and impact. We will describe the development of our fast-fueling capabilities at the National Renewable Energy Laboratory. Computational and thermodynamic modeling of hydrogen fueling system dynamics to optimize system capacity and filling rates will be discussed and further verified with experimental data. Developing hydrogen infrastructure with high-efficiency, reliability and a high standard of safety will provide a strong foundation to enable the decarbonization of transportation.

2 Solving Unit Commitment Problems with Demand Responsive Loads

Devon Sigler, National Renewable Energy Laboratory, Denver, CO, Contact: devon.sigler@nrel.gov

Large scale electrification of the transportation sector has the potential to stress the electric grid by increasing demand and changing energy consumption patterns. Yet, additional load added from vehicle electrification can act in a demand responsive manner to support grid operations. We present work focused on using variations of the Frank-Wolfe algorithm to solve unit commitment problems with high volumes of demand responsive loads. Such algorithms work towards enabling large scale grid simulations that can bench mark the potential impact of demand responsive electric vehicle charging. Through reformulation and relaxation of the problem we enable variations of the Frank-Wolfe algorithm to find time series decisions for demand responsive loads. Computational experiments on the IEEE Reliability Test System show our approach provides near optimal solutions.

3 Optimal Planning and Charging Scheduling for a Fast-charging Battery Electric Bus System Considering Distributed Solar PV

Yiming Zhang, Ziqi Song, Yi He, Utah State University, Logan, UT, Contact: yiming.zhang@usu.edu

A battery electric bus (BEB) is considered a promising alternative to conventional diesel buses. However, the high charging power induced by fast charging may impose an extra burden on the power grid and incur a high demand charge cost. In this study, we address the optimal planning and charging scheduling problem for a BEB system considering energy storage system (ESS) and distributed solar photovoltaic (PV). Based on different settings, three configurations are proposed to analyze the impact of the distributed solar PV on the total system cost. For each configuration, a mathematical model is developed to optimize the planning and charging scheduling. A numerical study is conducted to demonstrate the effectiveness of the proposed models. The results show that the utilization of the integration of ESS and distributed PV can effectively reduce the total system cost.

4 Integrated Charging Infrastructure Planning and Charging Scheduling of Battery Electric Bus Systems

Zhaocai Liu[1], Yi He[2], Ziqi Song[3], [1]National Renewable Energy Laboratory, Lakewood, CO, [2]Beijing University of Technology, Beijing, China; [3]Utah State University, Logan, UT, Contact: zhaocai.liu@nrel.gov

Considering the interdependence of system design and operational strategies, this study proposes a two-phase optimization framework for charging infrastructure planning and charging scheduling for battery electric bus systems. An integrated optimization model is developed in the first phase to simultaneously optimize charger deployment, onboard battery capacity, and charging schedules. A charging scheduling model is further proposed and a rolling horizon approach is utilized in the second phase to optimize the real-time charging scheduling of electric buses. Compared to existing electric bus system planning methods, the proposed integrated optimization model can reduce the total system cost by 19.5%. In addition, compared to uncontrolled charging, the proposed rolling horizon-based charging strategy can reduce the total charging cost by 68.3%.

Sunday, 5 PM–6:15 PM

SE43

CC - Room 205

Recent Advances in Nonconvex Optimization I

General Session

Session Chair

Salar Fattahi, University of Michigan, Ann Arbor, MI

Session Chair

Cedric Josz, Columbia University, Le Kremlin-Bicetre, France.

Session Chair

Richard Zhang, UC Berkeley, Berkeley, CA

1 New Results on the Trust Region Subproblem with Extra Second-order-cone Constraints

Samuel Burer, University of Iowa, Iowa City, IA

We study semidefinite relaxations of the Extended Trust Region Subproblem (ETRS), i.e., minimization of a nonconvex quadratic objective over the intersection of the unit ball with additional constraints. These "additional constraints" can include, for example, extra linear, second-order-cone, and ellipsoidal constraints. The ETRS appears in numerous applications and is also a basic substructure found within many mixed-integer nonlinear programs. By focusing on the case of extra second-order-cone constraints, we derive a new, strong relaxation, which enjoys computational advantages over existing relaxations. By the time of the conference, we also hope to have theoretical results supporting our empirical results. Fingers crossed!

2 Fantastic Lifts and Where to Find Them: Using Smooth Parametrizations for Non-smooth Optimization

Eitan Levin[1], Joe Kileel[2], Nicolas Boumal[3], [1]Caltech, Pasadena, CA, [2]University of Texas at Austin, Austin, TX, [3]École polytechnique fédérale de Lausanne, Lausanne, Switzerland.

Many optimization problems are reformulated via a smooth parametrization, or lift, of their domains. Examples include optimization over low rank matrices and tensors by optimizing over a factorization, the Burer--Monteiro approach to low rank semidefinite programs, and training neural networks by optimizing over their weights and biases. Such lifts give rise to two optimization problems, one optimizing a smooth cost function over a nonsmooth domain, and the other minimizing the composition of that cost with a lift map over a smooth manifold. The latter problem is smooth, and can be tackled with standard algorithms which may find various desirable points, like local minima or stationary points. In this talk, we prove when these points map to desirable points for the nonsmooth problem, and discuss the implications for the above examples.

3 Worst-case Complexity of an SQP Method for Nonlinear Equality Constrained Stochastic Optimization

Frank E. Curtis[1], Michael J. O'Neill[2], Daniel Robinson[3], [1]lehigh university, Bethlehem, PA, [2]The University of North Carolina at Chapel Hill, Chapel Hill, NC, [3]Lehigh University, Bethlehem, PA

A worst-case complexity bound is proved for a sequential quadratic optimization (commonly known as SQP) algorithm that has been designed for solving optimization problems involving a stochastic objective function and deterministic nonlinear equality constraints. Barring additional terms that arise due to the adaptivity of the monotonically nonincreasing merit parameter sequence, the proved complexity bound is comparable to that known for the stochastic gradient algorithm for unconstrained nonconvex optimization. The overall complexity bound, which accounts for the adaptivity of the merit parameter sequence, shows that a result comparable to the unconstrained setting (with additional logarithmic factors) holds with high probability.

4 Preconditioned Gradient Descent for Overparameterized Nonconvex Burer-monteiro Factorization with Global Optimality Certification

Gavin Zhang, University of Illinois at Urbana-Champaign, IL

We consider using gradient descent to minimize the nonconvex function \$f(X)=\phi(XX^{T})\$ over an \$n\ times r\$ factor matrix \$X\$, where \$\phi\$ is a convex cost function. While only a second-order stationary point \$X\$ can be provably found in reasonable time, if \$X\$ is rank deficient, then its rank deficiency certifies it as being globally optimal. This way of certifying global optimality necessarily requires the search rank r of the current iterate X to be overparameterized with respect to the rank $r^{\star}$ of the global minimizer $X^{\star}$. Unfortunately, overparameterization significantly slows down the convergence of gradient descent. In this paper, we propose an inexpensive preconditioner that restores the convergence rate of gradient descent back to linear in the overparameterized case, while also making it agnostic to possible ill-conditioning.

Sunday, 5 PM–6:15 PM

SE44

CC - Room 206
Networks in Data Science
General Session

Session Chair
Babak Aslani, George Mason University, Fairfax, VA

1 Models, Covariate Frameworks & Optimization Schemes for the Prediction of Song Performance and the Curation of Listener Communities

Kobi Abayomi[1], Paul Beata[2], Mathias DeJounge[2], Julien DeMori[2], Camille Taltas[2], Arash Haddadan[2], Moin Haque[1], Kevin Liu[2], Nakul Sathaye[2], Midigeshi Soumya[2], Arash Parnia[2], Jiajun Song[2], Guannan Zhao[2], Chaoyung Zheng[2], Daniel Lee[1], [1]Warner Music Group, New York, NJ, [2]Warner Music Group, New York, NY, Contact: abayomko@shu.edu

Music rights holders receive voluminous - though limited - tranches of data from their distribution partners: Spotify, AppleMusic, Amazon, Deezer, etc. We - the Data Science team at Warner Music Group - endeavor to extract meaning from a "*Schmutzdecke*" (a coinage from Biology suggesting a layer of mediation) that WMG receives from its D2C distribution partners, via carefully tuned models. Our unique instantiations of topological and semantic similarity on aural and demand data within a Bayesian hierarchical prediction framework yields actionable comprehension, illustration and programmatic advice to WMG on the curation and acceleration of listener demand.

2 Keyword Co-occurrence Network Methodology and Graph Data Science Algorithms for Systematic Pain Research Literature Review

Burcu Ozek, Zhenyuan Lu, Fatemeh Pouromran, Sagar Kamarthi, Northeastern University, Boston, MA, Contact: ozek.b@northeastern.edu

Pain research is expanding rapidly, making the traditional manual literature review process increasingly complex. This study develops an automated, systematic knowledge mapping and highlights future directions for the pain literature to help researchers. Network and graph data science algorithms provide a promising approach for systematic literature reviews. They discover the connections between articles and reveal hidden insights from large-scale and highly interconnected data. This study extracts keywords from 264,560 pain research papers, creates a keyword co-occurrence network (KCN) by these keywords, and analyzes KCN with data science algorithms. Our key findings demonstrate i) the number of new keywords in articles has grown by twenty times in the last two decades; and ii) main emerging concepts are machine learning, acute pain, and pain management.

3 Learn to Decompose Multi-objective Optimization Models for Large-scale Networks

Babak Aslani[1], Shima Mohebbi[2], [1]George Mason University, Fairfax, VA, [2]George mason university, Fairfax, VA, Contact: baslani@gmu.edu

Providing timely restoration plans for interdependent infrastructures facing disruptions has been a challenge for decision-makers. we defined three objective functions in three pillars of sustainability: a) economic, b) social, and c) environmental for the restoration problem. To solve the multi-objective optimization model, we develop a Learn to Decompose (LTD) framework, consisting of a multi-objective evolutionary algorithm based on decomposition (MOEA/D) and a Gaussian Process Regression (GPR) to periodically learn from the obtained Pareto Front and guide the search direction. We applied the proposed framework to benchmark problems and interdependent water and transportation networks in the City of Tampa, FL. The result demonstrates the proposed framework is feasible and applicable for large-scale networks.

Sunday, 5 PM–6:15 PM

SE45

CC - Room 207
Integer and Discrete Optimization
General Session

Session Chair
Matias Villagra, Columbia University, New York, NY

1 **Second-order Conic and Polyhedral Approximations of the Exponential Cone: Application to Mixed-integer Exponential Conic Programs**
Weijun Xie, Qing Ye, Virginia Tech, Blacksburg, VA, Contact: wxie@vt.edu
Exponents and logarithms are fundamental components in many important applications such as logistic regression, maximum likelihood, relative entropy, and so on. Since the exponential cone can be viewed as the epigraph of perspective of the natural exponential function or the hypograph of perspective of the natural logarithm function, many mixed-integer convex programs involving exponential or logarithm functions can be recast as mixed-integer exponential conic programs (MIECPs). To harvest the past efforts on MILPs and MISOCPs, this paper presents second-order conic (SOC) and polyhedral approximation schemes for the exponential cone with application to MIECPs. Our numerical study shows that the proposed methods show speed-ups over solver MOSEK for MIECPs, and the scaling, shifting, and polyhedral outer approximation methods work very well.

2 **Absolute and Relative MIP Gap Functions and Their Properties**
Rachael M. Alfant[1], Temitayo Ajayi[2], Andrew J. Schaefer[3], [1]Rice University, Houston, TX, [2]Nature Source Improved Plants, Ithaca, NY, [3]Rice University, Houston, TX, Contact: rma10@rice.edu
A critical measure of model quality for a mixed integer program (MIP) is the difference, or gap, between its optimal objective value and that of its linear programming relaxation. In many contexts, only an approximation of the right-hand side(s) is available - yet, there is no consensus on appropriate measures for MIP model quality over multiple right-hand sides. In this talk, we provide a framework by which to determine a MIP model's quality over multiple right-hand sides by formulating the expectation and extrema of absolute and relative MIP gap functions over finite discrete sets.

3 **A Closest Benders Cut Selection Scheme for the Benders Decomposition**
Chungmok Lee[1], Kiho Seo[2], Seulgi Joung[3], Sungsoo Park[4], [1]Hankuk University of Foreign Studies, Yongin-si, Korea, Republic of; [2]KAIST, Daejeon, Korea, Republic of; [3]Chonnam National University, Gwangju, Korea, Republic of; [4]Korea Advanced Institute of Science & Technology, Daejeon, Korea, Republic of. Contact: chungmok@hufs.ac.kr
This talk presents a novel Benders cut selection scheme based on geometric intuition, called closest Benders cuts. Classical Benders decomposition often shows very slow convergence because many "weak" Benders cuts are generated. Several criteria for selecting "stronger" Benders cuts have been proposed. The proposed closest Benders cut selection scheme can be seen as a generalization of the previous methods while providing the additional possibility of even stronger Benders cuts identification such as facets. The computational study comparing the existing state-of-the-art Benders cut selection methods shows that the proposed method outperforms the others.

Sunday, 5 PM–6:15 PM

SE46

CC - Room 208
Data Analytics for Urban Mobility and Smart Cities
General Session

Session Chair
Jingwei Zhang, UCLA Anderson School of Management, Los Angeles, CA

Session Chair
Auyon Siddiq, University of California-Los Angrles, Los Angeles, CA

1 **A Dynamic Model for Airline Fleeting and Scheduling**
Chiwei Yan[1], Archis Ghate[2], [1]University of Washington Seattle, Seattle, WA, [2]University of Washington, Seattle, WA, Contact: yan.cw08@gmail.com
COVID-19 has reshaped the global airline industry. Travel demands are volatile, and passengers have more flexibility in bookings and cancellations. More than ever, airlines have to be agile and adaptive in terms of their operational decisions. In this talk, we introduce a new dynamic model for airlines to make adaptive scheduling and fleeting decisions, based on evolving demand and booking signals. We derive theoretical, algorithmic, and managerial insights from this model. We present computational experiments based on real-world scenarios to demonstrate potential benefits of this approach.

2 **Planning Bike Lanes with Data: Ridership, Congestion, and Path Selection**
Jingwei Zhang[1], Sheng Liu[2], Auyon Siddiq[3], [1]UCLA

Anderson School of Management, Los Angeles, CA, [2]University of Toronto, Toronto, ON, Canada; [3]University of California-Los Angrles, Los Angeles, CA, Contact: jingwei.zhang.phd@anderson.ucla.edu

Urban bike lane expansion promotes cycling and reduces vehicle traffic, but narrows vehicle lanes and amplifies congestion. We study the bike lane planning problem while accounting for the conflicting effects. In an extensive case study on the City of Chicago with data collected from 8 sources, we first present a consistent estimator for travel-time parameters and then optimize new bike lane locations while enforcing traffic equilibrium. As a result, we estimate that adding 25 miles of bike lanes as prescribed by our model can lift ridership from 3.9% to 6.9%, with at most an 8% increase in driving times.

3 Drone Network Design for Multimodal Delivery

Ruijiu Mao[1], Long He[1,2], [1]National University of Singapore, Singapore, Singapore; [2]George Washington University, Washington, DC, Contact: maoruijiu@u.nus.edu

We aim to design a collaborative land-air network to help courier firms improve service performance and resolve the issue of long-tail distribution of delivery time. Specifically, we formulate an optimization problem that minimizes the cost of investment in drone systems to achieve a target in delivery time. By conducting a case study on order data from an e-commerce platform, we develop a drone network design that reduces the system average of the long-tail delivery time. We also discuss managerial insights about infrastructure design and drone technology.

4 Expanding Scheduled Transit with On-demand Mobility

Partha S. Mishra[1], Sebastien Martin[2], Sunil Chopra[3], Karen Smilowitz[3], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Cambridge, MA, [3]Northwestern University, Evanston, IL, Contact: partha.mishra@kellogg.northwestern.edu

The use of mobility-on-demand (MOD) to complement conventional shuttle transit has gained much traction in recent times. Such a hybrid transit mode has been studied in several contexts, like the first mile and last mile connectivity problems. We consider a stylized setup where a platform evaluates its options of transit for its customers at a single terminal based on its cost of operation and the average waiting time of the customers. It could deploy fixed frequency shuttles looping around the terminal, request MODs at the terminal, or use some hybrid combination of the two. We show that there is value to using a hybrid mode of operation for platforms that can accept a moderate range of average waiting time for their customers. Further, we show how this range is affected by variability.

Sunday, 5 PM–6:15 PM

SE47

CC - Room 209
Intermodal Rail and Yard Automation
General Session

Session Chair
Vishal Badyal, BNSF

Session Chair
Jeremiah Dirnberger, Wabtec Freight, Jacksonville, FL

1 Yard Automation Beyond Power Switches and Remote Control Locomotives

Jeremiah Dirnberger, Wabtec Freight, Jacksonville, FL, Contact: jeremiah.dirnberger@wabtec.com

As freight volume continues to grow, reliable yard operations will be critical for the railroads to attract more volume. Until now, the limited yard automation efforts have typically focused on power switches and Remote Control Locomotives (RCL). The barriers to achieving higher levels of automation are lower than mainline automation. Automation in Intermodal Terminals is more widespread. In the near term, combining visual inspection and monitoring technologies with remote-control train operations, drones and planning tools will provide significant variability reduction and productivity improvements in classification yards and intermodal terminals. This session will review an overall strategy, examples with the implications for OR practitioners and potential synergies between technologies deployed in Classification Yards and Intermodal Terminals.

2 Intermodal Railcar Network Analysis Utilizing ML

Muhannad H. Ramahi, TTX Company, Chicago, IL, Contact: muhannad.ramahi@ttx.com

We present a study/results of exploring a new technique for forecasting railroad operational metric(s) such as cycle time and railcars network mileage. The goal is to explore the new emerging techniques of machine learning against classical methods in predicting cycle time and railcar mileage for various fleets. Cycle time is an essential part of the business planning process that partly determines how many railcars are potentially needed for satisfying the network demand. Moreover, mileage prediction is critical in deciding how equipment maintenance is planned and budgeted.

3 **Railcar Network Analysis Using GPS**

Joseph Melchiors, TTX

As GPS becomes more prevalent within the railcar fleet, how can the rail industry leverage that information to improve Customer Service and car use efficiency? True GPS integration into the existing tracking and messaging infrastructure must recognize and handle uncertainties and timing issues from both GPS and railroad event reporting. TTX will present information on how they are combining GPS, EDI/TRAIN messaging, internal system reporting, and the North American Rail Network map to understand if and how they can work together to provide seamless railcar tracking and tracing.

Sunday, 5 PM–6:15 PM

SE48

CC - Room 210

Facility Location and Logistics for Disaster Operations Management

General Session

Session Chair

Vedat Bayram, TED University Cankaya V.D. 833 047 5189, Ankara, Turkey.

Session Chair

Lluvia (Weijia) Jing, Northeastern University, Boston, MA

1 **Post-disaster Restoration Scheduling and Community Function**

Bahar Shahverdi, Elise Miller-Hooks, George Mason University, FAIRFAX, VA, Contact: bshahver@masonlive.gmu.edu

Hazardous events can induce service loss in infrastructure lifelines, such as power, water, and transportation. These lifelines are critical to community function, supporting hospitals, schools, nursing homes, government buildings, and much more. This presentation proposes mathematical modeling and solution methods to optimize the scheduling of post-disaster restoration actions on these infrastructures for improved critical community function.

2 **Multi-criteria Path Planning for Teams of Unmanned Ground Vehicles in Unstructured Environments**

Sachet Khatiwada, Emmanuel Adjei, Pamela Murray-Tuite, Clemson University, Clemson, SC, Contact: sachetk@clemson.edu

Teams of unmanned ground vehicles (UGVs) may be used to deliver items (humanitarian relief, fire-fighting materials, troops) to dangerous or hard-to-reach areas that do not contain a formal transportation network and where information is imperfect. We provide an overview of a framework for routing teams of UGVs through an unstructured environment using multiple paths such that all the UGVs arrive at the destination at the same time. Using a priori information about the environment and other information, such as risk and travel time, a cost-to-go map is generated which is subsequently used as input to goal-directed, planning level, path algorithms. We present the results of the approach in different scenarios. DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.(OPSEC # 6037)

3 **Enhancing Cost Effectiveness and Efficiency of USAID's Food Aid Supply Chain: A Supply Chain Optimization Tool for Both On-going and Sudden-onset Demand Response**

Lluvia (Weijia) Jing, Ozlem Ergun, Northeastern University, Boston, MA, Contact: jing.we@northeastern.edu

Millions of tons of food aid are distributed each year by the U.S. Agency for International Development's (USAID) Office of Food for Peace (FFP). Yet, needs always exceed the food aid resources available to meet them. Efficiency gains in existing supply chains offer the potential for closing this gap. We developed a supply chain optimization tool (SCOT) to optimize the decision-making process for procurement, prepositioning, and shipping decisions under a merged supply chain with both on-going demand and sudden-onset demand, while assessing the range of potential efficiency/effectiveness gains and on-time delivery associated with alternative investments in and management of the food aid supply chain.

Sunday, 5 PM–6:15 PM

SE49

CC - Room 211

Routing and Consolidation Issues in Logistics

General Session

Session Chair

Abhay Sobhanan, University of South Florida, Tampa, FL

1 Middle Mile Consolidation Network Design: Maximizing Profit Through Flexible Lead Times

Lacy Greening, Jisoo Park, Mathieu Dahan, Alan Erera, Benoit Montreuil, ISyE Georgia Tech, Atlanta, GA

In this work, we propose an approach for designing a middle-mile consolidation network that aims to maximize the profit of large e-commerce retailers. We embed lead-time dependent sales volumes predictions into a new mixed-integer program (MIP) that determines shipment lead times and consolidation plans to maximize sales revenue net logistics cost. We propose a solution approach that uses an IP-based local search and dynamic lead time selection to find excellent consolidation plans for large, practically-sized instances. Preliminary results are illustrated using data from a U.S.-based e-commerce partner.

2 Hyperconnected Logistics Networks: Parcel Consolidation in Modular Handling Containers

Nidhima Grover[1], Benoit Montreuil[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: ngrover9@gatech.edu

In Physical Internet-based hyperconnected logistics, packages are routed through a multi-tier meshed network of logistic hubs, proven to be more efficient, sustainable, and resilient than traditional networks in literature. Packages are consolidated in modular containers to travel together for a long portion of their multi-hub journey, which reduces handling time in intermediate hubs. This research focuses on the dynamic optimization of parcel consolidation, considering each parcel's sequence of hubs in the path, service level, and dimensions. We develop an optimization model that minimizes handling costs while ensuring delivery time, consolidation targets, and other operational constraints are best met. We present computational results that demonstrate the increase in performance induced by effective consolidation.

3 Equitable Workload Allocation in Vehicle Routing Problem with Heterogeneous Drivers

Iman Dayarian[1], Vahid Mahmoodian[2], Hadi Charkhgard[2], [1]University of Alabama, Tuscaloosa, AL, [2]University of South Florida, Tampa, FL, Contact: idayarian@cba.ua.edu

Efficient solutions are not necessarily equitable. Maximizing the sum of utilities of all the players might not result in a sufficiently fair distribution of resources, responsibilities, and benefits among different stakeholders. Fairness considerations in the private logistics service sector are new and growing due to public or governmental pressures to improve equity in workload allocation among drivers or other personnel providing the service. This is more crucial when employing crowdsourced workforce considering their inherent heterogeneity in terms of skills, availability, and productivity levels. This research aims at creating a decision-support tool to strike a balance between efficiency and equitable workload allocation that ensures acceptance of operational plans, maintains employee satisfaction, and reduces bottlenecks in resource utilization.

4 Solving the Multi-depot Vehicle Routing Problem by a Genetic Algorithm with Learning to Evaluate Individuals

Abhay Sobhanan[1], Junyoung Park[2], Jinkyoo Park[3], Changhyun Kwon[4], [1]University of South Florida, Tamp, FL, [2]KAIST, Daejeon, Korea, Republic of; [3]Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of; [4]University of South Florida, Tampa, FL, Contact: sobhanan@usf.edu

In the Multi-Depot Vehicle Routing Problem (MDVRP), we can separate the decisions into two phases: assigning customers to a depot and then routing vehicles from each depot. The latter becomes a Capacitated Vehicle Routing Problem (CVRP) on its own. In this paper, we propose a simplified genetic algorithm that only determines the customer-depot assignments. We train a neural network to learn the objective function value generated by a CVRP solver and evaluate each customer-depot assignment decision by predicting the result of a CVRP for each depot. We show that such a simplified approach is effective via numerical experiments.

Sunday, 5 PM–6:15 PM

SE50

CC - Room 212

Digital Technologies in Business

General Session

Session Chair

Scott Schanke, 1</sup

1 Are Your Customers Paying Attention? Mobile Advertising in a Multiscreen Viewing Environment?

Siddharth Bhattacharya, George Mason University, Fairfax, VA

It is increasingly common for consumers to use an additional device like smartphone while watching TV, a phenomenon known as multiscreen viewing. While this additional device (or second screen) provides an extra advertising channel, little is known about how consumers respond to ads on second screen during a multiscreen viewing experience. Thus, in this research, we seek to understand how firms can optimize advertising on a second screen in light of how primary screen content influences consumer behavior on second screen. Our results indicate an inverse relationship between primary and second screen viewing. We also show that ad recognition is higher for ads appearing on second screen when supplemental content is displayed on primary screen, as opposed to when core content is displayed. Results of the research contribute to the literature on advertising in Marketing and IS.

2 Content and Style of Marketer Generated Content on Social Media: A Study of User Engagement on Hedonic and Utilitarian Product Pages on Facebook

Scott Schanke[1], Gautam Ray[2], Gedas Adomavicius[3], Mihir Wagle[3], [1]University of Wisconsin Milwaukee, Milwaukee, WI, [2]University of Minnesota, Minneapolis, MN, [3]University of Minnesota, Minneapolis, MN, Contact: schanke@uwm.edu

Digital platforms are playing an important role in customers' sales journey, but there is limited research on how product characteristics influence firm behavior on these platforms. This paper examines the relationship between firm-generated content and user engagement on product pages, and how characteristics moderate this relationship. Analyzing Fortune 1000 firm posts on Facebook, we study the relationship between content and style of a given post and the level of user engagement. The key finding is that content not traditionally expected for a product of a given type, generate more favorable engagement. Interestingly, irrespective of the type of the product, informal style achieves more favorable engagement.

Sunday, 5 PM–6:15 PM

SE51

M - Santa Fe

NSF Program Directors Panel

Panel Session

Session Chair

Georgia-Ann Klutke, National Science Foundation, Arlington, VA

NSF Program Directors Panel

Georgia-Ann Klutke, National Science Foundation, Alexandria, VA

A panel of NSF program directors will introduce their programs and answer questions from the audience.

Panelist

Reha Uzsoy, National Science Foundation, Alexandria, VA

Panelist

Yueyue Fan, National Science Foundation, Alexandria, VA

Panelist

Daan Liang, National Science Foundation, Alexandria, VA

Sunday, 5 PM–6:15 PM

SE52

M - Lincoln

Scheduling and Logistics Problems against Pandemics

General Session

Session Chair

Xiangtong Qi, Hong Kong University of Science & Technology, Hong Kong.

1 The Seating Assignment Problem with Social Distancing

Zikang Li[1], Xiangtong Qi[2], Qian Liu[3], [1]HKUST, Kowloon, Hong Kong; [2]Hong Kong Univ of Science & Technology (HKUST), Kowloon, Hong Kong; [3]Hong Kong University of Science and Technology-HKUST, Hong Kong, Hong Kong.

Social distancing, a non-pharmaceutical way to contain the spread of infectious disease, has been broadly recognized and practiced. In this paper, we consider the seat assignment problem with social distancing when encountering deterministic and stochastic demands. In a pandemic, the government may issue a minimum physical distance between people, which must be respected in the seating assignment. The problem is further complicated by the existence of groups of guests who will be seated together. To achieve such a goal, we provide an optimal assignment based on the column generation algorithm with given rows of seats and the demands of groups. We also develop a column-and-cut method to obtain an assignment with stochastic demands of groups under scenarios. With these results, we can provide a guideline for policies related to seat utilization rate.

3 Strategies for Using Rapid Antigen Tests (RAT) in Workplaces and Schools Under Uncertain Sensitivity

Ho Yin Wan[1], Xiangtong Qi[2], Jin Qi[3], [1]Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [2]Hong Kong University of Science & Technology (HKUST), Hong Kong, Hong Kong; [3]Hong Kong University of Science and Technology, Hong Kong, Hong Kong. Contact: hywanae@connect.ust.hk

Rapid Antigen Testing kits enable easy and quick assessment for identifying COVID-19. When compared to PCR Tests, their accuracy is yet to be certified. Literatures show there is a time-dependency on returning false negative result by using the RAT. There is an unidentified period for each patient even when they exercise frequent rapid testing. Longer unidentified period leads to higher risk to infect others. Risk models are therefore essential for one to assess the potential impacts. We collect individual-level data from COVID-19 in Hong Kong to quantify the time-dependent impacts for not identifying a patient. For given uncertainties, we propose an assessment model that quantify the safe of using RAT. We aim to apply the model in contextual setting such that the decision makers can decide for testing frequency and operation strategies to guarantee the level of safety.

Sunday, 5 PM–6:15 PM

SE53

M - Denver

Content Market Operations

General Session

Session Chair

Bharadwaj Kadiyala, University of Utah, Salt Lake City, UT

Session Chair

Dongwook Shin, HKUST Business School, Clear Water Bay, Hong Kong.

1 Why Platform Algorithms Shape What You Think

Sarah H. Cen[1], James Siderius[2], Asuman Ozdaglar[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: shcen@mit.edu

Social media platforms employ algorithms that simultaneously recommend content from friends and from news outlets. While some of these recommendations are anchored by the existing social network of users, outlet recommendations may be chosen by the platform to shape users' beliefs over time (e.g., nudging users toward political extremes to increase engagement). In this work, we model belief shaping as a linear dynamical system, in which each user's belief is influenced by their social network and content that the platform injects into their feed. We examine three questions: (i) how a platform should inject content from external outlets, (ii) how this content affects the short-term beliefs of exposed users, and (iii) how this content affects users' long-term beliefs through the social network. We explore these questions through both analytical results and simulations.

2 Exploring Fair, Stable and Optimal Income Pools in Volatile Industries

Timothy Chan[1], Ningyuan Chen[2], Craig Fernandes[1], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto, Mississauga, ON, Canada. Contact: craig.fernandes@mail.utoronto.ca

An income pool involves individuals coming together to sign a contract which stipulates that if any individual earns more than a salary threshold, that a portion of their earnings above this threshold will be shared amongst all pool members. We investigate income pools within professional baseball where even the best players must compete in the Minor league before they are eligible for the Major league. The average annual salary in the Minors is $8000, grossly incomparable to the $4.4 million in the Majors. The average probability of transferring from the Minors to the Majors is only 14%. As such, income pools involve Minor league players signing a contract that pledges a share of future potential Major league earnings. We explore the decision problem of which pools a player should join to maximize their expected utility, as well as define notions of fair, stable, and optimal pools.

Sunday, 5 PM–6:15 PM

SE54

M - Marriott 1

Invited Lecture: QPLEX - A Modeling and Computational Methodology for Transient Analysis of a Class of Stochastic Systems

General Session

Session Chair

Ton Dieker, Columbia University, New York, NY

Session Chair
Steve Hackman, 1</sup

1 QPLEX - a Modeling and Computational Methodology for Transient Analysis of a Class of Stochastic Systems
Ton Dieker[1], Steve Hackman[2], [1]Columbia University, New York, NY, [2]Georgia Institute of Technology, Atlanta, GA

This work was motivated by problems of managing stochastic networks featuring temporary overloads, small to moderate time-varying number of servers, non-homogeneous service-time distributions and complex routing of entities. Such problems require prediction of future system behavior over time so that appropriate adjustments can be made today.
In this tutorial, we present a methodology to predict transient distributions of key performance metrics over time, e.g., distributions of the number of customers or the virtual wait times in a queueing network. Our methodology is fundamentally non-parametric and non-Markovian. It includes a modeling framework capable of representing the characteristics described above, and a computational approach that quickly generates results by relying on approximate deterministic calculations. A key feature of our methodology is that no advanced knowledge of applied probability is required to understand the key ideas.
The primitives of our modeling framework are relatively few. In simple models, they might be scalars or probability mass functions. In more elaborate models, they can be specified as code fragments. The resulting model defines the dynamics from which the desired performance metrics can be computed exactly, but this is not practical due to the sheer size of the number of calculations required. Our computational approach introduces a vastly lower dimensional space where a much smaller number of calculations suffice. Experiments on a diverse and challenging testbed yield remarkably accurate results and the time to generate thousands of distributions is on the order of seconds. For several classical queueing systems our computational approach generates exact results.
Throughout this presentation, we illustrate our modeling framework and computational approach with many stochastic network examples. We conclude this tutorial with a brief discussion of future directions.

Sunday, 5 PM–6:15 PM

SE55

M - Marriott 2
Sequential Learning and Experimentation
General Session

Session Chair
Vivek Farias, MIT, Cambridge, MA

Session Chair
Ciamac Cyrus Moallemi, Columbia University, New York, NY

Session Chair
Andrew T. Zheng, Massachusetts Institute of Technology, Boston, MA

1 Learning to Personalize Treatments when Agents are Strategic
Evan Munro, Stanford University, Stanford, CA, Contact: munro@stanford.edu

There is increasing interest in allocating treatments based on observed individual characteristics: examples include targeted marketing, and individualized credit offers. We use a non-parametric model to show that treatment personalization introduces incentives for individuals to modify their behavior to obtain a better treatment. This shifts the distribution of covariates, which means the Conditional Average Treatment Effect (CATE) now depends on how treatments are allocated. The optimal rule without strategic behavior allocates treatments only to those with a positive CATE. With strategic behavior, we show that the optimal rule can involve randomization, which incentivizes distributions of CATEs that lead to more effective targeting. We propose a sequential experiment that converges to the optimal treatment allocation function.

2 A Spectral View of Thompson Sampling
Mohsen Bayati, Yuwei Luo, Stanford University, Stanford, CA

Recently, it has been shown that Linear Thompson Sampling (LinTS) can have a poor worst-case performance in stochastic linear bandit setting. This problem with LinTS is rooted in the geometry of the posterior covariance matrix. Motivated by this observation, we focus on spectral distribution of the posterior covariance matrix and study its connections with performance of LinTS.

3 Adaptivity and Counfounding in Multiarmed Bandit Experiments
Daniel Russo, Columbia University, New York, NY

Bandit algorithms offer efficiency benefits when learning to make effective decisions requires experimentation. They achieve this through adaptivity: early feedback is used to identify competitive parts of the decision space and future effort is focused there. Unfortunately, due to this adaptivity, these algorithms risk confounding in problems where nonstationary contexts influence performance. As a result, many practitioners resort to non-adaptive randomized experimentation, providing robustness but foregoing efficiency benefits. We develop a new model to study this issue and propose deconfounded Thompson sampling. We argue that this method strikes a delicate balance, allowing one to build in robustness to nonstationarity while, when possible, preserving the efficiency benefits of adaptivity.

4 Synthetically Controlled Bandits

Andrew T. Zheng, Massachusetts Institute of Technology, Boston, MA

We present a new dynamic approach to experiment design in settings where, due to interference or other concerns, experimental units are coarse. `Region-split' experiments on online platforms are one example of such a setting. The cost, or regret, of experimentation is a natural concern here. Our new design, dubbed Synthetically Controlled Thompson Sampling (SCTS), minimizes the regret associated with experimentation at no practically meaningful loss to inferential ability. We provide theoretical guarantees characterizing the near-optimal regret of our approach, and the error rates achieved by the corresponding treatment effect estimator. Experiments on synthetic and real world data highlight the merits of our approach relative to both fixed and `switchback' designs common to such experimental settings.

Sunday, 5 PM–6:15 PM

SE56

M - Marriott 3

E-commerce/Omni-channel Fulfillment and Operations

General Session

Session Chair

Linwei Xin, University of Chicago, Chicago, IL

1 Assortment Optimization Under a Two-category Choice Model

Tiancheng Zhao[1], Menglong Li[2], Xin Chen[1], Yuan Zhou[3], Jiachun Li[3], [1]UIUC, Urbana, IL, [2]City University of Hong Kong, Hong Kong, Hong Kong; [3]Tsinghua University, Beijing, China. Contact: tz14@illinois.edu

In this paper, we study an assortment optimization problem in which an assortment consists of products from two categories, and customers are allowed to choose a bundle of at most one product from each category. We allow arbitrary product interaction that determines the utility of each bundle. We show that the problem is NP-hard. Motivated by this, we design a 0.74-approximation algorithm based on an LP relaxation of the problem. This algorithm almost closes the integrality gap of the LP relaxation which is shown to be at most 0.75. Numerical experiments are conducted to demonstrate the quality and efficiency of our proposed algorithm.

2 Simple and Order-optimal Correlated Rounding Schemes for Multi-item E-commerce Order Fulfillment

Will Ma, Columbia University, Cambridge, MA

A fundamental problem faced in e-commerce is---how can we satisfy a multi-item order using a small number of fulfillment centers (FC's), while also respecting long-term constraints on how frequently each item should be using inventory from each FC? In a seminal paper, Jasin/Sinha (2015) identify and formalize this as a correlated rounding problem, and propose a scheme for randomly assigning an FC to each item according to the frequency constraints, so that the assignments are positively correlated and not many FC's end up used. Their scheme pays at most n/4 times the optimal cost on a n-item order. In this paper we provide the first substantial improvement of their scheme, paying only 1+\ln(n) times the optimal cost, which is tight. We also derive other schemes, all based on an intuitive new idea: items wait for FC's to "open" at random times but observe them on "dilated" time scales.

3 Assortment Planning Considering Split Orders

Duygu Soylemez[1], Oya Ekin Karasan[2], Alper Sen[2], [1]University of Chicago Booth School of Business, Chicago, IL, [2]Bilkent University, Ankara, Turkey. Contact: dsoyleme@chicagobooth.edu

When multi item orders cannot be satisfied through a single shipment due to not having all the items in an order in the same depot, packaging and transportation costs increase and the deliveries can be delayed. To minimize order splitting, it is crucial to determine the allocation of the limited capacities of the depots to items or to reduce the transportation costs by consolidation. In this study, heuristic algorithms based on the LP relaxation of a model in the literature are offered to solve this NP hard assortment planning problem. The analytical characterization of the optimal solution of this LP problem is revealed and an algorithm is suggested to find this solution. Also, the assortment allocation and consolidation problems are modeled together. An extensive numerical study is conducted to evaluate the quality of the solutions provided by offered methodologies.

4 Effective Online Order Acceptance Policies for Omni-channel Fulfillment

Su Jia[1], Jeremy Karp[2], R. Ravi[3], Sridhar R. Tayur[3], [1]CMU, Pittsburgh, PA, [2]Lyft, San Francisco, CA, [3]Carnegie Mellon University, Pittsburgh, PA

Omni-channel retailing has led to the use of traditional stores as fulfillment centers for online orders. Omni-channel fulfillment problems have two components: (1) accepting a certain number of on-line orders prior to seeing store demands, and (2) satisfying (or filling) some of these accepted on-line demands as efficiently as possible with any leftover inventory after store demands have been met. Hence, there is a fundamental trade-off between store cancellations of accepted online orders and potentially increased profits due to more acceptances of online orders. We study this joint problem of online order acceptance and fulfillment (including cancellations) to minimize total costs, including shipping charges and cancellation penalties in single-period and limited multi-period settings.

Sunday, 5 PM–6:15 PM

SE57

M - Marriott 4

Science-integrated Statistical Learning

General Session

Session Chair

Simon Mak, Duke University, Durham, NC

1 Gaussian Process Covariance Prediction via Separable Transformation

Ruda Zhang, University of Houston, Houston, TX, Contact: ruda.zhang@duke.edu

We propose GP[illegible], a Gaussian process (GP) model that approximates functions that output positive semi-definite matrices or multivariate Gaussian distributions. The GP is used to encode positive-definite matrices as covariances of Gaussian random vectors. We obtain a posterior process by matching the marginal posterior distributions at sample points to those in the data, using separable affine transformations. In particular, it allows both the mean and the covariance of the outcome to vary with the predictors. We examine the accuracy of this model in a simulation study, and apply it to the emulation of stochastic simulators. Preliminary results show several times better accuracy than existing methods.

2 Compositional Multifidelity Models for Uncertainty Quantification via Directed Graphs

Alex Gorodetsky, University of Michigan

We present an approach for constructing a multifidelity surrogate from ensembles of information sources of varying cost and accuracy. In this talk, information sources correspond to partial differential equations of varying fidelity: including multiple physics models and numerical discretization levels. The proposed approach encodes connections between information sources as function compositions structured as directed acyclic graphs. The framework generalizes the typical autoregressive hierarchical modeling that is prevalent in multifidelity uncertainty quantification. We show that this approach can lead to greater data efficiency and applicability to the common situation where information sources do not admit a strict hierarchy on several applications. Both maximum likelihood and Bayesian training are described.

3 A Graphical Multi-fidelity Gaussian Process Model, with Application to Emulation of Expensive Computer Simulations

Yi (Irene) Ji, Duke University

We present a novel Graphical Multi-fidelity Gaussian Process (GMGP) model that uses a directed acyclic graph to model dependencies between multi-fidelity simulation codes. It is an extension to the Kennedy-O'Hagan model for problems where different codes cannot be ranked in a sequence from lowest to highest fidelity. We also present a scalable recursive formulation and a non-linear extension to the GMGP model. The advantages of the GMGP model over existing methods are demonstrated via an application to heavy-ion collisions emulation, which shed light on the origins of the Universe shortly after the Big Bang.

4 Non-parametric Ridge Recovery of Image Time Series Given Temporal Parameterization

David Matteson, Yuchen Xu, Cornell University, Ithaca, NY

As a classical tool to extract curvilinear features in image processing framework, ridge detection has its straightforward application in material science problems, especially when filtering relatively stable atom-shaped objects in image series such as Transmission Electron Microscope (TEM). Other than implementing frame-by-frame object recognition, this work borrows strength of temporal correlatedness by inputting the (spatial-plus-temporal) image tensor, and adapts the ridge detection algorithm non-parametrically to extract explicit trajectories of object locations as a continuous function of time. The method demonstrates both effectiveness and efficiency with simulations, and delivers visible outperformance in a real TEM application compared to other material science benchmarks.

Sunday, 5 PM–6:15 PM

SE58

M - Marriott 5

Manufacturing Data Analytics

General Session

Session Chair

Hongyue Sun, University at Buffalo, Buffalo, NY

Session Chair

Luis Javier Segura, [1</sup]

1 Droplet Evolution Prediction in Material Jetting via Tensor Time Series Analysis

Luis Javier Segura[1], Zebin Li[2], Chi Zhou[2], Hongyue Sun[3], [1]University of Louisville, Louisville, KY, [2]University at Buffalo, Buffalo, NY, [3]University at Buffalo, Buffalo, NY, Contact: ljsegu01@louisville.edu

Droplet morphology and behavior substantially determine the quality of the Material Jetting (MJ) printed parts. However, obtaining consistent and stable droplet morphology and behavior is difficult because the droplets are very sensitive to different material and process parameters. This work investigates the droplet evolution prediction via Tensor Time Series (TTS) analysis. The cross-linked (i.e., underlying relationships shared across droplet evolution behaviors with diverse material and process parameters) and spatial-temporal relationships of the TTS are captured via Tensor Graph Convolutional Network (TGCN) and Tensor Recurrent Neural Network (TRNN), respectively. The method is tested in experimental and simulated droplet evolution data in the MJ process.

2 Multi-class Reinforced Active Learning for Droplet Pinch-off Behaviors Identification in Inkjet Printing

Zebin Li[1], Luis Javier Segura[2], Yifu Li[3], Chi Zhou[1], Hongyue Sun[1], [1]University at Buffalo, Buffalo, NY, [2]University of Louisville, Louisville, KY, [3]University of Oklahoma, Norman, OK, Contact: zebinli@buffalo.edu

Inkjet printing is an additive manufacturing technique that yields many innovations. The quality of the products is affected by the droplet pinch-off behaviors, which results in the importance of identifying them. However, annotating these behaviors is heavy since a large amount of images can be collected easily. Active learning (AL) is a machine learning method that incorporates human knowledge. However, it suffers from rigid handcrafted query strategies, which cannot handle the dynamics of the varying most informative data. To address this limitation, we propose a multi-class reinforced active learning (MCRAL) method in which the conventional AL is combined with reinforcement learning (RL). An intrinsic reward is designed to improve the model capacity. A graph convolutional network (GCN) is used for droplet feature extraction. The results show that MCRAL excels AL.

3 Computer Model Calibration with Multi-source Auxiliary Observations in Material Jetting

Christian Santiago Zuniga[1], Luis Javier Segura[1], Chi Zhou[2], Hongyue Sun[2], [1]University of Louisville, Louisville, KY, [2]University at Buffalo, Buffalo, NY, Contact: cszuni01@louisville.edu

Material Jetting (MJ) process is capable to produce intricate functional structures. The MJ process performance and quality of the printed products are largely affected by the deposited droplet volumes. However, obtaining consistent droplet volumes during the process is difficult to achieve because the droplets characteristics are very sensitive to material and process parameters. This work investigates a Bayesian model calibration and prediction method that captures the volume variations (i.e., discrepancy) and measurement error (i.e., measurement bias) of the jetted droplets using multi-source material (i.e., water and glycerol). The method is tested using simulated data and experimental observations in the MJ process.

4 Analysis of Upper-body Fatigue During Warehouse Worker Material Handling

Setareh Kazemi Kheiri[1], Zahra Vahedi[1], Sahand Hajifar[1], Saeb Ragani Lamooki[1], Fadel Mounir Megahed[2], Lora Cavuoto[1], Hongyue Sun[1], [1]University at Buffalo, Buffalo, NY, [2]Miami University, Oxford, OH, Contact: skazemik@buffalo.edu

Musculoskeletal disorders are among the most prevalent injuries in warehouses and distribution centers. It is important to detect the underlying causes of such disorders and take preventive measures to reduce them. In this study, a lab experiment was conducted to simulate a dynamic overhead order-picking task, under four different combinations of load and pace. During the task, wearable sensors were mounted on upper-body muscles of participants, and rated

perceived exertion (RPE) scores were reported every five minutes. To understand the impact of different task loads and paces on the accumulated fatigue in participants' upper extremities, functional ANOVA was conducted on RPEs. The results indicate there is a significant difference between task conditions on the RPEs. It was also found that the effect of task pace was more significant than task loads on the RPEs.

Sunday, 5 PM–6:15 PM

SE59

M - Marriott 6

Big Data Analytics for System Prediction and Quality Control

General Session

Session Chair

Honghan Ye, 1</sup

1 A Dynamic Recurrent Framework for Diagnostics and Predictive Analytics for Switching Behavior State Space Models

Md Tanzin Farhat[1], Ramin Moghaddass[2], [1]University of Miami, Coral Gables, FL, [2]University of Miami, Coral Gables, FL, Contact: tanzinfarhat@miami.edu

Any large-scale sensor-driven complex system with single or multiple latent states can have switching behavior that creates variable system dynamics, making it difficult to model with traditional approaches. Previous works have mainly focused on the use of deterministic relation or distribution assumptions to model dynamics to capture switching stages. Another concern in the literature is to predict the time to an event of interest keeping the dynamics variable into consideration. For this, a dynamic recurrent framework to perform predictive analytics and diagnostics for complex systems with switching behavior latent states is proposed. The proposed approach utilizes recurrent neural networks and Bayesian networks with a state-space structure to capture the switching effect along with a prediction for events of interest like remaining useful life.

2 A Sample-weighting Algorithm for Classification of Overlapped and Imbalanced Data with Mixed Numerical and Categorical Features

Henry J. Johnston[1], Dongping Du[2], [1]Texas Tech University, Lubbock, TX, [2]Texas Tech University, Lubbock, TX, Contact: henry.johnston@ttu.edu

Electronic Health Records (EHR) contain patient samples consisting of mixed numerical and categorical features, class overlap and imbalanced data. These problems pose great challenges to EHR data analysis and classification. Motivated by these problems, this study explores a Density Peaks Clustering (DPC) algorithm to detect class overlap in samples consisting of both numerical and categorical features. A suitable metric for mixed data is used to calculate distances between each pair of samples. Clusters are used to calculate weights that represent importance of samples in each class and reduce the influence of overlapped samples. The sample weights are then used to enhance classification performance of overlapped and imbalanced data. Classifiers are trained using the sample weights and the effectiveness of the technique is tested in a case study.

3 Optimal Test Design for Reliability Demonstration Under Multistage Acceptance Uncertainties

Bingjie Wang[1], Suiyao Chen[2], Lu Lu[3], Mingyang Li[4], [1]UNIVERSITY OF SOUTH FLORIDA, Tampa, FL, [2]Amazon, San Diego, CA, [3]University of South Florida, Wesley Chapel, FL, [4]University of South Florida, Tampa, FL, Contact: bingjiew@usf.edu

While designing a reliability demonstration test (RDT), the actual testing results are random, making the test acceptance decision highly uncertain. If a test is rejected, the product reliability will be improved and then re-assured by the next round of RDT. Such reliability growth and re-assurance will be repeated in a multi-stage fashion until an RDT is accepted. The conventional RDT design often has a limited planning horizon without anticipating the acceptance uncertainties of sub-sequent re-assuring RDTs. We expand the planning horizon by proposing an optimal RDT design under multi-stage acceptance uncertainties to minimize the overall anticipated costs of RDTs, reliability growth and warranty service. A case study is provided to illustrate the proposed work and demonstrate its cost efficiency over conventional designs.

4 Online Monitoring of High-dimensional Asynchronous and Heterogeneous Data Streams for Shifts in Location and Scale

Honghan Ye, University of Wisconsin- Madison, Woodbury, MN

In this paper, we propose a generic nonparametric monitoring framework to online monitor high-dimensional asynchronous and heterogeneous data streams, where sampling intervals of data streams are different from each other and measurements of each data stream follow arbitrary distributions. In particular, we first propose a quantile-based nonparametric CUSUM scheme to monitor each data stream locally for possible changes in both location and scale. Then, for unsampled data streams, a compensation method based on the Bayesian approach is introduced. Furthermore, we develop a global monitoring scheme of using the sum of top-*r* local statistics, which is able to quickly detect a wide range of possible shifts in location and scale in all directions. Simulations and a case study are conducted to evaluate the performance of the proposed method.

Sunday, 5 PM–6:15 PM

SE60

M - Marriott 7

Learning and Inference for Designing Policies in Stochastic Systems

General Session

Session Chair

Weina Wang, Carnegie Mellon University, Pittsburgh, PA

1 On Improving Model-free Reinforcement Learning Algorithms for Average-reward MDPs

Qiaomin Xie, University of Wisconsin-Madison, Madison, WI

We develop model-free algorithms for learning infinite-horizon average-reward MDPs. In the online setting, our algorithms, based on reference-advantage decomposition, provably achieve an $\tilde O(\sqrt{T} \mathrm{poly}(S,A,\mathrm{sp}(h^*)))$ regret after T steps, where $\mathrm{sp}(h^*)$ is the span of the optimal bias function. Our results firstly achieves the near-optimal order in T, and improves the best existing result with $\tilde O(T^{2/3})$ regret. In the setting with simulator, we propose an algorithm that finds an ϵ-optimal policy using $\tilde{O} \left(\frac{SA\mathrm{sp}^2(h^*)}{\epsilon^2}+\frac{S^2A\mathrm{sp}(h^*)}{\epsilon} \right)$ samples, while the corresponding lower bound is $\Omega\left(\frac{SA\mathrm{sp}(h^*)}{\epsilon^2}\right)$.

2 Efficient Decentralized Multi-agent Learning in Asymmetric Queuing Systems

Daniel Freund[1], Thodoris Lykouris[1], Wentao Weng[2], [1]MIT, Cambridge, MA, [2]MIT, Cambridge, MA, Contact: wweng@mit.edu

We study decentralized multi-agent learning in bipartite queuing systems, a standard model for service systems. In particular, N agents request service from K servers in a fully decentralized way, i.e, by running the same algorithm without communication. Previous decentralized algorithms are restricted to symmetric systems, have performance that is degrading exponentially in the number of servers, require communication through shared randomness and unique agent identities, and are computationally demanding. In contrast, we provide a simple learning algorithm that, when run decentrally by each agent, leads the queuing system to have efficient performance in general asymmetric bipartite queuing systems while also having additional robustness properties. Along the way, we provide the first UCB-based algorithm for the centralized case of the problem.

3 Learning and Balancing Unknown Loads in Large-scale Systems

Diego Goldsztajn[1], Sem C. Borst[1], Johan van Leeuwaarden[2], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Tilburg University, Eindhoven, Netherlands. Contact: d.e.goldsztajn@tue.nl

Threshold-based policies provide powerful mechanisms for balancing loads in a scalable manner, but crucially rely on knowledge of load patterns which are typically uncertain and time-varying. We consider a system of identical server pools where an admission threshold is used in an inner control loop to dispatch the incoming tasks. In an outer control loop, a learning scheme adjusts the threshold over time to keep it aligned with the unknown and time-varying offered load. We prove that, in a large-scale regime, the threshold remains constant along intervals of time where the offered load is suitably bounded, and that this results in a balanced distribution of the load. In fact, we examine a family of learning schemes which trade off stability of the threshold with the degree of load balance that can be attained.

4 Federated Minimax Optimization: Improved Convergence Analyses and Algorithms

Pranay Sharma, Carnegie Mellon University, Pittsburgh, PA, Contact: pranaysh@andrew.cmu.edu

In this work, we consider nonconvex minimax optimization, which is gaining prominence in many modern machine learning applications such as GANs. We analyze Local stochastic gradient descent ascent (SGDA), the local-update version of the SGDA algorithm. We prove that Local SGDA has order-optimal sample complexity for several classes of nonconvex-concave and nonconvex-nonconcave minimax problems, and also enjoys linear speed-up with respect to the number of clients. We provide a novel and tighter analysis, which improves the convergence and communication guarantees in the existing literature. For nonconvex-PL and nonconvex-one-point-concave functions, we improve the existing complexity results for single-node minimax problems.

Sunday, 5 PM–6:15 PM

SE61

M - Marriott 8
Grid Optimization GO Competition: Goals, Formulation and Analysis
General Session

Session Chair
Richard Paul O'Neill, ARPA-E, Silver Spring, MD

1 **Grid Optimization Go Competition: Goals and Formulation**
Jesse Holzer, Pacific Northwest National Laboratory, Richland, WA
The Grid Optimization (GO) Competition Challenge 3 has launched. This talk gives an overview of the model formulation and the questions we are aiming to address with it. The model includes multi-period unit commitment; AC bus/branch modeling; scheduling of energy and reserves; flexible loads; storage; and combined cycle generators. The model can be configured for use in an ISO/RTO context for applications of real-time (RT) look ahead, day ahead (DA) market clearing, and week ahead (WA) advisory. The model combines features that are considered in isolation in a sequence of models in current electricity industry practice, for example solving a DA unit commitment model with little regard for AC considerations, then solving an ACOPF with fixed commitments closer to RT. With this combined model and the solvers that competition entrants will develop, we want to ask and answer: Can the combined model be solved to high accuracy in a reasonable amount of time on practical instances? What are the incremental benefits to society of the combined solution, relative to the sequential approach? How will various industry trends, including increasing capacity of variable and uncertain generation resources, distributed energy resources, price sensitive load, and storage, affect the value of advanced computational tools for grid optimization?

2 **Go Competition Challenge 2: Analysis and Lessons Learned**
Brent Eldridge, Pacific Northwest National Laboratory, Baltimore, MD
The Grid Optimization (GO) Competition Challenge 2 is nearly finished. This competition focused on a security constrained AC optimal power flow problem with fast start unit commitment, transmission switching, and a detailed post-contingency model. The Final Event trial finished in September 2021, and the Monarch of the Mountain ongoing trial will finish in October 2022. This talk reviews the results so far and presents some lessons learned regarding the impact of solver time limits, the value and computational difficulty of model features like transmission switching and flexible load, the challenges of working with confidential industry data, and other outcomes of the competition.

3 **Grid Optimization (GO) Competition Challenge 2 Case Studies**
Farnaz Safdarian, Texas A&M University, College Station, TX
The case studies used in Grid Optimization (GO) Competition Challenge 2 include 16 synthetic grids with 84 scenarios created by three data teams, and six industry (actual) datasets composed of 36 scenarios that cannot be made publicly available. The synthetic grids are created based on publicly available data such as census data and load per capita and generator data and do not include any confidential information. Scenarios are created based on changes in the load and the availability of renewable energy resources. All power flow network configuration data files are provided in specific formats as an input for competitors. The input data is validated based on actual grids. The difficulty of each grid is assessed and the existence of a feasible solution for each grid is verified. The results achieved by different teams are analyzed and their performance on synthetic grids and actual industry grids are compared.

4 **Make It Real. Exploring the Gaps Between Power System Optimization Problems and Reality**
Scott Greene, University of Wisconsin Madison, Madison, WI, Contact: sgreene1@wisc.edu
For decades, the electric power industry has been the source of demanding scheduling and allocation problems. The availability of computational tools has affected how power system engineers operate and model the grid while the heuristics and approximations exploited in practice in turn influence the evolution of software. This presentation examines the problems created for ARPA-E's Grid Optimization Competition and their association with current and future power grid and electricity market operations. Topics addressed include voltage control, demand aggregations, congestion management, security, reliability, and risk management. The formulations of the GO Competition problems are compared to typical industry practice and available software solutions.

Sunday, 5 PM–6:15 PM

SE62

M - Marriott 9

Electric Vehicle Management in Coupled Power-transportation Systems

General Session

Session Chair

Yunhe Hou, University of Hong Kong, Hong Kong, Hong Kong.

Session Chair

Yue Chen, The Chinese University of Hong Kong, Sha Tin

1 Power and Transport Nexus - Autonomous Electric Vehicle Fleet Operation and Optimization

Hongcai Zhang, University of Macau

Autonomous vehicles (AVs) that transport passengers or goods without human intervention will not only free human drivers from burdensome driving labor, but also promote transportation accessibility, cut down mobility costs, enhance energy efficiency, and reduce green-house gas emission. When AVs are electrified, which we refer to as autonomous electric vehicles (AEVs), then the last two aforementioned advantages will be further enhanced, particularly if the electricity is supplied from clean energy. The adoption of AEVs will significanty strengthen the power transportaiton nexus. To enhance the synergy between smart power grid & intelligent tranpsortation, this talk discusses some primary operation and optimization strategies of AEV systems on coupled power & transportation networks.

2 Modeling of Electric Vehicle Load in the Wireless Charging Scenario and Its Impact on the Distribution Network

Xin Cui[1], Liang Liang[2], Yunhe Hou[1], [1]the University of Hong Kong, Hong Kong, China; [2]Harbin Institute of Technology, Shenzhen, Shenzhen, China. Contact: cuixin@eee.hku.hk

Wireless charging of EVs on the power track is influenced by the traffic flow and has a certain impact on the power grid. In order to ensure the stable and reliable operation of the distribution network and reasonably schedule such EV load resources, it is necessary to analyze the EV charging load in combination with wireless charging characteristics and transportation information. Based on a general lithium battery model and vehicle motion equation influenced by the traffic flow, the static and dynamic charging load model of a single EV on a power track is given. Combined with the probability distribution of the initial state of charge, transportation network, and user travel habits, the charging load model of multiple EVs on the power track is presented. Finally, the influence of EV load on the distribution network is analyzed based on an example simulation.

3 Impact of COVID-19 on Learning-based Electric Vehicle Charging: Challenges and Solutions

Tongxin Li, Zachary Lee, Steven Low, Caltech, Pasadena, CA

The rapid growth of electric vehicles (EVs) in the last decade reduces carbon emissions of the transportation sector. We first introduce a large-scale adaptive charging network (ACN) infrastructure with a public dataset (ACN-Data). We showcase some applications of ACN-Data in control and learning-based EV research. With EV charging data collected in the past 3 years, we analyze the impact of COVID-19 on users' charging behavior, which poses challenges to existing control and learning-based charging algorithms. Finally, we highlight an MPC-regularized policy gradient charging method, which trusts user inputs in lieu of historical data records if they are biased because of pandemic-related policy shifts or human behaviors; and trusts data if user inputs are adversarial.

4 Online Distributed Routing Problem of Electric Vehicles

Zaiyue Yang, Southern University of Science and Technology, Shenzhen, China. Contact: yangzy3@sustech.edu.cn

Considering the penetration of numerous electric vehicles (EV) into the transportation sector, the EV routing problem that jointly optimizes the charging and routing of EVs becomes increasingly important. First, we start with an offline EVs routing and charging (EVRP) problem which is a large-scale mixed integer nonlinear program. A method is proposed to decompose the offline EVRP into a master problem and a set of sub-problems. To further speed up the computation, we relax the mixed integer master problem to a linear program, and a novel valid cut is added to reduce the number of iterations. In order to adapt to the online setting, we introduce the virtual depot and utilize the rolling-horizon framework to tackle uncertain future information. Numerical results validate that the speed of proposed algorithm is faster than current algorithms by several orders of magnitude.

Sunday, 5 PM–6:15 PM

SE63

M - Marriott 10

Environment, Sustainability and Urban Infrastructure
General Session

Session Chair
Wei Qi, McGill University

Session Chair
Aiqi Zhang, Hong Kong, Hong Kong.

Session Chair
Ronald McGarvey, University of Missouri, IMSE and TSPA, Columbia, MO

1 **Urban Infrastructure Planning to Manage Stormwater**
Sheng Liu[1], Wei Qi[2], Aiqi Zhang[3], [1]University of Toronto, Toronto, ON, Canada; [2]McGill University, Montreal, QC, Canada; [3]Rotman School of Management, University of Toronto, Toronto, ON, Canada. Contact: aq.zhang@rotman.utoronto.ca
We propose an urban water infrastructure planning problem that integrates the sewage systems and retention basins as control methods. Leveraging the traditional Intensity-duration-frequency (IDF) Curve to characterize rainfall scenarios, we analyze the flooding cost of each scenario and show that even the scenarios with same return periods on the IDF Curve can result in entirely different flooding costs, providing a perspective of operations management for the planning. Applying robust optimization techniques, we provide tractable infrastructure solutions that hedge against worst-case rainfall scenarios. Finally, we extend our model to the case of capacitated sewage systems and multiple catchments.

2 **Mitigating Climate-induced Floods via Real-time Operation of Urban Stormwater Systems: The Case for Model Predictive Control**
Marcus Nobrega Gomes Jr[1], Ahmad Taha[2], Marcio Giacomoni[1], Eduardo Mario Mendiondo[3], [1]University of Texas at San Antonio, San Antonio, TX, [2]Vanderbilt University, Nashville, TN, [3]University of Sao Paulo, Sao Carlos, Brazil.
Urban stormwater systems face tremendous challenges due to the climate change, which will increase the frequency and severity of storms, resulting in more flooding. Due to advances in sensing and actuating technology, computation power, weather/climate forecast, and control theory, there are great opportunities to mitigate climate-induced flooding via real-time operation of urban stormwater systems. To this end, we develop a novel non-linear state-space model of hydrologic and hydrodynamic processes in watersheds, reservoirs, and channels. We tested reactive controls and compared them to a model predictive control (MPC) using a synthetic case study. MPC outperforms the reactive controls not only for design and rare storms but also for continuous simulations. The tested MPC approach is flexible and performed well even under relatively short prediction horizons.

3 **Exploring Social Dimension for Sustainable Solid Waste Management Optimization**
Jenny Gutierrez-Lopez[1,2], Ron McGarvey[1], [1]University of Missouri, Columbia, MO, [2]Escuela Superior Politecnica del Litoral (ESPOL), Guayaquil, Ecuador. Contact: jgutierrezlopez@mail.missouri.edu
The goal of this study is to present a sustainable and engaged solid waste management multi-objective optimization framework to recommend waste treatment strategies. The objective functions consider the three pillars of sustainability attempting to (1) minimize total costs, (2) minimize environmental impacts, and (3) maximize service quality. The novel feature of this study is that it also incorporates a social score threshold as a constraint such that the framework reflects not only expert's perspectives at local government and organizations in solid waste management but also considers views of residents of the city. Results are expected to illustrate complexities in solid waste management decisions, provide suggestions to manage conflicting criteria and demystify trade-offs of different waste treatment strategies.

Sunday, 5 PM–6:15 PM

SE64

M - Indiana A
New Algorithmic Concerns in Market Revenue Management
General Session

Session Chair
Vijay Kamble, University of Illinois at Chicago, Chicago, IL

Session Chair
Swati Gupta, ISyE Georgia Tech, Atlanta, GA

1 **Markdown Pricing Under Unknown Parametric Demand Models**
Su Jia, Andrew A. Li, R. Ravi, Carnegie Mellon University,

Pittsburgh, PA, Contact: aali1@cmu.edu
Consider the problem of pricing a single product under unknown demand, with the objective of maximizing expected revenue over T rounds, subject to a markdown pricing constraint. Previous work has shown a tight $T^{3/4}$ regret bound under minimal, non-parametric assumptions on the demand curve (whereas the same problem without markdown constraint admits $T^{2/3}$ regret).
We investigate this same problem assuming the demand curve comes from a known parametric family. Specifically, we ask: (1) Can the $T^{3/4}$ regret bound be improved with extra assumptions on the functional form of the demand function? (2) Is markdown pricing still harder than unconstrained pricing under these additional assumptions? To answer these, we introduce a concept called markdown dimension that measures the complexity of the given parametric family, and present tight regret bounds under this framework.

2 Bayesian-Nash-Incentive-Compatible Mechanism for Blockchain Transaction Fee Allocation

Zishuo Zhao[1], Xi Chen[2], Yuan Zhou[3], [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]New York University, New York, NY, [3]Tsinghua University, Beijing, China. Contact: zishuoz2@illinois.edu
In blockchain systems, the design of transaction fee mechanisms is essential for stability and satisfactory for both miner and users. A recent work has proven the impossibility of collusion proof mechanisms with non-zero miner revenue which is DSIC for users. In our work, we relax the DSIC requirement for users to BNIC, and designed a so-called soft second-price mechanism to ensure a form of collusion-proofness with a positive miner revenue, breaking the zero-revenue barrier while preserving reasonable truthfulness.

3 Fair Assortment Planning

Qinyi Chen[1], Negin Golrezaei[2], Fransisca Susan[1], Edy Baskoro[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Lexington, MA, [3]Institut Teknologi Bandung, Bandung, Indonesia. Contact: qinyic@mit.edu
Assortment planning decisions of online platforms have a significant impact on customers' choices, and many platforms employ algorithms that feature items with the highest popularities. This, however, can lead to too little visibility for the rest of the items, making them leave the platform, which in turn hurts the platform's long-term goals. Motivated by that, we introduce and study a fair assortment planning problem, which requires any two items with similar merits to be offered similar visibility. We propose a framework to find near-optimal solutions to this problem, using the Ellipsoid method and a separation oracle to its dual. We then develop two approximate separation oracles, which result in a polynomial-time 1/2-approx. algorithm and an FPTAS for our problem. Finally, we conduct a case study on the MovieLens dataset, demonstrating the efficacy of our algorithms.

4 Ensuring Comparative Fairness at the Time of Purchase in Demand Learning

Vijay Kamble, University of Illinois at Chicago, Chicago, IL
A multi-segment pricing strategy satisfies comparative fairness at the time of purchase if the price received by a segment isn't much worse (up to a certain degree of publicly allowable disparity) than that received by any segment in the past. We design novel algorithmic approaches to satisfy this notion of fairness in the process of demand learning for the case where the revenue functions are known to be smooth and strongly concave. These approaches ultimately achieve the same optimal regret guarantees (up to logarithmic factors) as those achievable without the fairness constraint. This algorithmic framework can help firms address the rising concerns of inequitable treatment in dynamic pricing.

Sunday, 5 PM–6:15 PM

SE65

M - Indiana B
Inclusive and Sustainable Operations
General Session

Session Chair
ABHINAV Shubham, NULL, Atlanta, GA

1 Do Irrelevant Alternatives Influence Choices in Environmental Decisions?

Mirel Yavuz[1], Guia Bianchi[2], Charles J. Corbett[3], Tayler Bergstrom[3], Aimee Drolet[3], Timothy F. Malloy[4], Deepak Rajagopal[5], Rakesh Kumar Sarin[3], Francesco Testa[2], [1]University of California, Los Angeles, Los Angeles, CA, [2]Sant'Anna School of Advanced Studies, Pisa, Italy; [3]University of California, Los Angeles, Los Angeles, CA, [4]University of California, Los Angeles School of Law, Los Angeles, CA, [5]UCLA Institute of Environment and Sustainability, Los Angeles, CA, Contact: mirel.yavuz.phd@anderson.ucla.edu
Although several tools exist to collect environmental information, there is minimal guidance on making decisions based on such information. Decision-makers are subject to a wide range of context effects in other

domains. This experimental study finds that attraction and compromise effects occur in the context of sustainability-related decision-making.

2 Race and Facility Emissions

Abhinav Shubham, Ravi Subramanian, Georgia Institute of Technology, Atlanta, GA, Contact: ashubham3@gatech.edu

Environmental justice researchers have found evidence of racial minorities bearing disproportionate environmental burdens. However, it is unclear how facility level operational choices contribute to this disparity. We conduct an empirical investigation into the environmental and operational choices of facilities in host communities with substantial presence of racial minority populations.

3 Evaluating Small Business Preference Programs in Public Procurement: Evidence from U.S. Federal Government R&D Contracts

Dwaipayan Roy[1], Anant Mishra[2], Kingshuk K. Sinha[3], [1]University of Virginia Darden School of Business, Charlottesville, VA, [2]Carlson School of Management, University of Minnesota, Minneapolis, MN, [3]University of Minnesota SCO, Minneapolis, MN, Contact: royd@darden.virginia.edu

We examine whether the performance of R&D contracts awarded through the Set-Aside program differs from those awarded through open competition and, if so, in what way. Furthermore, we examine how characteristics of the contracting environment—namely, contractor firm experience (i.e., the number of R&D contracts executed by a contractor firm for the federal government) and contract award timing (i.e., awarded *early* in a federal fiscal year)—interact with the set-aside status of an R&D contract to affect its performance.

4 Does Leader Disability Influence the Productivity Performance of Teams with Workers with Disabilities? An Empirical Study in the Apparel Industry

Dustin Cole[1], Sriram Narayanan[2], Shawnee Vickery[2], [1]Auburn University, Auburn, AL, [2]Michigan State University, East Lansing, MI

This research examines the impact of a direct supervisor with a disability on the productivity of workers with disabilities through the lens of Leader-Member Exchange Theory (LMX). Through both quantitative analysis and a qualitative study we find that a supervisor with a disability mitigates the potential productivity decline as the number of workers with a disability increases. A potential mechanism for this is greater task stability of supervisors with disabilities which came out as a major theme of the qualitative study.

Sunday, 5 PM–6:15 PM

SE66

M - Indiana C
ENRE/Electricity Flash Session
Flash Session

Session Chair
Erhan Kutanoglu, University of Texas-Austin, Austin, TX

1 Optimizing Decommissioning Strategy for Thermal Power Plants in the Climate Resilient Power System -- Case Study of Decommissioning Plan in China

Ziting Huang, Johns Hopkins University, MD

To comply with more stringent carbon emissions goals, old thermal power plants now face challenges of being forced to decommission earlier than the scheduled retirement year. The study aims to explore the optimized decommissioning strategy for existing thermal plants using the economic dispatch in the power system considering the extreme climatic events and renewables uncertainty. Four strategies are available to thermal plants regarding such a decision: to retire as scheduled, to retrofit with carbon capture and storage devices, to decommission early, and to redevelop into new renewable energy site. The study will focus on the coal power industry in China.

2 Data-driven Operations for a Smart Vehicle-grid System

Ziliang Jin[1], Jianqiang Cheng[2], Kai Pan[3], Zuo-Jun Max Shen[4], Yulan Amanda Wang[1], [1]The Hong Kong Polytechnic University, Kowloon, Hong Kong; [2]University of Arizona, Tucson, AZ, [3]Hong Kong Polytechnic University, Hung Hom, Hong Kong; [4]University of California Berkeley, Berkeley, CA, Contact: ziliang-lms.jin@connect.polyu.hk

We consider a vehicle-grid integration system, which is supported by vehicle-to-grid (V2G) technology. Our goal is to identify the potential of V2G in such synergy. To address this problem, we propose a two-stage robust mixed-integer linear programming (MILP) model which jointly optimizes grid's planning and EV sharing company's operations under uncertainties. Due to its large-scale computational difficulty, we propose three different approaches (new strong valid inequalities, ADMM, and hybridization of machine learning and optimization) that are applicable in different sample sizes to boost the solving efficiency. Finally, we show the potential of V2G by numerical results.

3 Two-stage Robust Optimization with Decision-dependent Uncertainties

Yunfan Zhang, Feng Liu, Tsinghua University, Beijing, China. Contact: zhang-yf18@mails.tsinghua.edu.cn

Decision-dependent uncertainties impose great challenges to the current robust optimization (RO) framework. We investigate the two-stage RO problems that involve two classes of decision-dependent uncertainty sets (DDUS) including 1) polyhedral DDUS whose right-hand-side vector has a dependency on the here-and-now decisions; and 2) transformable DDUS that comprises a coupling function concerning certain exogenous uncertain parameters. A novel iterative algorithm based on the Benders dual decomposition and a variant of C&CG method based on scenario mapping are proposed, where advanced optimality and feasibility cuts are applied to incorporate the uncertainty-decision coupling.

4 Robust Generation Dispatch with Strategic Renewable Power Curtailment and Decision-dependent Uncertainty

Yue Chen, The Chinese University of Hong Kong, Sha Tin, Hong Kong. Contact: yuechen@mae.cuhk.edu.hk

This talk introduces a novel two-stage robust generation dispatch (RGD) model, where the curtailment strategy is optimized in the pre-dispatch stage. Therefore, the problem casts down to a robust optimization under decision-dependent uncertainty (DDU). To overcome the difficulty in solving the RGD with DDU, an adaptive column-and-constraint generation (AC&CG) algorithm is developed. We prove that the proposed algorithm can generate the optimal strategy in finite iterations. Numerical examples validate the practicability and scalability of the proposed model and algorithm.

5 Two Bird, One Stone: Modeling Time-based Energy Attribute Certificates for 24/7 Carbon-free Electricity Procurement and Carbon-optimized Procurement

Qingyu Xu, Neha Patankar, Aneesha Manocha, Jesse D. Jenkins, Princeton University, Princeton, NJ, Contact: xuqingyu0610@gmail.com

We enhance a capacity expansion planning model, GenX, to model a Time-based Energy Attribute Certificate (TEAC) system, with which we model two voluntary clean-energy-procurement schemes: 24/7 carbon-free electricity (24/7 CFE) procurement and carbon-optimized (CO) procurement. 24/7 CFE participating consumers procure TEACs from CFE generated in each hour to match their hourly demand, while carbon-optimized procurement aims to maximize the system-level CO2 emissions reduction using hourly marginal emission rates. We analyze the two schemes by showing their procured portfolios, cost premiums, and emission impacts on the California electricity system in 2030.

6 Using Geographic Load Shifting to Reduce Carbon Emissions

Line Roald[1], Julia Lindberg[1], Bernard Lesieutre[2], [1]University of Wisconsin - Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI, Contact: roald@wisc.edu

Two rapidly increasing categories of electric load, namely electric vehicle charging or operation of hyperscale data centers, exhibit flexibility in either when or where electricity is consumed. We discuss how these loads can interact with the electricity market to minimize the carbon emissions of their electricity consumption, even as the market operator targets cost minimization. We propose to locational marginal carbon emissions as a new metric to guide load shifting, and discuss how this metric can be defined using tools from sensitivity analysis and multi-parametric programming. We then demonstrate its efficacy compared to existing metrics on a standard test case.

7 Routing and charging facility location for EVs under nodal pricing of electricity: A bilevel model solved using special ordered set

Felipe Feijoo, 1</sup

8 Integrated Prediction and Optimization for Power Grid Resilience Planning

Erhan Kutanoglu, University of Texas-Austin, Austin, TX

We analyze the resilience planning problem for the power grid and make the case for integrating prediction and optimization. We focus on two extreme weather events (flood causing heavy rain events and cold snaps). We propose models to enhance the grid resilience by significantly improving mitigation and adaptation planning, rather than focusing on recovery. We propose a comprehensive modeling and methodological framework for the integration of scenario generation, impact predictions and optimization-based resilience planning. We demonstrate the overall approach and present results using a synthetic but realistic Texas-size power grid. We finally tie the overall analysis to our latest work on equitable resilience planning and climate change adaptation of the power grid.

Sunday, 5 PM–6:15 PM

SE67

M - Indiana D
Pricing and Learning
General Session

Session Chair
Yeqing Zhou, Eindhoven University of Technology, Eindhoven, Netherlands.

1 Simple Policies for Joint Pricing and Inventory Management
Adam Elmachtoub[1], Harsh Sheth[2], Yeqing Zhou[3], [1]Columbia University, New York, NY, [2]Columbia University, New York, NY, [3]Eindhoven University of Technology, Eindhoven, Netherlands.
In this paper, we study the fundamental joint pricing and inventory control problem where the customers are price sensitive, and the demand rate can be controlled by the price. In this setting, an optimal policy is highly dynamic, with price varying over time to leverage supply and demand. We analyze the effectiveness of simpler policies, where only a small number of prices are offered throughout, and offer insights of how these policies compare to their dynamic counterparts. We find that when there is no backlogging, a single price can be used to be a *log(S)* factor away for holding costs while doing just as good on revenue and ordering costs under exponential demand. This factor can be improved to 1.5 when the demand is linear. When there is backlogging, using three prices instead of one gives us similar performance guarantees.

2 Optimal Feature-based Market Segmentation and Pricing
Titing Cui, Michael L. Hamilton, University of Pittsburgh, Pittsburgh, PA, Contact: mhamilton@katz.pitt.edu
In this work, we study semi-personalized pricing strategies where a seller uses features about their customers to segment the market, and where customers are offered segment specific prices. Specifically, we study market segmentation and pricing under the assumption that the seller has trained a (noisy) regression model mapping features to valuations. We establish novel hardness and approximation results for when model noise is independent. In the common case when the noise in the model is log-concave, we show the joint segmentation and pricing problem can be efficiently solved and characterize a number of attractive structural properties about the optimal feature-based market segmentation and pricing.

3 Speed Service with Spotlight Products: Assortment Optimization and Pricing with Service Rate Consideration
Zhe Liu[1], Shixin Wang[2], [1]Imperial College Business School, London, United Kingdom; [2]CUHK Business School, Hong Kong, Hong Kong. Contact: zhe.liu@imperial.ac.uk
Quick-service restaurants, such as fast-food franchises and coffeehouse chains, recommend items with spotlight menu that may shorten customers' decision time and hence speed up the service, but with a trade-off of possibly lower profit margin. We study such assortment optimization problems when service rate is affected by the recommendation and plays a role in the revenue rate objective. Formulated as a sequential recommendation problem in a queueing setting under the multinomial logit model, we obtain structural properties of the impact of arrival rate and system capacity on optimal assortment, and find optimality conditions for attractiveness-ordered or fare-ordered nested policies. We also characterize the optimal joint assortment and pricing under common price sensitivity.

4 Uncertain Search with Knowledge Transfer
Woonghee Tim Huh, Michael Jong Kim, Meichun Lin, University of British Columbia, Vancouver, BC, Canada. Contact: meichun.lin@sauder.ubc.ca
We study a problem of sequential learning and choosing from a group of similar alternatives. The unknown payoff of accepting an alternative depends on a set of common features that enables knowledge transfer across the group. There is also an idiosyncratic value for each alternative that needs to be learned by sampling over time. The problem is whether to accept the current alternative, continue sampling, or switch to the next one. We model it as a Bayesian dynamic program and analyze structural properties.

Sunday, 5 PM–6:15 PM

SE68

M - Indiana E
Learning and Optimization in Pricing
General Session

Session Chair
Hansheng Jiang, University of California, Berkeley, Berkeley, CA

1 The Effect of Privacy Policy on Pricing and Revenue
Ningyuan Chen[1], Ming Hu[2], Jialin Li[3], Sheng Liu[4], [1]University of Toronto, Mississauga, ON, Canada; [2]University of Toronto, Minneapolis, MN, [3]University of Toronto, Toronto, ON, Canada; [4]University of Toronto,

Toronto, ON, Canada. Contact: jln.li@rotman.utoronto.ca
Retailer(s) may collect or purchase historical data to build demand model that can be used to give optimal pricing at the current stage. However as what is becoming prevailing, user information would be hided in such data as required by regulators to protect users' privacy. This policy will have an impact on the so-believed optimal price and revenue when users' features have correlation with prices in history, which is often observable in data. We show that in cases of monopoly, the retailer will suffer revenue loss under privacy policy when sample size is large; whereas for duopoly the difference on equilibrium revenue is closely related to the coefficient(s) of users' feature(s) in the model. Our analysis also shows what kind of features, when hided, will be most harmful to revenue.

2 Policy Optimization Using Semi-parametric Models for Dynamic Pricing

Mengxin Yu, Yongyi Guo, Jianqing Fan, Princeton University, Princeton, NJ, Contact: mengxiny@princeton.edu
In this paper, we study the contextual dynamic pricing problem where the market value of a product is linear in some observed features plus some market noise (with unknown distribution). Products are sold one at a time, and only a binary response indicating the success or failure of a sale is observed. We propose a dynamic statistical learning and decision-making policy that combines semi-parametric estimation and online decision-making to minimize regret (maximize revenue). Under mild conditions, we show that for a market noise c.d.f. F with m-th order derivative, our policy achieves a sublinear regret. The upper bound is further reduced to sqrt root of T if F is super smooth whose Fourier transform decays exponentially. These upper bounds are close to the lower bound where F belongs to a parametric class.

3 Linear Contextual Dynamic Pricing

Jianyu Xu, University of California Santa Barbara, Santa Barbara, CA, Contact: xu_jy15@ucsb.edu
Feature-based dynamic pricing are formally studied as an online learning problem where a seller sets appropriate prices for a sequence of products (described by their features) on the fly and learns from the binary feedbacks ("Sold" if valuation >= price and "Not Sold" otherwise). We study this problem by making a linear use of these features. In specific, we consider the following two models: (a) a "linear valuation" problem where customers' valuations are a linear mapping of features adding iid noises, and (b) a "linear policy" problem where we are agnostic of the valuation mechanism and only aim at competing with the best linear pricing policy. For both of these two problems, we design algorithms with provable regret upper bounds and propose information-theoretic lower bounds under a variety of assumptions.

4 Network Revenue Management: A PAC-Bayesian Approach

N. Bora Keskin[1], David Simchi-Levi[2], Prem Talwai[3], [1]Duke University, Durham, NC, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT, Cambridge, MA, Contact: talwai@mit.edu
We consider a seller offering a large network of N products over a horizon of T periods. The seller is unaware of the parameters of the products' linear demand model, and can dynamically adjust product prices to learn the the model based on sales observations. The seller aims to minimize their revenue loss relative to a clairvoyant who knows the underlying demand model. We consider a sparse set of demand relationships between products and focus particularly on two different sparsity frameworks: (1) L_0 sparsity, which constrains the number of connections in the network, and (2) off-diagonal sparsity, which constrains the magnitude of cross-product price sensitivities. We propose a dynamic pricing-and-learning policy that combines PAC-Bayesian and OFUL approaches, and achieves asymptotically optimal performance in terms of N and T.

Sunday, 5 PM–6:15 PM

SE69

M - Indiana F
Theory and Practice in Revenue Management
General Session

Session Chair
Yonatan Gur, Stanford University, Stanford, CA

1 Trading Safety Stock for Service Response Time in Inventory Positioning

Hanzhang Qin[1], David Simchi-Levi[2], Ryan Ferer[3], Jonathan Mays[4], Ken Merriam[4], Megan Forrester[5], Alex Hamrick[5], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Accenture, Atlanta, GA, [4]Accenture, Atlanda, GA, [5]The Home Depot, Atlanda, GA, Contact: hqin@mit.edu
We study the inventory placement optimization problem, where demand is sensitive to service response time, under the online retailing setting. The main challenge is to achieve the optimal trade-off between revenue benefits from shorter delivery time and inventory operation costs. To predict the

effects of modified demand under service response time variations, we introduce a demand prediction and elasticity model to quantify the sensitivity in demand for particular product categories. We also propose a novel data-driven two-stage stochastic programming approach complementing the demand prediction and elasticity model, which optimally trades safety stock for service response time. We then illustrate the efficiency of our approach through data provided by an e-commerce retailer in North America.

2 Leveraging Consensus Effect to Optimize Feed Ranking in Online Discussion Boards

Joseph Carlstein[1], Gad Allon[1], Yonatan Gur[2], [1]University of Pennsylvania, Philadelphia, PA, [2]Stanford University, Stanford, CA, Contact: jc95@wharton.upenn.edu

Online discussion boards are designed for facilitating discussions between groups of users. To stimulate engagement, these platforms suggest arriving users a recommended "feed" of comments made by other users. In this study we collaborate with Ment.io, an online discussion board catering to groups in business and education settings. From their data, we identify and empirically validate a new engagement driver capturing the level of discussion *consensus*. This driver suggests that, when designing the recommended feed, the platform should consider not only comments that would yield present engagement, but also ones that would maximize *future* engagement by managing the desired discussion consensus level. Based on this, we propose a new dynamic model and a practical class of algorithms that integrate both considerations to maximize engagement along the discussion path.

3 Designing Layouts for Sequential Experiences: Application to Cultural Institutions

Ali Aouad[1], Abhishek Deshmane[2], Victor Martinez de Albeniz[3], [1]London Business School, London, United Kingdom; [2]IESE Business School, Barcelona, Spain; [3]IESE Business School, Barcelona, Spain. Contact: adeshmane@iese.edu

Experience providers - ranging from retail platforms to cultural institutions - need to decide on how to display an assortment of items for physical and digital interactions. In this paper, we develop a data-driven analytics framework to optimize these layout-related decisions for maximum user engagement. We develop a new dynamic choice model, called Pathway MNL, that represents visitor activity as a sequence of conditional logit experiments. Through an ongoing collaboration with the Van Gogh Museum, we validate the model on large-scale logs of visitor activity recorded through audio guides. We uncover significant relationships between visitors' choices and layout-related factors, among others. Finally, we analyze the resulting mathematical program for layout optimization and identify simple layout interventions that can significantly lift visitor engagement.

4 Regret Minimization with Dynamic Benchmarks in Repeated Games

Ludovico Crippa[1], Yonatan Gur[1], Bar Light[2], [1]Stanford University, Stanford, CA, [2]Microsoft Research, New York, NY

In repeated games, the dynamics arising when all players deploy strategies with no-regret relative to a static benchmark have been extensively studied. However, static benchmarks are limited and can perform poorly in natural dynamic scenarios. In this work we study the dynamics that emerge when players adopt strategies with guarantees relative to dynamic benchmarks. Our main result shows that the empirical distribution of plays still converges to the Hannan set. Our results imply that, despite being more stringent than static comparators, these different classes of strategies drive comparable game dynamics. This characterization allows one to adopt analyses from settings that consider a static benchmark, which we demonstrate by extending results on the Price of Anarchy to our setting.

Sunday, 5 PM–6:15 PM

SE70

M - Indiana G

Machine Learning for Social Good

General Session

Session Chair

Leonard Boussioux, MIT, Cambridge, MA

Session Chair

Vassilis Digalakis, Massachusetts Institute of Technology, CAMBRIDGE, MA

Session Chair

Lily Xu, Harvard University, Cambridge, MA

1 How Many Pooled Covid Tests are Enough?

Ilias Zadik, Massachusetts Institute of Technology, Cambridge, MA

The problem of pooled or group testing, which was of paramount importance over the recent COVID-19 pandemic, tests on parallel subsets of a population of individuals with the goal to detect a subset of infected ones. The perhaps simplest, yet mathematically optimal in terms of number of required tests, such testing procedure is to choose the individuals participating in each test independently at random. Yet, identifying the infected individuals using this testing procedure seems to require a large (exponential) time. We will discuss recent work on trying to understand whether such a number of tests vs time trade-off is actually fundamental or not.

2 Patterns and Predictors of Urban Emissions in the United States: A Typology Approach

Alexa Weinman, Jimi Oke, University of Massachusetts Amherst, Amherst, MA, Contact: aweinman@umass.edu

Notably, 4.25% of the global population resides in the US, which contributed 11% of global greenhouse gas emissions in 2019. Furthermore, cities accounted for 63% of total US emissions in 2012 (Gately et al., 2015). Yet, their patterns and predictors have been relatively understudied. To address these gaps, we first analyze multivariate emissions patterns in over 300 US urban areas to develop novel typologies. Second, we estimate models to predict these typologies based on explanatory variables from mobility, socioeconomic, geographic, urban form, environmental, and public health categories. This approach provides deeper insights into the drivers of urban emissions and can facilitate future analyses of climate change mitigation strategies.

3 A Scientific Mapping on Polymer Nanoparticles in Cancer Drugs Through Global Publications

Xindan Kang[1], Mohammadhossein Amini[1], Majid Jaberi-Douraki[2], [1]Washington University in St.Louis, St. Louis, MO, [2]Kansas State University, Manhattan, KS, Contact: k.xindan@wustl.edu

In this study, we mine published studies in various reputed journals across different countries in the area of anticancer drugs. We mainly focus on the studies where anticancer drugs are carried by functionalized polymer nanoparticles in different types of cancers. Our dataset contains 240000 publications indexed through the Scopus database from 1980 to the present, where the number of publications peaked after 2010. We apply various text mining and data-analytic techniques to find current trends, core objectives, distinguished scientists, and the most prominent research groups in this field. Our findings show the potential patterns underlying the changes in cancer treatment to provide references for polymer nanoparticles' future development.

4 Hurricane Forecasting: A Novel Multimodal Machine Learning Framework

Cynthia Zeng, Massachusetts Institute of Technology, Cambridge, MA

This work describes a novel machine learning (ML) framework for tropical cyclone intensity and track forecasting, combining multiple ML techniques and utilizing diverse data sources. Our multimodal framework, called Hurricast, efficiently combines spatial-temporal data with statistical data by extracting features with deep-learning encoder-decoder architectures and predicting with gradient-boosted trees. We evaluate our models in the North Atlantic and Eastern Pacific basins on 2016-2019 for 24-hour lead time track and intensity forecasts and show they achieve comparable mean average error and skill to current operational forecast models while computing in seconds. Furthermore, the inclusion of Hurricast into an operational forecast consensus model could improve over the National Hurricane Center's official forecast, thus highlighting the complementary properties with existing approaches. In summary, our work demonstrates that utilizing machine learning techniques to combine different data sources can lead to new opportunities in tropical cyclone forecasting.

Sunday, 5 PM–6:15 PM

SE71

M - Arizona

Data Protection and Privacy in Redistricting

General Session

Session Chair

Soraya Ezazipour, Oklahoma State University, Stillwater, OK

1 Presenter

Christopher T. Kenny[1], Shiro Kuriwaki[2], Cory McCartan[3], Evan Rosenman[4], Tyler Simko[1], Kosuke Imai[5], [1]Harvard University, Cambridge, MA, [2]Stanford University, Cambridge, MA, [3]Harvard University, Cambridge, MA, [4]Harvard University, Cambridge, MA, [5]Harvard University, Cambridge, MA, Contact: christopherkenny@fas.harvard.edu

Census statistics play a key role in public policy decisions and research. However, given the risk of revealing individual information, many statistical agencies are considering disclosure control methods based on differential privacy, which add noise to tabulated data. Unlike other applications of differential privacy, however, census statistics must be postprocessed after noise injection to be usable. We study the impact of the U.S. Census Bureau's latest disclosure avoidance system (DAS) on a major application of census

statistics, the redrawing of electoral districts. We find that the DAS systematically undercounts the population in mixed-race and mixed-partisan precincts, yielding unpredictable racial and partisan biases. While the DAS leads to a likely violation of the “One Person, One Vote” standard, it does not prevent accurate predictions of race.

2 Redrawing Attendance Boundaries to Promote Racial and Ethnic Diversity in Elementary Schools

Keyu Zhu[1], Nabeel Gillani[2,3], Pascal Van Hentenryck[4], [1]Georgia Institute of Technology, Atlanta, GA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Northeastern University, Boston, MA, [4]Georgia Institute of Technology, Atlanta, GA

Most US school districts assign children to schools based on where they live, drawing “attendance boundaries” to define catchment areas that often recapitulate neighborhood demographic segregation in schools. Focusing on elementary schools, we ask: how much might we reduce school segregation by redrawing attendance boundaries? We simulate alternative boundaries for 98 US school districts serving over 3 million students, minimizing White/non-White segregation while imposing constraints on travel times and school sizes. Across districts, we observe a median 12% relative decrease in segregation requiring nearly 20% of students to switch schools and, surprisingly, a slight reduction in travel times. We explore the sensitivity of these results under different privacy-preservation strategies to inform practicable desegregation efforts across school districts.

3 Casual Inference in Redistricting

Zachary Schutzman, MIT, Cambridge, MA, Contact: zis@mit.edu

Drawing districts to achieve a purpose, whether a positive one like equitable and effective representation or a nefarious one like locking in a partisan advantage is an exercise in using data to infer demographic attributes and predict the voting behavior of living in a jurisdiction. In a formal sense, these inferences about identity and voting patterns erodes their privacy, yet these privacy concerns are given little attention. On the other side, analysts seeking to uncover the motives and impacts of a districting plan have to perform similar privacy-violating analyses. This sets up a tension between privacy and effective representation, though we generally consider both to be desirable. We’ll discuss the data analysis domain experts perform in the redistricting setting, how that analysis chips away at privacy, and highlight points of conflict between those two values.

4 What is the “Real” Population of My District? The Worst-case Effects of Differential Privacy

Soraya Ezazipour, Austin Buchanan, Oklahoma State University, Stillwater, OK

To protect the privacy of respondents, the US Census Bureau added random noise to the 2020 Census data, including to the population counts. This has led to concerns that districts that are reported to be equally populous may actually deviate beyond what is legally acceptable. In this presentation, we aim to understand the worst-case impacts of noising on district populations. We build single districts with maximum actual population such that their census-reported population is legal. To solve this optimization problem, we use integer programming techniques. For our data, we use the actual 2010 population counts and the noised 2010 population counts. We apply the approach to county-level, tract-level, and block-level instances of congressional redistricting.

Sunday, 5 PM–6:15 PM

SE72

M - California

Social Media Analytics in Operations and Supply Chain Management

Joint Session

Session Chair

jiayuan Zhang, University of Rhode Island, kingston, RI

1 Embeddedness and Complexity of Nexus Supplier in Multitier Supply Chains from Information-communication Technology (ICT) Industry

Kara Li Liu, Koray Ozpolat, Seung Kyoon Shin, University of Rhode Island, Kingston, RI, Contact: karaliliu@uri.edu

Nexus supplier in multitier supply chains (MSCs) has drawn attention from industry due to disruptions and risk through the pandemic. It is challenging for firms to map extended supply chains, gain insights into current industry trends, and adapt to rapid changes in the business environment. Our study addresses recent issues related to ICT nexus supplier through its embeddedness and complexity in supply networks. Using the latent Dirichlet allocation (LDA) topic modeling approach and unstructured data of SEC filings, we demonstrate how to identify the emerging issues and investigate the effects of nexus supplier in MSCs for the ICT industry.

2 Using Social Media Data to Explore Supply Chain Vaccine Challenges

jiayuan Zhang, University of Rhode Island, kingston, RI

This study uses social media data to explore supply chain vaccine challenges. We find that product, production, allocation, distribution, and global procurement are the main supply chain challenges in the vaccination process. Actionable insights based on the findings are provided.

3 Learning when Reading: Evidence from an Online Mobile Reading Platform

Yuchen Liu, University of Washington, Seattle, WA

Online reading platforms offer a by-chapter purchase method and implement a novel in-chapter online review function. However, how such intervention would affect consumer purchase decisions remains to be uncovered. In this study, we build a structural model on the data from a leading China online reading platform to unveil the consumer learning process enabled by the by-chapter purchase method and the impact of in-chapter review content on consumer decisions. We found evidence that consumers learn the quality of different book genres at a different pace. In addition, our analysis reveals that the in-consumption reviews of different topics have heterogeneous effects on consumers' sequential purchase decisions. Meanwhile, the current reading spot of consumers out of the whole book and the informativeness of chapter names also affect consumer purchase intention.

4 Maximizing Propagation Times in Networks Using First Passage Times

Niloufar Daemi, Juan Sebastian Borrero, Baski Balasundaram, Oklahoma State University, Stillwater, OK

In a Markov chain, the minimum first passage times are defined as the first time the chain reaches a given state starting from some other state. In this work, we apply this concept in social network analysis where we define the minimum first passage time as the first time a user in a social network is exposed to a rumor or an offensive post. We propose an interdiction model where the goal is to interdict vertices to maximize the minimum first passage time. Interdicting a user decreases the probability of sharing the information with other users and results in longer first passage times. We formulate the problem as a mixed integer linear programming and solve it using decomposition algorithms.

Sunday, 5 PM–6:15 PM

SE73

M - Colorado

Emerging Topics in Service Operations

General Session

Session Chair

Jiding Zhang, 1</sup

1 Estimating The Effects of Online Food Delivery on Small-Business Restaurants During Covid-19 in California

Hailong Cui[1], Xin Tong[2], [1]University of Minnesota, Minneapolis, MN, [2]University of Southern California, Los Angeles, CA, Contact: hailongc@umn.edu

We use econometric methods to study the impact of online food delivery on small-business restaurants in California during COVID-19. To do this, we collect and analyze two types of data (proprietary data from a food distributor supplying to these restaurants and restaurant-level data via surveys and web-crawling).

2 Causal Bandits: Online Decision-making in Endogeneous Settings

Yifang Chen[1], Jingwen Zhang[1], Amandeep Singh[2], [1]University of Washington, Seattle, WA, [2]Wharton School, Philadelphia, PA, Contact: yifangc@cs.washington.edu

The deployment of multi-armed bandits has become commonplace in many marketing applications. However, regret guarantees for state-of-the-art linear bandit algorithms such as Optimism in the Face of Uncertainty Linear bandit (OFUL) make strong exogeneity assumptions wrt arm covariates. This assumption is very often violated in many economic contexts and using such algorithms can lead to biased decisions. In this paper, we consider the problem of online learning in linear stochastic multi-arm bandit problems with endogeneous covariates. We propose an algorithm we term \textit{BanditIV}, that uses instrumental variables to correct for this bias and prove strong regret guarantees for the algorithm. We carry out extensive Monte Carlo simulations to demonstrate the performance of our algorithm compared to other recently developed methods.

3 A Hybrid Machine Learning-optimization Framework to Distinguish Positive-agers from Cognitive-decliners using Resting-state Functional MRI Data

Mohammad Fili, Luning Bi, Guiping Hu, Iowa State University, Ames, IA

Classification models rely on the class labels to learn and estimate the boundaries between different classes. Sometimes the labels are not available, or the labeling procedure is complicated. In this study, we proposed a hybrid machine learning-optimization framework to optimally assign the class labels to the observations. The proposed algorithm incorporates the information from a separate dataset called shadow dataset to find the class labels. The algorithm utilizes Bayesian Optimization to optimize the decision variables pertinent to the labeling procedure.

Sunday, 5 PM–6:15 PM

SE74

M - Florida
Finance Student Paper Competition
Award Session

Session Chair
Wang Ruodu, University of Waterloo, Waterloo, ON, Canada.

Session Chair
Feinstein Zach, Stevens Institute of Technology, Hoboken, NJ

Session Chair
Cai Ning, Hong Kong University of Science and Technology, Kowloon, Hong Kong SAR, China.

1 Bitcoin Mining and Electricity Consumption
Ling Qin[1], Min Dai[2], Steven Kou[3], Shuaijie Qian[2], [1]The Hong Kong university of Science and Technology, Hong Kong, Hong Kong; [2]National University of Singapore, Singapore, Singapore; [3]Boston University, Boston, MA
We propose a dynamic industry equilibrium model for Bitcoin electricity consumption in a general framework, including Bitcoin miners' optimal entry and exit with technology innovation. Using average operating costs to approximate the true operating costs, we overcome the difficulty of strong path-dependency incurred by the interaction among entry, exit, and technology innovation. The model can capture the upside and downside co-movements of miners' computing power, electricity consumption, and mining revenue. Our model predicts that the Bitcoin electricity consumption will not grow indefinitely and the ratio of Bitcoin electricity consumption to the miners' revenue must fluctuate within a certain range.

2 Efficient Simulation of Polyhedral Expectations with Applications to Finance
Lewen Zheng[1], Dohyun Ahn[2], [1]The Chinese University of Hong Kong, Shatin, Hong Kong; [2]Chinese University of Hong Kong, Shatin, Hong Kong.
We consider the problem of estimating the expectation over a convex polyhedron specified by a set of linear inequalities. This problem encompasses a multitude of financial applications including systemic risk quantification, portfolio management, and exotic option pricing. We particularly focus on the case where the target event is rare, which corresponds to extreme systemic failures, large portfolio losses, and deep out-of-the-money options in the aforementioned applications, respectively. This rare-event setting renders the naive Monte Carlo method inefficient and requires variance reduction techniques. To address this issue, we develop a novel and strongly efficient method for the computation of the said expectation in a general rare-event setting by exploiting the geometry of the target polyhedron and concentrating the sampling density almost within the polyhedron. The proposed method significantly outperforms the existing approaches in various numerical experiments in terms of accuracy and computational burden.

3 Scalable Reinforcement-Learning Trading Framework with Dynamic Financial Data Embedding
Jinghai He, Cheng Hua, Zeyu Zheng, University of California, Berkeley, Berkeley, CA
We develop a scalable reinforcement learning (RL) framework for generic trading, where a trader wishes to maximize expected cumulative discounted returns by learning an effective policy to map her specified streaming financial data to trading orders. To handle the high dimensionality of financial data and its associated computational challenges, our proposed framework utilizes an embedding projection from the original space to a lower-dimensional embedding space. The algorithm employs a policy training procedure in the embedding space and dynamically adjusts the embedding projection by backpropogating the updated policy performance in an online meta-learning manner. Our algorithm is scalable due to embedding and dynamic embedding adjustment. We implement our framework to learn trading policies and backtest on stock index constituents (Standard & Poor's 500 Index and China Security Index 500). The learned trading policies obtain an annualized return of 50.72% when trading S&P 500 constituents, outperforming widely used benchmarks, including passive (23.94%) and active investment strategies such as mean-variance (21.24%) and reinforcement learning with raw state inputs (26.84%).

Sunday, 5 PM–6:15 PM

SE75

M - Illinois

Recent Advances in Asset Pricing and Market Microstructure

General Session

Session Chair

Scott Robertson, Boston University Questrom School of Business, Saint Louis

1 Activism Trading and Monge-Kantorovich Duality

Ibrahim Ekren[1], Eunjung Noh[2], Reda Chhaibi[3], [1]Florida State University, Tallahassee, FL, [2]Florida State University, Tallahassee, FL, [3]Université Toulouse Paul Sabatier, Toulouse, France.

Motivated by activism trading, we solve a generalized Kyle's model type problem using the theory of optimal transport and backward stochastic partial differential equations. Our problem can be recast into a terminal utility maximization problem with distributional constraints, and hence the theory of optimal transport between spaces of unequal dimension becomes a natural tool. The pricing rule is established using the structure of Monge-Kantorovich duality, and the optimal trading strategy is obtained by analyzing a backward version of the filtering problem from the market maker's point of view. In the special case of the classical Kyle's model, the optimal trading strategy we find is distinct from the classical bridge based construction.

2 Consistency of MLE for Partially Observed Diffusions, with Application in Market Microstructure Modeling

Sergey Nadtochiy, Illinois Institute of Technology, Chicago, IL

In this talk, I will present a tractable sufficient condition for the consistency of maximum likelihood estimators (MLEs) in partially observed diffusion models, stated explicitly via the stationary distribution of the fully observed system. This result is then applied to a model of market microstructure with latent (unobserved) price process, for which the estimation is performed using real market data for liquid NASDAQ stocks. In particular, we obtain an estimate of the price impact coefficient, as well as the micro-level volatility and the drift of the latent price process (the latter is responsible for the concavity of expected price impact of a large meta-order). Joint work with Y. Yin.

3 Rational Expectations Equilibrium with Heterogeneous Information Flows

Scott Robertson, Boston University Questrom School of Business, Saint Louis

In this talk, we consider equilibria in the presence of dynamically evolving asymmetric information. "Insiders" obtain private signals about the terminal value of an asset at intermediate times, and at each signal time, the "uninformed" agent receives a noisy version of the respective insider's signal. Both the filtration and asset price process jump at each signal time, and markets are in general incomplete. After establishing existence of a dynamic noisy rational expectations equilibrium for a finite set of signal times, we pass to the continuous time limit where the fundamental filtration is enlarged by a continuous signal flow process. Results are valid for constant absolute risk aversion investors, and where the factor process follows a multi-dimensional OU process. After presenting OU results, we will discuss extending to general factor processes.

Sunday, 5 PM–6:15 PM

SE76

M - Michigan

Human-machine Interactions

General Session

Session Chair

Song-Hee Kim, Seoul National University, Gwanak-gu, Korea, Republic of.

Session Chair

Jordan D. Tong, University of Wisconsin Madison, Madison, WI

1 Can Machines Learn to be Human? Can Humans Learn to Leverage Machines? Integrating Artificial Intelligence and Behavioral Science in Operations Management

Andrew M. Davis[1], Charles J. Corbett[2], Elena Katok[3], Shawn Mankad[1], [1]Cornell University, Ithaca, NY, [2]University of California-Los Angeles, Los Angeles, CA, [3]University of Texas at Dallas, Richardson, TX, Contact: adavis@cornell.edu

The use of Artificial Intelligence ("AI") in operations management research, focuses on how to utilize large amounts of data to improve predictions. These techniques offer a great deal of promise, but are not without drawbacks (e.g., fairness concerns). One remedy for addressing some of these drawbacks is to employ Behavioral Science methodologies. Conversely, Behavioral Science seeks to better understand how individuals make decisions in various environments. But, the availability of large data sets means that AI techniques can be used to understand behavior in certain settings which were previously intractable for Behavioral Science. In this article, we aim to explore how AI and Behavioral Science can be employed together to solve a wide range of problems within operations management.

2 Algorithmic Assistance with Recommendation Dependent Preferences

Bryce Mclaughlin, Jann Spiess, Stanford Graduate School of Business, Stanford, CA, Contact: brycem@stanford.edu

When algorithms provide recommendations, we typically think of them as information about which choices will lead to beneficial outcomes.But when a decision-maker obtains a recommendation, they may not only react to the information. The decision-maker may view the recommendation as a default action, making it costly for them to deviate, such as when a judge is reluctant to overrule a high-risk assessment or a doctor fears the consequences of deviating from recommended procedures. We consider the effect and design of recommendations when they affect choices not just by shifting beliefs, but also by imposing a cost on the decision-maker whenever they deviate from the recommended action.

3 The Impact of Forced Intervention on AI Adoption

Dennis Zhang[1], Xinyu Cao[2], [1]Washington University in St Louis, ST LOUIS, MO, [2]NYU, NYC, NY

This paper studies whether and how forced external interventions can catalyze long-term behavioral change, with a focus on the adoption of artificial intelligence (AI) technologies. Specifically, we investigate whether forcing people to use or not to use AI for a period of time can change their post-intervention AI usage, making use of a field experiment among salespeople in a major online education platform in China.

4 Improving Human-Algorithm Collaboration: Causes and Mitigation of Over- and Under-Adherence

Maya Balakrishnan[1], Kris Johnson Ferreira[2], Jordan D. Tong[3], [1]Harvard Business School, Boston, MA, [2]Harvard Business School, Boston, MA, [3]University of Wisconsin Madison, Madison, WI, Contact: mbalakrishnan@hbs.edu

Even if algorithms make better forecasts than human decision-makers (HDMs) on average, HDMs may have private information which the algorithm does not have access to that can improve algorithmic forecasts. How can we help HDMs effectively use and adjust algorithmic recommendations in such situations? We propose a mathematical model that captures how an HDM combines information they directly observe with an algorithmic prediction to make a final demand forecast. HDMs take a weighted average between their own forecast and the algorithm's where the weights depend only on aggregate relative historical performances. We validate our model with a lab experiment where participants make demand forecasts while having access to an algorithm's recommendations. In a follow up experiment, we design algorithmic transparency to help HDMs use private information more effectively.

Sunday, 5 PM–6:15 PM

SE77

M - Texas

Incorporating Consumer Preferences in Behavioral OM

General Session

Session Chair

Xiaoyang Long, University of Wisconsin-Madison, Madison, WI

1 Effects of Consumers' Context-dependent Preferences on Product Bundling

Qianbo Yin[1], Baojun Jiang[2], Sean Zhou[3], [1]Shanghai University of Finance and Economics, Shanghai, China; [2]Washington University in St. Louis, Saint Louis, MO, [3]Chinese University of Hong Kong, New Territories, Hong Kong. Contact: baojunjiang@wustl.edu

Bundling can change the consumers' choice set and affect their purchase decision. It is well-documented that consumers' preferences depend on the bundling context. This paper investigates the effects of consumers' context-dependent preferences on the firm's optimal bundling strategy in various competitive situations. We show that context-dependent preferences can change the firm's optimal bundling strategy.

2 Choice Overload with Search Cost and Anticipated Regret: Theoretical Framework and Field Evidence

Xiaoyang Long[1], Jiankun Sun[2], Hengchen Dai[3], Dennis

Zhang[4], [1]University of Wisconsin-Madison, Madison, WI, [2]Imperial College London, London, United Kingdom; [3]UCLA Anderson School of Management, Los Angeles, CA, [4]Washington University in St Louis, ST LOUIS, MO, Contact: xiaoyang.long@wisc.edu

An important but under-studied problem in the design of recommendation systems in online retail is how many products to offer in a recommendation set. In this work, we conduct a large-scale field experiment involving 1.6 million consumers on an online retail platform to causally examine how consumer behavior changes as the number of products in a recommendation set increases. Our field experiment results show that the consumers' likelihood of making a purchase first increase and then decrease as the number of options increases, thus providing evidence of the choice overload effect. Moreover, we find that a large proportion of the decrease in purchase rate can be attributed to a decrease in consumers' likelihood to start a search. We demonstrate that our empirical results are consistent with the predictions of a model that incorporates consumers' anticipated regret.

3 Consumer Attitudes on Corporate Workforce Diversity Disclosure

Jimin Nam[1], Maya Balakrishnan[2], Ryan Buell[3], [1]Harvard Business School, Boston, MA, [2]Harvard Business School, Boston, MA, [3]Harvard Business School, Boston, Contact: jnam@hbs.edu

Firms are facing increased pressure to take more action on diversity, equity, and inclusion (DEI). In this research, we examine how consumers perceive the strategic decision by firms to engage in the disclosure of diversity information regarding their workforce, more specifically the EEO-1 report. In terms of attitudes and perceived commitment to DEI initiatives, we find that there is no negative consequence for firms to disclose EEO-1 reports—even if that information reflects a non-diverse workforce. Furthermore, we find that consumers perceive firms with greater attitudes and perceive the firm to be more committed to DEI when the firm discloses their EEO-1 report as compared to when they learn that the firm chooses not to disclose. This result holds regardless of what that information reflects in terms of workforce diversity.

4 Pricing and Inventory Management when Consumers' Emotions Run High

Ozalp Ozer[1], Arun Kumar Rout[2], A. Serdar Simsek[3], [1]Amazon, Richardson, TX, [2]The University of Texas at Dallas, Richardson, TX, [3]University of Texas-Dallas, Richardson, TX

We derive demand distributions for a product for which consumers have uncertain valuation. Due to this uncertainty, consumers may experience disappointment-elation or regret-rejoice after their decision. Hence, we develop a novel consumers' choice model that accounts for the impact of anticipated disappointment-elation or regret-rejoice on consumer behavior. We show that the anticipation of disappointment-elation decreases product demand when consumers are disappointment averse. However, the anticipation of regret-rejoice has no impact on product demand even when consumers are regret averse. We also utilize these demand functions to characterize (both analytically and numerically) a firm's optimal pricing and inventory strategies for a product with uncertain consumer valuation.

Sunday, 5 PM–6:15 PM

SE78

M - Utah

Machine Learning and Online Platforms

General Session

Session Chair

Mochen Yang, University of Minnesota, Minneapolis, MN

1 The Effect of Peer-to-peer Tangible Donation on Donors and Receivers' Participation in Online Charity Platform

Sojung Yoon[1], Gauri Subramani[2], Mani R. Subramani[1], Mochen Yang[1], [1]University of Minnesota, Minneapolis, MN, [2]Lehigh University, Bethlehem, PA, Contact: yoon0180@umn.edu

Despite the prevalence of charity platforms, several problems remain to be addressed; Platforms that allow tangible donation are underexplored, the role of donation on engagement behavior of givers and receivers is not understood well, and receivers' behavior is undermined. In this research, we focus on a crowdfunding charity platform that facilitates peer-to-peer tangible donation and examine such donation on users' engagement in an online charity platform. We find that, after giving (receiving) donation, givers increase (receivers reduce) their engagement behavior by writing more (fewer) posts and comments than non-givers (non-receivers). Overall, our additional analyses ensure robustness of our findings and explore underlying mechanisms.

2 **Predicting Ad Recall Using Consumer Psychophysiological Data**

Ramin Zandvakili[1], William Hedgcock[2], Mochen Yang[3], Jason Chan[3], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, [3]University of Minnesota, Minneapolis, MN, Contact: zandv003@umn.edu

Psychophysiological measures are increasingly being used in both academia and commercially to assess consumer responses to marketing. However, little is known about the effectiveness of these tools to measure memory and recall compared to self-reported measures. In a study, we tracked psychophysiological signals from the eyes, face, and heart of each participant while they were watching movie trailers. In addition, we recorded their self-reported level of affective measures and their interest in the trailer, movie, and its genre. Using the data, we built machine learning models and compared the predictive power of psychophysiological and self-reported data for recalling trailers reported one week after the experiment. Our results show that psychophysiological signals significantly outperform self-reported data in predicting trailer recalls.

3 **Countering State-Sponsored Media Through Labeling: Evidence from Facebook**

Patricia Moravec, Nicholas Wolczynski, Avinash Collis, University of Texas at Austin, Austin, TX, Contact: nicholas@mccombs.utexas.edu

While attention has been turned toward disinformation, social media pages controlled by governments have been able to share information to encourage social media users toward beliefs without sharing content that may be clearly labeled as false. In an effort to combat the effect of foreign government persuasion attempts, Facebook debuted a 'state-controlled media' label in June 2020 in order to alert users that a post originates from a Page associated with the government of China, Iran, or Russia. We conduct an online randomized experiment to better understand the causal impact of these labels on intentions to engage with content on Facebook and augment our experiment by analyzing field data from Facebook. We find that labels are effective in reducing engagement on social media, but could be far more effective if Facebook clearly alerted users to the presence of the new label.

4 **User Profiling and Vulnerability Introduction Prediction in Social Coding Repositories: A Dynamic Graph Embedding Approach**

Agrim Sachdeva, Indiana University

Social coding repositories such as GitHub host open-source code that is mission-critical to the world's economy. Open-source code is especially vulnerable, and most vulnerabilities are introduced by human error. An important mitigation strategy is "shifting left" or preventing the introduction of vulnerabilities. One of the ways this can be achieved is targeted security strategy, such as conducting targeted security software development trainings. This requires the identification of high-risk actors, and prediction of the introduction of vulnerabilities. By adapting a continuous dynamic graph embedding approach and introducing a novelty that takes into account unique characteristics of vulnerability introduction, our proposed method can help predict of the introduction of the type and severity vulnerabilities in social coding repositories.

Sunday, 5 PM–6:15 PM

SE79

JWM - Room 201

Innovative Product Development and Production

General Session

Session Chair

Panos Kouvelis, Washington University in St. Louis, Clayton, MO

Session Chair

Iva Rashkova, Washington University-St Louis, St Louis, MO

1 **Evaluating the Environmental Impact of Government Subsidy on the Adoption of Resource Efficient Durable Products**

Haoying Sun[1], Stephen M. Gilbert[2], [1]University of Kentucky, Lexington, KY, [2]University of Texas-Austin, Austin, TX, Contact: haoying.sun@uky.edu

We use a durable goods framework to study how the government subsidy on energy-efficient products shifts demand and subsequently affects the manufacturer's incentive of investing in quality improvement measures. Then, we show how these changes in turn influence the total life cycle energy consumption.

2 **Crowdsourced Drug Discovery**

Brian Lee, Hui Zhao, Pennsylvania State University, University Park, PA

Crowdsourced drug discovery (CDD) platforms have emerged recently to fill the development void of commercially challenging drugs such as antibiotics by synthesizing compounds to test for their drug properties and effectiveness. Such platforms allow scientists to submit their designs for drug compounds and observe other scientists' ideas. The openness creates an opportunity for remixing (i.e., incorporating others' ideas into their designs), potentially improving the collective effort for drug discovery. This study aims to explore the relationship between the performance of crowdsourced drug discovery and remixing activities.

3 Behavioral Aspects in The Design of Procurement Auctions: The Capacity to Bid

Ivan Lugovoi[1], Jurgen Mihm[2], [1]KLU, Hamburg, Germany; [2]Insead, Fontainebleau, France. Contact: ivan.lugovoi@hec.edu

Practical experience and academic research have shown that the design of a tender may have a substantial impact on its outcome. A recent focus on behavioral biases has complemented our understanding of rational aspects in auction design. But while extant work has focused mainly on individual behavioral biases, we focus on organizational biases afflicting entire organizations. Particularly, we are interested in understanding how a buyer should consider the bidders "capacity to bid". We conduct an empirical investigation of large-scale tenders of pharmaceutical products performed by German health insurance companie in order to study which tender designs influence the number of participants. We thus hope to give tender designers practical advice based on rigorous analysis.

4 Drug Shortages and New Drug Approvals: An Empirical Investigation

Iva Rashkova[1], Panos Kouvelis[2], [1]Washington University-St Louis, St Louis, MO, [2]Washington University in St. Louis, Clayton, MO, Contact: irashkova@wustl.edu

We leverage a combination of publicly available data sources to study the link between new drug approvals and drug shortages. Specifically, we classify drug approvals by therapeutic class of the drug as well as by type - brand name, generic with or without market exclusivity. We observe that the event of a new drug shortage reported by the FDA is correlated with a subsequent drug approval for the same firm. Interestingly, the time lag between these events is increasing in the attractiveness of the drug approval's type. With the time lag identified based on the drug approval type, we also find a positive correlation between the time-to-recovery for an individual drug-shortage event and the associated drug approval. Our results potentially offer healthcare providers and policymakers insights into industry-wide capacity and resource allocation trends.

Sunday, 5 PM–6:15 PM

SE80

JWM - Room 202

Group Decision and Negotiation

General Session

Session Chair

Rodrigo Ulloa, Arizona State University, Tempe, AZ

1 Incorporating Agency into the Fair Allocation of Pennsylvania's Opioid Settlement Funds

Robert A. Newton[1], Paul Griffin[2], Qiushi Chen[2], [1]Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA

Recent settlements with opioid distributors and manufacturers differ from the 1998 settlement with "Big Tobacco" as the amount of funds received by a state from the opioid settlement is contingent upon substate entities (counties, municipalities) also dropping their lawsuits. A major critique of the 1998 tobacco settlement was how little of the settlement flowed to the substate level, driving a need for assurances from the states for more local distributions in order for substate entities to participate. Informed by the determination of a "fair allocation" in Pennsylvania, we present an optimization model with constraints for both fairness and participation, incorporating substate agency into the state allocation process.

2 An Experimental Study of Career Concerns in Groups

Chen Wei, Washington University in St.Louis, St Louis, MO, Contact: chen.wei@wustl.edu

Workers usually work in groups and may face trade-offs between working on their own tasks and supporting other group members. When workers have career concerns, their decisions may be driven by the desire to influence external perceptions of their abilities. This paper studies career concerns in groups using a laboratory experiment where workers can allocate effort between their own tasks and other group members' tasks. Under this framework, we first investigate how workers allocate effort when they have career concerns. Then, given these workers have career concerns, we study their decisions when their performance is measured aggregately (i.e., group performance) rather than separately.

Our experimental results are consistent with the theoretical predictions. We discuss implications for managers and firms that are trying to build supportive working environments.

Sunday, 5 PM–6:15 PM

SE81

JWM - Room 203
OR in Practice Flash Session
Flash Session

Session Chair
Stephen E. Garrett, Entos Consulting International, Dayton, OH

1 Ml Approximations of Operational Subproblems in Strategic Planning

Chun Ye, Zhikun Gao, Amazon.com, Seattle, WA, Contact: ychun@amazon.com

We consider a two-stage stochastic program used to capture last mile capital investment decisions for a large e-tailer. In the first stage, the decision on where to add incremental last mile delivery capacity for the e-tailer's internal carrier is made. Given the planned capacity and realized demand, the second stage problem decides how to optimally allocate packages between the internal carrier vs an external carrier in order to minimize variable cost. To mitigate problem scalability, we outline an approach to use ML to "summarize" the optimal second stage package allocation decisions as a function of different problem parameters that can be used as a surrogate model for first stage problem.

2 Fleet Planning with Demand Fluctuation, Reliability, Overhead, and Growth Considerations

Yaniv Mordecai, [1</sup]

The number of machines, vehicles, or servers that satisfies demand depends on more than the ratio between total demand and unit capacity. Service providing units (SPUs) exhibit partial reliability, availability, and autonomy. Demand fluctuates, projected growth is likely, and service level may be tracked. We present an algorithm to determine the minimal SPU fleet size that satisfies demand and guarantees the service level probability (SLP), under multiple realistic factors. The algorithm relies on the cumulative binomial distribution. We present the algorithm, its python-based implementation, and its application to delivery vehicle fleets and cloud servers. We discuss problem scales, demand peaks, and degraded performance options.

3 End-to-end Strategic Fulfillment Network Design at Wayfair

Ryo Kimura, Wayfair, Boston, MA, Contact: rkimura@wayfair.com

Wayfair's fulfillment network is one of our most important assets for enabling fast, reliable, and cost efficient deliveries across our vast catalog of home goods. However, its size and complexity makes it difficult to determine the end-to-end effects of various strategic investments to the network. We present a nonlinear multi-commodity network design approach to tackle this problem, and discuss some of the innovations we have made particularly related to modeling expected duration in the network which is critical to optimizing and scaling up Wayfair's outbound fulfillment capabilities.

4 An MINLP Model for the Optimal Management of Carbon Intensity Along Sustainable Supply Chains

Ignacio E. Grossmann[1], Demian Presser[2], Diego Cafaro[3], Pratik Misra[4], Sanjay Mehta[5], [1]Carnegie Mellon University, Pittsburgh, PA, [2]INTEC (UNL-CONICET), Santa Fe, Argentina; [3]INTEC(UNL-CONICET), Santa Fe, Argentina; [4]Air Products and Chemicals, Allentown, PA, [5]Air Products, Allentown, PA, Contact: grossmann@cmu.edu

Carbon intensity is an indicator of greenhouse gas emissions per unit of product processed, stored and transported along a supply chain. It represents a measure of carbon environmental impact. Supply chains must develop rigorous techniques to track carbon intensity and meet market regulations. We present an MINLP model for the optimal planning of production operations, overseas shipping and onshore transportation. We address the modeling and optimization of global supply chains under carbon intensity constraints. We assess the impacts of this indicator on the optimal solutions and how to optimally determine carbon intensity targets.

5 On the Philosophy of Management Science

Stephen E. Garrett, Entos Consulting International, Dayton, OH, Contact: garrettste@aol.com

One of the subdivisions of TIMS (a predecessor Institute to INFORMS) was the College on the Philosophy of Management Science. The College may no longer exist, but questions around the nature and practice of management science continue. These include the proper domain of management science, its methods of inquiry, the development of the discipline, and the training and preparation of management scientists. While some aspects of these issues are addressed in the natural pursuit of management science, there is no central focus to these efforts. This presentation will argue that INFORMS consider re-establishing a subdivision on the Philosophy of Management Science. It will also seek to remind the membership that Management Science gives INFORMS the last two letters of its name.

6 Empirical Analysis of What Improves the Careers of Heads of Procurement and Supply Chain Management

Thorsten Makowski, Skema, lille, France. Contact: thorsten.makowski@skema.edu

The aim of this paper is to identify which attributes help people working in procurement and supply chain management early and later in their career to be successful. For that the data of a global study with 1000+ participants, plus online available data from LinkedIn career profiles plus additional interviews of especially successful executives were analyzed. The study tries to answer whether a career is influenced by factors like age, transfer between different industry functions, changing frequency of employees etc. Also attributes like academic developments, language skills or certifications etc. are analyzed. Because of its empiric character the study is significantly restricted to an analysis of correlations between attributes and success, while it is based on the used methodology not possible to come to a certain causality.

Sunday, 5 PM–6:15 PM

SE82

JWM - Room 204

Minority Issues Forum (MIF) Paper Competition

General Session

Session Chair

Michelle M. Alvarado, University of Florida

1 Unveiling Hidden Energy Poverty Using the Energy Equity Gap

Destenie S. Nock[1], Shuchen Cong[2], Lucy Yueming Qiu[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Stanford, Contact: scong@andrew.cmu.edu

Income-based energy poverty metrics miss people's behavior patterns, particularly those who reduce their energy consumption to limit financial stress. Using a residential electricity consumption dataset, we determine the outdoor temperature at which households start using home cooling systems. We calculate the relative energy poverty within a region, defined as the energy equity gap. The energy equity gap between low and high-income groups ranges from 4.7°F to 7.5°F. In 2015-2016, out of 4,577 households, we found 86 energy-poor and 214 energy-insecure, meaning they are at risk of heat-related illness and death. Surprisingly, 83 of these households were missed by traditional income based measures of energy poverty.

2 Distributionally Robust Optimization Approaches for a Stochastic Mobile Facility Fleet Sizing, Routing, and Scheduling Problem

Karmel S. Shehadeh, Lehigh University, Bethlehem, PA

A mobile facility is a facility-like vehicle that can serve customers in manners similar to static facilities but can also move from one place to another to bring services closer to otherwise-underserved communities. In this paper, we propose two distributionally robust optimization (DRO) models for a mobile facility fleet-sizing, routing, and scheduling problem (MFRSP) with time-dependent and random demand, as well as computationally efficient methodologies for solving these models. We present extensive computational experiments comparing the operational and computational performance of the proposed models and a stochastic programming model, demonstrating when significant performance improvements could be gained and illustrating the potential for impact in practice.

3 Trying and Failing: Biases in Donor Aversion to Rejection

Kaitlin Daniels[1], Leon Valdes[2], [1]Washington University in St. Louis, Olin Business School, Saint Louis, MO, [2]University of Pittsburgh, Pittsburgh, PA

Non-profit organizations (NPOs) play a key role in advancing the UN Sustainable Development Goals. To achieve this, they rely on donations of physical goods - which are not always wanted or needed. We explore how donors respond to rejection using a controlled experiment: subjects choose whether to complete a task to generate a donation, which is accepted with a fixed (but unknown) probability. We measure donation decisions and beliefs about this probability and compare these measures against a for-profit condition where the subject, not an NPO, may benefit from the task. Our results identify a mechanism by which rejections affect donations: via a reduction in beliefs of future success. We also find evidence of self-serving bias: when high effort is needed, beliefs respond more negatively to rejection in the donation condition. We propose ways for NPOs to alleviate this bias.

Sunday, 5 PM–6:15 PM

SE83

JWM - Room 205
spORts II
General Session

Session Chair
Eli Olinick, Southern Methodist University, Dallas, TX

1 **Web Scraping Social Media Data as a Proxy for Player Popularity in European Football Leagues**
Nicholas F. Parham, Colorado School of Mines, Golden, CO
Social media data serves as a powerful proxy for an influential entity's popularity; however, social media indices are either unreliable or incomplete. By implementing various web scraping techniques in Python, a reliable and complete solution can be constructed. Using this, professional European football player and club popularity can be introduced into machine learning models aimed at predicting player market values.

2 **Predicting English Premier League Player Transfer Fees**
Garrett Miyaoka, Colorado School of Mines, Goulden, CO
During the 2021 summer transfer window, English Premier League teams signed 103 different players to 20 different teams at a total cost of $1.36 billion. We implement neural network regression to predict fair and expected transfer fees.

3 **Integer-linear Programs in Sports Applications**
Mark Husted, Colorado School of Mines, Golden, CO
Modern sports fans are in constant search for the latest and most accurate information about their favorite teams. By using mixed integer-linear programs with advanced solvers, such as CPLEX and Gurobi, complex season standings models are able to be solved. We present some of the logic and math on some of the more complicated instances posted on RIOTSports.net.

4 **Show Me the Money: Explaining MIP-Generated Magic Numbers**
Eli Olinick[1], Alexandra Newman[2], [1]Southern Methodist University, Dallas, TX, [2]Colorado School of Mines, Golden, CO
So-called magic numbers capture the attention of fans across a variety of professional sports, and provide information regarding when a team has clinched or been eliminated from a playoff spot, and, additionally, when a team has captured or lost the opportunity for a first-place final standing prior to post-season play. Mixed integer programming (MIP) models for determining magic numbers for a variety of professional sports have been proposed in the literature and implemented in practice. Often the proof that a magic number is correct relies on showing that a MIP model is infeasible. So, although fans enjoy tracking these numbers, most must take them on faith. We discuss strategies for and challenges of automating the process of justifying magic numbers to sports fans in plain English.

Sunday, 5 PM–6:15 PM

SE84

JWM - Room 206
Advances in Input Uncertainty
General Session

Session Chair
Sara Shashaani, North Carolina State University, Raleigh, NC

Session Chair
Kimia Vahdat, North Carolina State University, raleigh, NC

1 **Distributionally Robust Optimization for Input Model Uncertainty in Simulation-based Decision Making**
Soumyadip Ghosh[1], Mark S. Squillante[2], [1]IBM TJ Watson Research Center, Yorktown Heights, NY, [2]IBM Research, Yorktown Heights, NY, Contact: ghoshs@us.ibm.com
We consider a new approach to solve distributionally robust optimization formulations that address nonparametric input model uncertainty in simulation-based decision making problems. Our approach for the minimax formulations applies stochastic gradient descent to the outer minimization problem and efficiently estimates the gradient of the inner maximization problem through multi-level Monte Carlo randomization. Using theoretical results that shed light on why standard gradient estimators fail, we establish the optimal parametrization of the gradient estimators of our approach that trades off between computation time and statistical variance. We apply our approach to nonconvex portfolio choice modeling under cumulative prospect theory, where numerical experiments demonstrate the significant benefits of this approach over previous related work.

2 **Distributionally Robust Stratified Sampling for Stochastic Simulations with Time-varying Input Models**

Seung Min Baik[1], Eunshin Byon[2], Young Myoung Ko[1], [1]Pohang University of Science and Technology, Pohang, Korea, Republic of; [2]University of Michigan, Ann Arbor, MI, Contact: gshs27@postech.ac.kr

Our study proposes a robust version of the stratified sampling method under input uncertainty due to changes in the probability distribution over time. The conventional stratified sampling method induces a unique sampling strategy for a fixed input model. However, we often encounter situations where the nature of the input model, e.g., wind speed of a specific location or inter-arrival time of the customer, changes over time. Since we have a limited budget insufficient to run a simulation every time with a different input model, we need an efficient sampling strategy accounting for uncertainty caused by input model changes. We, therefore, propose a procedure for constructing and solving an optimization problem to minimize the worst-case estimator variance among uncertain future input models using the distributionally robust optimization framework.

3 Robust Machine Learning with Monte Carlo Methodology

Kimia Vahdat, Sara Shashaani, North Carolina State University, Raleigh, NC, Contact: kvahdat@ncsu.edu

Prediction error estimation in machine learning (ML) models has three prominent roles: estimating the model's performance on unseen data, optimizing for the best model hyper-parameters, and comparing multiple algorithms. The quality of an estimator is measured by its bias and variance. A correct variance estimate of the prediction error is crucial for accurate inference and comparison between models. Quantifying bias can also capture the sensitivity of the error estimator to the data on hand. This talk aims to estimate the prediction error of ML models using a novel sampling scheme that enables the user to quantify the bias and variance estimations correctly with non-parametric methods. We redefine the ML model as a Monte Carlo (MC) simulation model, utilizing established uncertainty quantification methods in the MC literature.

4 Resampling Stochastic Gradient Descent for Robust Inference

Zitong Wang, Henry Lam, Columbia University, New York, NY, Contact: zw2690@columbia.edu

Stochastic gradient descent (SGD) or stochastic approximation is widely used in model training and stochastic optimization thanks to its computational advantages and robustness. While there is a huge literature on analyzing its convergence, inference on the obtained solutions from SGD has only been recently studied, yet is of importance due to the growing need of uncertainty quantification. We propose a novel resampling-based method to construct confidence intervals for SGD solutions, by running multiple, but few, SGDs in parallel via resampling with replacement from the data. Our inference approach that allows minimal SGD runs, yet bypassing the intricate mixing conditions in existing batching-type methods, is built upon a new simple result on the asymptotic independence between resampled and original SGDs using a recently developed Berry-Esseen-type bound.

Sunday, 5 PM–6:15 PM

SE85

JWM - Room 207
JFIG Paper Competition I
Award Session

Session Chair
Frank E. Curtis, Lehigh University, Bethlehem, PA

Session Chair
Kuhn Daniel, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland.

1 Representing Random Utility Choice Models with Neural Networks

Ali Aouad[1], Ali Désir[2], [1]London Business School, London, United Kingdom; [2]INSEAD, Fontainebleau, France.

Motivated by the successes of deep learning, we propose a class of neural network-based discrete choice models, called RUMnets, which is inspired by the random utility maximization (RUM) framework. This model formulates the agents' random utility function using the sample average approximation (SAA) method. We show that RUMnets sharply approximate the class of RUM discrete choice models: any model derived from random utility maximization has choice probabilities that can be approximated arbitrarily closely by a RUMnet. Reciprocally, any RUMnet is consistent with the RUM principle. We derive an upper bound on the generalization error of RUMnets fitted on choice data, and gain theoretical insights on their ability to predict choices on new, unseen data depending on critical parameters of the dataset and architecture. By leveraging open-source libraries for neural networks, we find that RUMnets outperform other state-of-the-art choice modeling and machine learning methods by a significant margin on two real-world datas

2 A Decomposition Algorithm for Two-Stage Stochastic Programs with Nonconvex Recourse

Cui Ying, Hanyang Li, University of Minnesota, Minneapolis, MN

We consider a decomposition method for solving a class of nonconvex two-stage stochastic programs, where both the objective and constraints of the second-stage problem are nonlinearly parameterized by the first-stage variables. Due to the failure of the Clarke regularity of the resulting nonconvex recourse function, classical decomposition approaches such as Benders decomposition and (augmented) Lagrangian-based algorithms cannot be directly generalized to solve such models. By exploring an implicitly convex-concave structure of the recourse function, we introduce a novel decomposition framework based on the so-called partial Moreau envelope. The algorithm successively generates strongly convex quadratic approximations of the recourse function based on the solutions of the second-stage convex subproblems and adds them to the first-stage master problem. Convergence under both fixed scenarios and interior samplings is established. Numerical experiments are conducted to demonstrate the effectiveness of the proposed algorithm.

3 Adjustability in Linear Robust Optimization

Peter Zhang[1], Ningji Wei[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Texas Tech University, Lubbock, TX

We investigate the concept of adjustability - the difference in objective values between two types of dynamic robust optimization formulations: one where (static) decisions are made before uncertainty realization, and one where uncertainty is resolved before (adjustable) decisions. This difference reflects the value of information and decision timing in optimization under uncertainty, and is related to several other concepts such as interchangeability in games and optimality of decision rules in robust optimization. We develop a theoretical framework to quantify adjustability based on the input data of a robust optimization problem with linear objective, linear constraints, and fixed recourse. We make very few additional assumptions. In particular, we do not assume constraintwise separability or parameter nonnegativity that are commonly imposed in the literature for the study of adjustability. This allows us to study important but previously underinvestigated problems, such as formulations with equality constraints and problems with both upper and lower bound constraints. Based on the discovery of an interesting connection between the reformulations of the static and fully adjustable problems, our analysis gives a necessary and sufficient condition - in the form of a theorem-of-the-alternatives - for adjustability to be zero when the uncertainty set is polyhedral. Based on this sharp characterization, we provide a mixed-integer optimization formulation as a certificate of zero adjustability. Then, we develop a constructive approach to quantify adjustability when the uncertainty set is general, which results in an efficient and tight algorithm to bound adjustability. We demonstrate the efficiency and tightness via both theoretical and numerical analyses.

Sunday, 5 PM–6:15 PM

SE86

JWM - Room 208

Airport Planning and Operations

General Session

Session Chair

Nuno Antunes Ribeiro, Singapore University of Technology and Design, Singapore, Singapore.

1 Strategic Model to Optimize Terminal Airspace Operations

Wayne Ng, Nuno Ribeiro, Singapore University of Technology and Design, Singapore, Singapore. Contact: wayne_ng@mymail.sutd.edu.sg

The Terminal Maneuvering Area (TMA) of congested airports are a critical region to be managed effectively, as they are a key bottleneck of the air traffic management system. This research aims to help air traffic managers evaluate different airspace design and planning scenarios through an optimization modeling approach. We combine linear programming optimization and metaheuristic approaches to develop an efficient modelling approach to solve the TMA optimization problem. The model optimizes decisions related to runway sequencing, aircraft speeds, and utilization of holding stacks and vectoring to minimize air traffic delays.

2 Bottleneck Analysis of Pre-Pandemic ASEAN Commercial Air Traffic Network

Peter Jackson, Benjamin Tan, Gengling Dai, Singapore University of Technology and Design, Singapore, Singapore. Contact: peter_jackson@sutd.edu.sg

In anticipation of a return to pre-COVID-19 traffic levels, we report on the anticipated sensitivity of network-wide air traffic delays to isolated service interruptions at perceived bottlenecks in the ASEAN (plus Hong Kong, China) air traffic network. We focus on six airports (SIN, KUL, HKG, CGK, BKK, MNL) and four routes (L644+M722, G579+B470, M758, L642+M771) and explore the impact of a temporary service interruption at peak times at or along each of these capacity constrained components. We employ an optimization-based air traffic flow management model with the objective of both minimizing fight arrival delays and maximizing the success rate of passenger hub connections by delaying, rerouting, and/or cancelling fights at the aircraft trajectory level.

3 Airport Slot Allocation with Social Considerations

Suresh Kumar Jakhar, Indian Institute of Management Lucknow, Lucknow, India. Contact: skj@iiml.ac.in

We propose a mechanism to allocate slots at congested airports. Our slot allocation mechanism satisfies the following goals: (a) It incorporates the valuations of the slots by the airlines, (b) It provides opportunities for the flights connecting remote cities to the congested airport, and (c) It incorporates congestion cost and controls the number of allocated slots to minimize congestion. The allocation function provides the resulting slot allocations, and the payment function provides the payments to be made by each flight movement as a function of slot valuations, congestion level, and city-type connected.

4 A Modelling Approach to Optimize Airport Scheduling Limits in Airport Demand Management

Xie Peining[1], Nuno Antunes Ribeiro[1], Sebastian Birolini[2], [1]Singapore University of Technology and Design, Singapore, Singapore; [2]University of Bergamo, Dalmine (BG), Italy. Contact: nuno_ribeiro@sutd.edu.sg

In today's overcrowded aviation industry, congestion mitigation is a key priority as it allows to implement smooth and regular air traffic operations. Airport demand management mechanisms aim to mitigate air traffic congestion by restricting the imbalances between demand and capacity through scheduling limits. This research proposes an optimization modeling approach to examine typical airport demand patterns and estimate optimal scheduling limits that approximate the Pareto-frontier of three conflicting objectives: slot rejections, slot displacement and expected flight delays.

Sunday, 5 PM–6:15 PM

SE87

JWM - Room 209

MCGDM: MultiCriteria Group Decision Making Models

General Session

Session Chair

Danielle C. Costa Morais, Universidade Federal de Pernambuco - UFPE, Recife - PE, Brazil.

Session Chair

Adiel Teixeira De Almeida, Universidade Federal de Pernambuco, Recife PE, Brazil.

1 Divide and Conquer? Experimental Evidence from Interdependent Operational Tasks

Yun Shin Lee[1], YoungSoo Park[1], Enno Siemsen[2], [1]Korea Advanced Institute of Science and Technology, Seoul, Korea, Republic of; [2]University of Wisconsin-Madison, Madison, WI

We examine when and how task division improves operational performance when sub-tasks are highly interdependent. Specifically, we divide the newsvendor ordering task into two interdependent sub-tasks: preparing a forecast and setting a service level. Using a behavioral experiment, we demonstrate that the level of cognitive burden is a moderator for the relationship between task division and performance. The effect of task division on performance is greater when the cognitive burden is high; performance improves through a reduction in random judgment errors in the final decision through more effective synchronization between sub-tasks. Specifically, under task division, we observe counteracting behavior, which describes an individual's tendency to make decisions that can counteract their partner's mistake.

2 Supporting The Expansion Program of An Educational Institute in Brazil: Ranking States with The Fitradeoff Method

Eduarda Asfora Frej, Pedro Henrique Albuquerque, Universidade Federal de Pernambuco, Recife, Brazil. Contact: eafrej@cdsid.org.br

This work addresses a multicriteria group decision problem of ranking states in Brazil in order to support the expansion program of an education institute in the country. The FITradeoff multicriteria method is applied to conduct the elicitation with the decision makers. The combination of two preference modeling paradigms - elicitation by decomposition and holistic evaluation - is explored in a flexible way. Throughout this application, it is possible to analyze several benefits that the combination of these two preference modeling types can bring improvements to the decision process, including the possibility of shortening the elicitation process. Insights on how to deal with group decision making problems with the new features of the FITradeoff method are also presented.

3 Group Decision Model to Reduce Unauthorized Water Consumption

Ana Clara Cachina Saraiva[1], Danielle Costa Morais[1], PASCALE ZARATE[2], [1]Universidade Federal de Pernambuco, Recife, Brazil; [2]University Toulouse Capitole 1 - IRIT, TOULOUSE, France. Contact: anaclaracsaraiva@gmail.com

Unauthorized Water Consumption (UWC) is the misuse of water by theft or clandestineness. It reflects a system with technical, economic, social, and environmental problems that significantly impact society and need quick solutions for its combat. A Group Decision Support Model to evaluate alternatives developed to combat UWC becomes necessary. FITradeoff is highly appreciated, and with a voting procedure, the individual rankings obtained in FITradeoff can be condensed into a single result. This article presents a case study applied to a concessionaire in Brazil; 3 Decision-Makers evaluated 34 alternatives. Borda Count aggregated the 3 rankings to obtain a representative result for all. As a result, a final ranking was obtained to assist the concessionaire in the fight against UWC, taking into account the achievement of social, environmental, and economic benefits.

4 Secure Group Decision-Making in AHP

Konrad Kulakowski, Jacek Szybowski, Sebastian Ernst, AGH University of Science and Technology, Krakow, Poland. Contact: konrad@kulakowski.org

At the core of the Analytic Hierarchy Process (AHP) is a common belief that experts are honest, that is, that their opinions reflect theirinner views. But unfortunately, this may not always be true.Hence, like sometimes voters during elections, people involved in decision-making may try to manipulate the ranking result. For example, they may evaluate alternatives strategically to strengthen their preferred candidate and weaken another. In the presented paper, we propose heuristics that can help identify potentially dishonest experts. We also show how these heuristics can be used to aggregate results in group decision-making using the AHP.

Monday, 8AM–9:15AM

MA01

CC - Room 101

Statistical Foundation of Streaming Data Analysis

General Session

Session Chair

Ruizhi Zhang, University of Georgia, Athens, GA

Session Chair

Yajun Mei, ISyE Georgia Tech, Atlanta, GA

1 Asymptotically Optimal Sequential Multiple Testing

Jay Bartroff, University of Texas at Austin, Austin, TX, Contact: bartroff@austin.utexas.edu

I will discuss asymptotically optimal multiple testing procedures for sequential data for controlling FDR/FNR and other metrics. For FDR/FNR and related metrics, the procedures are closely related to those proposed and shown by Song & Fellouris (2017, Electron. J. Statist.) to be asymptotically optimal for controlling type 1 and 2 familywise error rates (FWEs). By appropriately adjusting the critical values of the Song-Fellouris procedures, they can be made asymptotically optimal for controlling any error metric that is bounded between multiples of FWE in a certain sense. Not fitting into this category are the generalized error metrics gamma-FDP and k-FWER, and more complex procedures can be constructed that are asymptotically optimal for these metrics. Our analysis includes regimes in which the number of null hypotheses approaches infinity.

2 Active Sequential Change-point Detection Under Sampling Control

Yajun Mei, ISyE Georgia Tech, Atlanta, GA

Active sequential change-point detection problem occurs in many real-world problems such smart manufacturing or biosurveillance when one monitors multi-dimensional data streams under the sampling control due to limited capacity in data acquisition, transmission or processing. In such a scenario, one needs decide how to smartly observe which local components or features at each and every time, and then uses the observed data to quickly raise an alarm once a change has occurred subject to the false alarm constraint. In this talk, we develop efficient active change-point detection algorithms through bandit sampling policies. Numerical simulations and case studies will be presented to demonstrate the usefulness of our proposed algorithms, and future potential research directions will also be discussed.

3 Sequential Change Diagnosis

Austin Warner[1], Georgios Fellouris[2], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, Contact: fellouri@illinois.edu

We will discuss the problem of sequential change diagnosis, where the goal is to detect a change in a monitored process and to accurately identify the type of the change, while controlling the false alarm rate. We will highlight a drawback of many methods in the literature: the implicit, heavy use of pre-change data in order to determine the post-change regime. Moreover, we will propose a recursive algorithm that resolves this issue without the use of tuning parameters and without sacrificing the worst-case delay in detection.

4 Quickest Detection of The Change of Community Via Stochastic Block Models

Ruizhi Zhang, University of Georgia, Athens, GA

Community detection is a fundamental problem in network analysis and has important applications. In many cases, the community structure of the network may change at some unknown time and thus it is desirable to come up with efficient monitoring procedures that can detect the change as quickly as possible. In this work, we use the Erd\H{o}s-R\'{e}nyi model and the bisection stochastic block model (SBM) to model the pre-change and post-change distributions of the network, respectively. We then propose an efficient monitoring procedure by using the number of k-cycles in the graph. The asymptotic detection properties of our proposed procedure are derived when all parameters are known. A generalized likelihood ratio (GLR) type detection procedure and an adaptive CUSUM type detection procedure are constructed to address the problem when parameters are unknown.

Monday, 8AM–9:15AM

MA03

CC - Room 103

Domain-driven Big Data Predictive Analytics

General Session

Session Chair

Xingwei Yang, Queen's University, Toronto, ON, Canada.

Session Chair

Mehdi Kargar, Ryerson University, Toronto, ON, Canada.

Session Chair

Morteza Zihayat, Ryerson University, Toronto, ON, Canada.

1 Representations of Songs and Artists from Audio Features & Consumption Patterns for Modeling Music Demand

Julien De Mori, Guannan Zhao, Paul Beata, Arash Haddadan, Kevin Liu, Philip Watson, Kobi Abayomi, Warner Music Group, New York, NY

Forecasting listener demand for music, in particular streaming demand, requires understanding of demand patterns for similar music. Music listening has shifted to nearly completely digital: this generates a wealth of data on user streaming patterns. We can further extract insights from measurable audio characteristics of musical content. This yields a contextual and flexible notion of similarity, without depending on pre-defined categorical labels such as genres or demographics but augmented by listener demand preferences. We present various approaches to modeling song and artist representations for music similarity estimation, and evaluate them on relevant downstream tasks, including demand forecasting.

2 Temporal Peak-managing and Clustering for Continual Learning from Manufacturing Data

Minseok Han, Jong-Seok Lee, Sungkyunkwan University, Suwon, Korea, Republic of. Contact: sasack3218@skku.edu

Process data collected from manufacturing sites generally varies with time due to environmental changes such as facility maintenance and equipment aging. A predictive model accordingly tends to perform worse as time goes apart from its learning timepoint. To ensure the long-term validity of a prediction model, re-learning strategy has emerged as a critical issue in manufacturing analytics. This research proposes a continual learning framework that tracks temporal changes of data and incorporates those into re-learning decisions. The proposed method trains several local prediction models based on a temporal clustering system. By detecting structural changes over time for each cluster, it determines in real time whether the corresponding model requires re-learning. The effectiveness of the proposed method is demonstrated based on real manufacturing data.

3 SMRT: A Structural Model of Latent Ratings and Topics in Text

Desheng Ma[1], Shawn Mankad[2], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, Contact: dm852@cornell.edu

We propose a structural model of latent ratings and topics (SMRT), a data driven statistical approach that incorporates ratings, the review text, and review-specific covariates. Specifically, we construct a hierarchical mixed membership model to infer topics and latent topic ratings from reviews by parameterizing the topics, their prevalence, and their contribution to the overall rating with a generalized linear model on document-level covariates. Our empirical study on Yelp online reviews during 2020 provides evidence that the lockdowns and reopening are significantly associated with the discussion and sentiment around the topics of responsiveness and wait time: key service quality metrics of managerial significance, which highlights how SMRT can extract meaningful insights and help answer business questions from user-generated data on digital platforms.

Monday, 8AM–9:15AM

MA04

CC - Room 104
Applied Data Mining
General Session

Session Chair
Zahra Sedighi-Maman, 1</sup

1 An Optimization-based Learning for Decision Making in Mechanical Ventilation Management

Maryam Alimohammadi, Shengfan Zhang, University of Arkansas, Fayetteville, AR

Learning and decision-making using electronic health records are challenging due to the complex temporal data's heterogeneity, noisiness, and irregularity. We proposed a framework to find the optimal time window sizes to reduce the missingness and noisiness of data. By aggregating data and using descriptive statistics over the optimal time windows, we show improvement in performance for mechanical ventilation outcome prediction in ICU, in comparison to the traditional classification methods. Additionally, the time to stop mechanical ventilation in ICU is a critical decision to ensure intervention success while considering resource utilization. We demonstrate how the improved prediction of ventilation outcome before the start of ventilation or at the beginning of the ventilation can facilitate decision-making on weaning from mechanical ventilation in the ICU.

2 An Interpretable Two-stage Modeling Approach for Lung Cancer Survivability Prediction

Zahra Sedighi Maman[1], Jonathan Heath[2], [1]Adelphi University, Garden City, NY, [2]Georgetown University, Washington, DC

We propose a two-stage data analytic framework that is capable of classifying survival status for 0.5-, 1-,1.5-, 2-, 2.5- and 3-year time-points (Stage I) and predicting the number of survival months within 3-years(Stage II) using recent SEER data from 2010 to 2017. By implementing a comprehensive data preparation phase, we demonstrate that a statistical and interpretable approach like GLM performs comparable to more complex models at a considerably lower computational cost. We quantify/visualize the effect of individual features on survival status using the Odds Ratio in Stage I and the effect of individual features on survival length using coefficient values in Stage II. Our proposed two-stage approach, which exploits GLM, may assist physicians in their decision-making process by prioritizing the most important factors related to lung cancer survivability.

3 Distributionally Robust Dataset Selection for Learning Models

Utku Tarik Bilgic[1], Bo Zeng[2], Xiaoning Qian[3], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, [3]Texas A&M University, Pittsburgh, PA, Contact: utb3@pitt.edu

While training a model, there may be insignificant points in the dataset. Also, the dataset can contain outliers and/or noisy points, which may lead to poor training. In this study, we present our distributionally robust dataset selection model for training regression (and classification) models. We unveil the relation of these robust models with machine learning models and present new interpretations. We developed an efficient online learning algorithm with theoretical guarantees for large datasets. Numerical results will be presented to demonstrate the performance of our proposed models and online algorithm.

Monday, 8AM–9:15AM

MA05

CC - Room 105
Advances in Learning Algorithms in Application
General Session

Session Chair
Timothy Keaton, Purdue University, West Lafayette

1 Non-Dominated Sequential Experimental Designs

Peter Norwood, North Carolina State University

Many online learning problems seek to optimize reward and information gain simultaneously. We can estimate the reward and information gain associated with each action at each decision point. We propose a sampling method that only considers actions that maximize some convex combination of these two -- the non-dominated set of actions. By defining information gain with optimal experimental design criteria, we can sample from only the non-dominated set while maintaining consistency and asymptotic normality. Extensive simulation experiments show bandit algorithms run on only the non-dominated set perform favorably compared to their unrestricted counterparts.

2 **Randomization Tests for Adaptively Collected Data**

Yash Nair, Lucas Janson, Harvard University, Cambridge, MA, Contact: yashnair@college.harvard.edu

Randomization testing enables a range of inferential tasks, such as testing independence of random variables and constructing conformal prediction intervals, but its use is generally restricted to exchangeable data. Yet in many applications, data is collected adaptively, e.g., via a bandit algorithm. We present a general framework for randomization testing on adaptively collected data, encompassing the few existing results in this area as well as many other important settings. The key to our framework is the ability to resample the data and compute likelihood ratios between the resampled data and the original data based purely on the known adaptive assignment algorithm. We present novel resampling algorithms for a range of popular adaptive assignment algorithms and data-generating environments, and demonstrate our framework's power and efficiency via simulations.

3 **Bandits with Priors**

Timothy Keaton, Arman Sabbaghi, Purdue University, West Lafayette, IN, Contact: keatont@purdue.edu

Bayesian Multi-Armed Bandit (MAB) algorithms, most prominently Thompson sampling, are effective at sequentially assigning treatments to experimental units to identify the best treatment(s) while controlling the regret, or opportunity cost, of exploration. However, they have traditionally been viewed as less flexible than existing non-Bayesian MAB algorithms due to their supposed lack of design in terms of tuning parameters. We demonstrate via simulation studies that the prior distribution in a Bayesian MAB algorithm does indeed serve an important role as a tuning parameter, affecting both the expected regret and the algorithm replication variance of regret obtained from Thompson sampling. Ultimately, our consideration of Bayesian prior specifications can help researchers design MAB algorithms with different and desirable properties.

Monday, 8AM–9:15AM

MA06

CC - Room 106

Innovations in Data Mining Education

Panel Session

Session Chair

Jacqueline Johnson, SAS Institute, Raleigh, NC

1 **Innovations in Data Mining Education**

Jacqueline Johnson, SAS Institute, Cary, NC

Presenters will share unique methods for utilizing analytics software and engaging students through projects and gamification. We will explore a course at Purdue University that teaches data mining with student projects and culminates in students receiving feedback about how their analytics process answered business objectives. We will also consider Enterprise Systems, at the University of Arkansas, an environment built through industry partnerships equipped with industry solutions and real-word data. Last, we will describe Cortex, an analytics simulation game from HEC Montreal. Students compete to fit the best model to predict fundraising and learn predictive modeling techniques!

2 **Panelist**

Jean-Francois Plante, HEC Montreal, Montreal, QC, Canada.

3 **Panelist**

Matthew A. Lanham, Purdue University, Lafayette, IN

4 **Panelist**

Ronald Freeze, University of Arkansas, AR

Monday, 8AM–9:15AM

MA08

CC - Room 108

Deep Learning/Machine Learning I

Contributed Session

Session Chair

Yuliia Lut, Columbia University/LinkedIn, New York, NY

1 **Mitigating The Bias of Data Collection Used in Machine Learning Through Instances**

Aida Khosh Raftar Nouri, Memorial University of Newfoundland, St Johns, NL, Canada. Contact: akhoshraftar@mun.ca

An important challenge in machine learning is *bias* in data - wherein states represented in a dataset are distorted with respect to the real world state data. Biased data used to train machine learning models can result in compromised decisions for organizations, and society. This research will examine the proposition that a source of bias in data is *class-based data collection (CBDC)*, in which data about entities is collected on the assumption that these entities will be assigned to predetermined CBDC collect specific attributes of entities relevant to a certain classification of those entities, resulting in an unrepresentative data. I propose that an instance-based data collection (IBDC) model provides a detailed representation of the data that mitigate bias. An experiment will be performed using both a CBDC and proposed IBDC to measure level of bias and ML performance.

2 Gnss Data Analysis, Positioning, and Attitude Determination Using Neural Networks

Raul de Celis, Luis Cadarso, Rey Juan Carlos University, Fuenlabrada, Spain. Contact: raul.decelis@urjc.es

Position and attitude measurements are intimately connected to accurate navigation and control of aerial Vehicles. By monitoring two vectors in two different reference frameworks, such as the inertial and body reference frames, the rotation of an aircraft can be approximated. With a GNSS sensor-based matrix with at least three sensors and calculating their position to fix these pairs of vectors may be done using GNSS carrier phase measurements only resolving carrier phase ambiguity. Multipath, frequent lock loss, cycle slips, and significant clock drifts make precise integer ambiguity resolution difficult, especially with low-cost GNSS receivers. This innovative neural network-based technique improve the reliability of carrier phase ambiguity resolution and optimize the management of large amounts of data.

3 Dynamic Object Detection with Labeling Images Applying Domain Knowledge

Donghwan Shin[1], Taesu Cheong[1], Jangmook Kang[2], [1]School of Industrial Management Engineering, Korea University, Seoul, Korea, Republic of; [2]Department of Hacking & Security, Far East University, Eumseong-gun, Chungcheongbuk-do,, Korea, Republic of. Contact: ppuya1212@korea.ac.kr

A wildfire is an unpredicted fire that occurs in wildlands such as forests, or grasslands. Due to climate change, and an increase in the population living in proximity to high wildfire hazard areas, wildfires have become increasingly destructive in recent years. It could destroy not only an ecosystem but also human life. In related research, optical flow and pattern-based algorithms or convolution neural network-based models are used for fire detection. Our research focuses on fire, smoke, and smog data which is applied to a detection system that is embeddable into a security camera. We show the importance of deep learning models such as YOLOv5 or EfficientDet for fast and accurate dynamic object detection.

4 Differentially Private Synthetic Minority Oversampling Technique

Yuliia Lut[1], Ethan Z. Turok[2], Rachel Cummings[1], [1]Columbia University, New York, NY, [2]Columbia University, New York, NY, Contact: yl4737@columbia.edu

The problem of learning from imbalance datasets, in which the classes are not equally represented, arises often in practice. A widely used method to combat imbalanced learning is resampling from the minority class. However, when confidential or sensitive attributes are present, data replication can lead to privacy leakage that has a disproportionally larger effect on the minority class. Therefore, privacy-preserving preprocessing techniques are needed. Differential privacy has been a powerful tool for machine learning models when the training data is sensitive. In this work, we present a differentially private synthetic minority oversampling technique (DP-SMOTE). Our algorithm guarantees privacy to the minority samples as the minority class is often more sensitive. We demonstrate how our preprocessing technique decreases privacy leakage in a empirical study.

Monday, 8AM–9:15AM

MA09

CC - Room 109
FinTech
Contributed Session

Session Chair

Wei-Ting Chen, National Chi-Nan University, Nantou, Australia.

1 Analysis of Rare Events Using Multidimensional Liquidity Measures Based on High-frequency Trade and Quote (taq) and Limit Order Book (lob) Market Data

Margarita Zaika, Dragos Bozdog, Ionut Florescu, Stevens Institute of Technology, Hoboken, NJ, Contact: dbozdog@stevens.edu

In this work, we develop methodologies for detection and analysis of rare events in high-frequency financial data. Multidimensional liquidity measures based on Trade and Quote (TAQ) and Limit Order Book (LOB) are investigated, analyzed, and transformed though dimensionality reduction techniques. Several methods for rare events detection are applied to the liquidity measures dataset such as Isolation Forest, Local Outlier Factor and Mahalanobis Distance and they are compared based on their relative performance. The rare events methodology is reviewed and compared based on trading data during the beginning of COVID-19 outbreak. A new intensity measure is introduced to assess the occurrence of the rare events clusters.

2 High-frequency Liquidity in The Chinese Stock Market: Measurements, Patterns, and Determinants

Ruixun Zhang[1], Chaoyi Zhao[1], Yufan Chen[1], Lintong Wu[1], Yuehao Dai[1], Ermo Chen[1], Zhiwei Yao[1], Yihao Zhou[1], Lan Wu[2], [1]Peking University, Beijing, China; [2]Peking University, BEIJING, China.

We explore a broad range of high-frequency liquidity measures for the Chinese stock market, based on a comprehensive tick-level dataset for stocks with approximately 16.7 billion events in 2020. We summarize their liquidity levels and key distributional properties. Order interarrival times follow Weibull distributions, implying that Poisson flow is not an appropriate model for order flow in the Chinese stock market. We conduct extensive analysis for the intraday and cross-sectional patterns of liquidity. In particular, spectral analysis reveals novel intraday periodicities in liquidity at whole-minute frequencies. Finally, we propose the *aggressive-passive imbalance* analogous to the order flow imbalance, and develop an order-based model of the change in bid-ask spread that sheds light on the universal mechanism of spread formation with respect to order flows.

3 A Continue Bubble Detection Mechanism for Cryptocurrencies

Jing-Rung Yu[1], Wei-Ting Chen[1], WenYi Lee[2], [1]National Chi-Nan University, Nantou, Taiwan; [2]National Taipei University of Business, Taipei City, Taiwan.

Cryptocurrency market uncertainty is a significant factor causing the price bubbles in the NFT and Defi markets. We develop an early digital financial bubble detection mechanism for cryptocurrencies and provide real-time monitoring of fluctuations of cryptocurrencies using the method developed by Phillips and Shi. We have examined a period from 2017 to the first quarter of 2022, which includes the rise of the COVID-19 pandemic, the Ukraine-Russian war, and the US rate rise.

Monday, 8AM–9:15AM

MA10

CC - Room 110
Artificial Intelligence
Contributed Session

Session Chair
Sarvesh Sundaram, Northeastern University

1 Psychological Reactions to Artificial Intelligence in The Workplace: A State-of-the-art Review

Yuan Cheng, Renmin University of China, Beijing, China.

With the growing prevalence of artificial intelligence (AI) in the workplace, more and more scholars and practitioners have shown interest in understanding how employees react to AI. However, despite the increasingly prominent of research, scholars from a wide array of disciplines have utilized a wide range of theoretical and methodological perspectives, resulting in fragmented and disconnected literature. What we need is a synthesis of existing research to gain a more comprehensive and holistic view of the field. This study provides an integrative review and synthesis by organizing the literature into several dominant themes. For each theme, this study summarizes and discusses the theoretical arguments, research methods, and major findings. Finally, this study proposes promising theoretical and methodological opportunities for future research.

2 Prediction of Tool Wear Based on Machine Learning Methods for Cutting Process

koo ho-geun[1], Soomin Lee[1], Wonkeun Jo[1], hyein kim[2], Jeongin Koo[3], Juheon Kwak[1], Dongil Kim[1], [1]Chungnam National University, Daejeon, Korea, Republic of; [2]Korea Institute of Industrial Technology, Cheonan-si, Korea, Republic of; [3]Korea Institute of Industrial Technology, Cheonan, Korea, Republic of.

Predicting tool wear in cutting processes is important. As the cutting process progresses, the tool wear increases; it affects the product quality. Since the actual measurement of the tool wear during cutting process is expensive, another approach to predict the tool wear is required. We predict the tool wear by using time-series data collected from sensors during the cutting process and cutting force predicted through a neural network. Features are extracted from the collected time series data and predicted cutting force data. Then a subset of feature that has a high correlation with tool wear is selected. We employed various machine learning models to predict the tool wear with the selected features. Experimental results involving a real-world cutting process data showed that the proposed method showed an excellent performance.

3 Generalist Agentive Ai and The Power of Multimodal Foundation Models

Ross Gruetzemacher, Wichita State University, Wichita, KS, Contact: ross.gruetzemacher@wichita.edu

Language models have taken the world of natural language processing by storm over the past few years. Powered by the transformer architecture, these simple foundation models are capable of very impressive feats such as programming and domain-specific reasoning. However, foundation models are not limited to language, and multimodal foundation models—trained on different types of data, such as images and text—are poised to have a tremendous impact on all aspects of business and society. For example, earlier this year Google's DeepMind demonstrated the first generalist agentive AI, Gato. This presentation will discuss these recent advances and their implications for industry over the remainder of the decade.

4 Smart Prognostics and Health Management: A Smart Manufacturing Framework Enabled by Artificial Intelligence and Digital Twins

Sarvesh Sundaram, Northeastern University, Boston, MA, Contact: sundaram.s@northeastern.edu

The manufacturing shop-floor is undergoing a rapid transformation with of Internet of Things (IoT) capable wireless sensors and field devices that generate large volumes of data. Prognostics and Health Management (PHM) deals with monitoring of system health and maintenance activities of shop-floor devices. Component level prognostics at large manufacturing facilities can be complex due to the heterogeneity in the underlying technology of the machinery. Forecasting of tool conditions can be expedited using Artificial Intelligence (AI) and other data-driven methods. We propose Smart Prognostics and Health Management (SPHM), a framework for Smart Manufacturing enabled by AI and Digital Twins. As a use-case, we demonstrate Fault Detection and Remaining Useful Life (RUL) estimation on data from a milling machine experiment.

Monday, 8AM–9:15AM

MA12

CC - Room 113

Human-AI Teams

General Session

Session Chair

NIcholas Wolczynski, University of Texas at Austin

1 Explainable Ai for Employees: Loan Officer Preferences and Profitability Implications for Firms

Stephanie Kelley[1], Anton Ovchinnikov[2,3], Adrienne Heinrich[4], [1]Ivey Business School, University of Western Ontario, London, ON, Canada; [2]Queen's University, Smith School of Business, Kingston, ON, Canada; [3]INSEAD, Fontainebleau, France; [4]The Union Bank of the Philippines, Aboitiz Data Innovation, Pasig, Philippines.

Little is known about what forms of explainability build confidence and trust in AI models for "non-AI people" in organizations. We generate machine learning models to predict loan customer default data from an Asian lender. We then generate post-hoc explanations (e.g., importance, SHAP) for both positive and negative lending outcomes, and conduct a choice-based conjoint survey to explore the explainability preferences of lending officers. We evaluate the results with Hierarchical Bayes to estimate employee preferences and study the impact of employee heterogeneity on the results. The study uncovers the explainability preferences for employees, including individual versus global explanations, and feature counts. The findings help firms to build trust in AI-based algorithms amongst bank employees using explainable AI methods, whilst balancing profitability.

2 Human-AI Complementarity: The Role of Explainable AI

Max Schemmer, Karlsruhe Institute of Technology, Karlsruhe, Germany. Contact: max.schemmer@kit.edu

In many application areas, Artificial intelligence (AI) can improve human decision-making. Teaming between AI and humans may even lead to complementary team performance (CTP), i.e., a level of performance beyond the one that can be reached by AI or humans individually. Interestingly enough, CTP does not often materialize in previous research. This may be due to the fact that previous work did not focus on the presence of a fundamental prerequisite for CTP—the existence of complementarity potential between humans and AI. We focus on the existence and exploitation of such potential for effective human-AI decision-making. To provide common ground, we identify possible sources of complementarity potential and derive a classification for human-AI decision integration mechanisms to exploit this potential.

3 Trust Repair in Human-Robot Interaction

Connor Esterwood, University of Michigan, Ann Arbor, MI, Contact: cte@umich.edu

Humans and robots must work together to function as an effective team. Teamwork requires trust which changes over time. Specifically, trust increases when robots perform successfully but decreases when robots inevitably make mistakes. The latter of these can be especially challenging as repairing trust is often more difficult than damaging it. Fortunately, a handful of trust repair strategies have emerged which have the potential to repair trust. Unfortunately, these strategies seem to produce unpredictable and variable results with some proving effective at certain times but not at others. One explanation for this variability may be individual differences and in particular one's positive attitudes towards robots. This presentation will focus on a study examining this phenomenon and its corresponding results along with possible future research directions.

4 Understanding Human-AI Decision-making in The Real-world: From Observational Studies to Theoretical Models

Anna Kawakami[1], Luke Guerdan[1], Zhiwei Steven Wu[2], Haiyi Zhu[1], Kenneth Holstein[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: akawakam@andrew.cmu.edu

Organizations are increasingly leveraging AI-based decision support tools (ADS) to improve human decisions. A growing body of work has examined human-AI decision-making in simplified contexts through online experimental studies. However, much less is known about the opportunities and pitfalls of introducing ADS tools in complex, real world contexts. In this talk, we discuss findings from observational studies in the context of AI-augmented child welfare decision-making, examining how organizational structures and incentives, amongst other factors, influence workers' reliance on ADS. Building on these findings, we develop a framework based on structural causal modeling which brings clarity to key challenges in the design and evaluation of ADS. We discuss how this framework can guide the design of more robust experimental studies on human-AI decision-making.

Monday, 8AM–9:15AM

MA13

CC - Room 114

Recent Advances in Multi-level Network Optimization and Their Applications

General Session

Session Chair

Ningji Wei, Carnegie Mellon University, Philadelphia, PA

1 Supervalid Inequalities in Binary Interdiction Games and Applications in Greedoid Interdiction

Ningji Wei[1], Jose L. Walteros[2], [1]Carnegie Mellon University, Philadelphia, PA, [2]University at Buffalo, Buffalo, NY, Contact: ningjiwei@cmu.edu

Binary interdiction games (BIGs) are Stackelberg games where a leader's strategy either interacts or not with the follower's structure, and if it does, then the structure becomes unavailable for the follower. Every binary interdiction game adopts a set-covering-like integer programming (IP) formulation. In this work, We derive a general class of supervalid inequalities, inequalities that can remove non-trivial suboptimal solutions, to improve the performance of the general IP formulation. Such supervalid inequalities are induced by a certain bipartition of the leader's strategy space. We prove the existence of these inequalities in all BIGs and develop a partial verifier to identify them. Finally, we demonstrate the effectiveness of this framework in the class of Greedoid interdiction games, where the follower's structures form a basis of a Greedoid.

2 Adjusting Customers' Utility Functions Via Bilevel Optimization

Svetlana Riabova, Jose L. Walteros, University at Buffalo, Buffalo, NY, Contact: sriabova@buffalo.edu

We investigate the leader's ability to slightly shift the follower's preference in a way that favors the leader while guaranteeing that the follower's objective is not damaged. By doing that, the leader usually incurs a cost associated with the effort they make to change the follower's problem. The goal of our analysis is to evaluate incentive mechanisms designed to affect the follower's utility function alongside the cost of employing such mechanisms. We illustrate our work with an example application in online retail, where the leader introduces variable pricing to shift delivery preferences to reduce the routing cost. The lower level problem is modeled using a structure that allows us to exploit strong duality and work with a single-level reformulation of the relaxed problem while employing delayed constraint generation.

3 Maximizing Node Activation Network Flow Problems Under Nonsimultaneous Flow Assumptions

Robert Curry, United States Naval Academy

In this work, we study a nonsimultaneous network flow problem, in which resources are transported through a network of nodes via arcs in order to maximize the value of activated nodes. A node is defined as activated whenever some positive number of resources are allocated or transported to that node during some time period. We assume the network consumes some nonnegative units of a finite budget for moving such resources through the network. These problems have applications in disaster relief, wireless sensor network optimization, and defense settings. We present two mixed integer programs (MIPs) for solving this problem as well as computationally effective Branch And Price algorithm for its solution. Furthermore, we present a series of preliminary results to display the efficacy of our approach compared to the MIPs.

4 Designing Network Inspection Operations: A Mean-variance Formulation with Bayesian Learning

Bastián Bahamondes[1], Mathieu Dahan[1], Saurabh Amin[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Massachusetts Institute of Technology, Cambridge, MA

Motivated by the challenge of efficient identification of failures in infrastructure networks, we design inspection schedules conducted by resource-constrained ground crews equipped with unmanned aircraft systems (UASs). We formulate an optimization problem to maximize a weighted sum of the expected value and variance of the most recent failure distribution in inspected regions of a network. After each inspection epoch, the information on identified failures is used to perform a Bayesian update on the failure distribution, which impacts the subsequent inspection schedules. We derive a mixed-integer program to obtain coordinated crew-UAS inspection schedules over tree networks. The resulting strategies capture the tradeoff between prioritizing the full exploration of a region versus reducing the uncertainty in failure locations using partial explorations.

Monday, 8AM–9:15AM

MA14

CC - Room 115

Models and Algorithms for Smart Fleet Operations

General Session

Session Chair

Michael Hyland, University of California, Irvine, Irvine, CA

1 Competition and Cooperation of Autonomous Ridepooling Services: Game-based Simulation of a Broker Concept

Roman Engelhardt, Patrick Malcolm, Florian Dandl, Klaus Bogenberger, Technical University of Munich, Munich, Germany. Contact: roman.engelhardt@tum.de

Autonomous ridepooling services can improve future transport efficiency by offering shared rides. Nevertheless, because a sufficient user base is required for pooling to take effect, their performance can suffer if multiple operators split demand. A simulation framework is presented to evaluate the impact of competition and cooperation among ridepooling providers. Two different kinds of interaction via a broker platform are compared. In the first, the broker forwards trip offers from operators to customers, who can then freely choose an operator. In the second, a regulated broker platform manipulates operator offers to shift the system towards a system optimum. Results show that all stakeholder can benefit from a regulated broker: operators increase profit, customers experience higher service rates and cities benefit from increased pooling efficiency.

2 Fast and Scalable Shared Fleet Algorithms for Large-scale Applications

Krishna Murthy Gurumurthy[1], Akhil Vakayil[2], Felipe de Souza[1], Taner Cokyasar[3], Jeffrey Larson[4], [1]Argonne National Laboratory, Lemont, IL, [2]Georgia Institute of Technology, Atlanta, GA, [3]Argonne National Laboratory, Darien, IL, [4]Argonne National Laboratory, Argonne, IL, Contact: kgurumurthy@anl.gov

Dynamic ride-sharing offered by shared fleets has been proven to be useful in improving the network state and boosting the fleet's efficiency. Solving this in a fast and scalable manner, while doing so in an integrated manner compliant with travel behavior has been missing in recent literature. An iterative algorithm is proposed with objectives to minimize fleet hours and traveler hours and is implemented for large regional demand through the agent-based POLARIS framework. This presentation will highlight the algorithm, compare and contrast it with a greedy heuristic counterpart that does just as well, and provide motivation for moving toward large-scale solution settings.

3 MODELINg and OPTIMIZING MOBILITY-ON-DEMAND SHARED-RIDE SERVICEs with WALKING LEGS

Zifan Wang[1], Michael Hyland[2], Navjyoth J. S. Sarma[2], [1]RMSI North America Inc, New York, NY, [2]University of California, Irvine, Irvine, CA

Most mobility-on-demand (MOD) shared-ride services are door-to-door. However, in the past few years, several studies and real-world MOD services start introducing walking legs to the shared-ride trips so that travelers may be asked to walk for a short distance to the prescribed pickup locations and/or to their final destinations. Compared to the conventional door-to-door shared-ride services, shared-ride with walking legs services may bring benefits such as reduced system vehicle-distance-traveled. Yet, critical analysis on the trade-offs among various service-related metrics such as walking time, traveler total trip time, vehicle travel distance of MOD share-ride services with walking legs is still rare. This presentation aims to provide more insights on such trade-offs using our recent simulation results.

4 Mixed-service Operation and Pricing of Shared-use Autonomous Mobility Systems

Hoseb S. Abkarian[1], Hani S. Mahmassani[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: masmah@northwestern.edu

We study a new mixed-service (mixed-purpose) operation of shared-use autonomous mobility systems (SAMS) where customers can request rides either immediately or through reservations and use the vehicle for a point-to-point service or a time-slot-based rental service, respectively. An optimization-based strategy for assignment is presented for vehicle-to-customer matching with a dynamic pricing problem formulated as a Markov Decision Process and subsequently solved through a reinforcement learning algorithm. We also adopt a learning method of estimated time of arrival (ETA) of vehicles to customers (i.e. customers' wait times) to be accurately reflected in customer's choice process. Insights from fixed fleet operation of an autonomous mixed-service operation are presented.

Monday, 8AM–9:15AM

MA15

CC - Room 120

Innovation in Healthcare Delivery

General Session

Session Chair

Kamalini Ramdas, London Business School, London, United Kingdom.

Session Chair

Nazli Sonmez, Bilkent University, London, United Kingdom.

1 Identifying The Bottleneck Unit: Impact of Congestion Spillover in Hospital Inpatient Unit Network

Song-Hee Kim[1], Fanyin Zheng[2], Joan Brown[3], [1]Seoul National University, Seoul, Korea, Republic of; [2]Columbia University, New York, NY, [3]Keck Medicine of USC, Los Angeles, CA, Contact: songheekim@snu.ac.kr

We use 5-year data from a hospital with 16 inpatient units to empirically examine whether and how much congestion propagates through the network of inpatient units. We find that the magnitude of the congestion spillover is substantial in our study hospital. We then use counterfactual analyses to empirically identify the bottleneck unit---the unit that has the biggest impact on system performance when an intervention is applied to increase its capacity.

2 Uniformly Conservative Exploration in Reinforcement Learning

Wanqiao Xu[1], Jason Yecheng Ma[2], Kan Xu[3], Hamsa Sridhar Bastani[4], Osbert Bastani[2], [1]Stanford University, Stanford, CA, [2]University of Pennsylvania, Philadelphia, PA, [3]University of Pennsylvania, Philadelphia, PA, [4]Wharton School, Philadelphia, PA, Contact: wanqiaox@stanford.edu

A key challenge to deploying reinforcement learning in practice is avoiding excessive (harmful) exploration in individual episodes. We propose a natural constraint on exploration---*uniformly* outperforming a conservative policy (adaptively estimated from all data observed thus far), up to a per-episode exploration budget. We design an algorithm that uses a UCB reinforcement learning policy for exploration, but overrides it as needed to satisfy our exploration constraint with high probability. We prove that our approach remains conservative while minimizing regret in the tabular setting. We experimentally validate our results on a sepsis treatment task and an HIV treatment task, demonstrating that our algorithm can learn while ensuring good performance compared to the baseline policy for every patient.

3 Artificial Intelligence on Call: The Physician'S Decision of Whether to use Ai in Clinical Practice

Tinglong Dai[1], Shubhranshu Singh[2], [1]Johns Hopkins University, Baltimore, MD, [2]Johns Hopkins University, Baltimore, MD, Contact: dai@jhu.edu

Physicians are increasingly able to use AI systems to aid their medical decision-making. This paper examines a physician's decision regarding whether to use an assistive AI system when prescribing a treatment plan for a patient. Using AI helps the physician generate an informative signal that lessens clinical uncertainty. It can also change the physician's legal liability in the event of patient harm. We analyze two patient-protection schemes that determine physician liability when using AI and show that in both schemes, the physician has an incentive to use AI in low-uncertainty scenarios, even if AI provides little value. Furthermore, the physician may avoid using AI in higher-uncertainty scenarios where AI could have aided in better decision-making. As AI becomes more precise, the physician may become more hesitant to use it on certain patients.

4 Improving Group Testing in a Pandemic

Tong Wang, Kamalini Ramdas, S. Alex Yang, London Business School, London, United Kingdom. Contact: tongw@london.edu

In a pandemic, we rely on accurate tests to identify positive cases and reduce infection, yet large scale tests can be costly to run and subject to capacity constraints. Group testing can efficiently test populations and significantly save testing capacities. In a group test, samples are first pooled and tested. If the result is negative, every individual in the group is healthy. Otherwise, individual tests are conducted to detect the infected individuals. The appropriate group size depends on the underlying risk level of individuals. In this study, we examine different approaches that health policy makers or health administrators can use to improve group formation for the pooling stage of the testing procedure in the presence of heterogeneous risk levels among individuals.

Monday, 8AM–9:15AM

MA16

CC - Room 121

Modeling for Screening or Treatment Policies in Healthcare

General Session

Session Chair

Qiushi Chen, Penn State University, University Park

Session Chair

Yu-Hsin Chen, State College

1 Developing Personalized Diabetic Retinopathy Screening Recommendations

Poria Dorali[1], Zahed Shahmoradi[2], Christina Weng[3,4], Taewoo Lee[5], [1]University of Houston, Houston, TX, [2]Norfolk Southern Corporation, Atlanta, GA, [3]Baylor College of Medicine, Houston, TX, [4]Ben Taub Hospital, Houston, TX, [5]University of Pittsburgh, Pittsburgh, PA, Contact: pdorali@uh.edu

Diabetic retinopathy (DR) is the leading cause of blindness among working-age Americans. While regular screening can help prevent up to 98% of DR-related vision loss, currently only 30-60% of patients adhere to annual screening guidelines due to inconvenience and limited access to eye care. Teleretinal imaging (TRI) is emerging as an affordable tool that has the potential to increase screening rates, yet little is known how TRI-based screening should be recommended in conjunction with traditional screening exams. We develop a POMDP model that determines personalized screening policies that take into account patient-specific characteristics such as age, A1C level, cost savings preferences, and adherence behavior. We also analyze the cost-effectiveness of the personalized policies against current standardized guidelines.

2 Tuberculosis Treatment Modeling Using Laboratory Test Results

Maryam Kheirandish Borujeni, Shengfan Zhang, University of Arkansas, Fayetteville, AR, Contact: mkheiran@uark.edu

In this research, a sequential decision model is developed for effective tuberculosis (TB) treatment planning. Patients may develop acquired drug resistance during the course of treatment. However, there are no biomarkers to predict severity of the disease or predict the progression of interventions. Some laboratory tests are available to detect the existence or drug-resistance of TB bacteria in human's body. Although these tests are time-consuming, expensive, and not perfect, they are the only tests available for decision-making. We use these test results to develop a mathematical model to help physicians decide if they should continue the current regimen and/or administer a new test in each follow-up session.

3 A Tool to Inform Global Hepatitis C Elimination in Developing Countries

Huaiyang Zhong[1], Alec Donovan Aaron[2], Lindsey Hiebert[3], John Ward[3], Jagpreet Chhatwal[1], [1]Harvard Medical School, Mass General Hospital, Boston, MA, [2]Mass General Hospital, Boston, MA, [3]The Task Force for Global Health, Atlanta, GA, Contact: hzhong2@mgh.harvard.edu

The World Health Organization (WHO) recently launched a global campaign for eliminating hepatitis C virus (HCV) as a public health threat by the year 2030. However, most countries do not have a national strategy for HCV screening and treatment that can lead to HCV elimination. We developed a microsimulation model to assess various combinations of screening and treatment strategies, and built an online, publicly accessible tool to help policy makers identify a path to HCV elimination.

4 Optimize Risk-based Autism Screening Under Limited Diagnostic Service Capacity

Yu-Hsin Chen, Qiushi Chen, Pennsylvania State University, University Park, PA

Autism Spectrum Disorder (ASD) is a developmental disorder that affects 1 in 44 children in the US. The current diagnosis process for ASD experiences a long delay due to insufficient accuracy in screening tools and limited diagnostic service capacity. To improve the early diagnosis of ASD children, we developed a mathematical programming model to optimize the diagnostic referral decisions based on individuals' risk at different ages and the length of diagnostic waitlist during the screening process. Using a detailed individual-level simulation model, we found that compared with the fixed policies which have the same risk threshold across all ages, optimal policies with risk threshold adapted to the waitlist length achieved a lower average diagnosis age and a higher early diagnosis rate below age 4.

Monday, 8AM–9:15AM

MA17

CC - Room 122

Applications of Advanced Analytics in Healthcare Industrial Practice

General Session

Session Chair

Kiatikun Louis Luangkesorn, Highmark Health, Wexford, PA

1 Predicting Disease Severity in Patients Hospitalized with COVID-19

Mina Ostovari, Claudine Jurkovitz, Keshab Subedi, Bayo M. Gbadebo, Mia Papas, ChristianaCare Health Services Inc., Wilmington, DE

The study aimed to identify risk factors for severe illness in patients with COVID-19. The outcome was the WHO Clinical Progression Scale (WHO-CPS) measured after hospital admission. We used electronic health records data to predict the WHO-CPS from patient demographic and clinical characteristics. The study period was from March 2020 to August 2022. The predictors included patient age, sex, race, ethnicity, insurance, Elixhauser comorbidity count, BMI, flags for hypertension, diabetes, chronic pulmonary disease, heart failure, renal failure, and a variable that indicated the time from the onset of the pandemic. The study population included 8852 patients with an average age of 60±18. The variable importance feature of random forest identified age, BMI, and time from the onset of the pandemic as the most significant predictors of the outcome.

2 Solving The Two Population Sir Model to Provide Early Estimates of Peak and Duration of a Covid-19 Wave

Louis Luangkesorn, HIghmark Health, Pittsburgh, PA, Contact: kiatikunlouis.luangkesorn@highmarkhealth.org

During the COVID-19 pandemic, new variants of the virus created waves of cases as the virus has increased virulence. In addition, with variants that are immune evasive prior infection to an earlier variant does not confer immunity and prior vaccination only protects a portion of the vaccinated population. Healthcare organizations need to be able to estimate the impact of a new wave in order to assess and manage resources needed to manage future caseloads. This work solves the initial value problem for an infectious disease model that accounts for partial vaccine effectiveness applied to a metropolitan area using insurance claims. The goal is to have a model that effectively provides early estimates of the peak and duration of an epidemic wave in its initial stages. The results from the model will be used to inform healthcare provider interventions and policy.

3 Designing High Quality, Efficient, and Accessible Provider Networks for Healthcare

Bishal Karki, Kiran Jambhale, Highmark Health, Pittsburgh, PA

As a health insurance company, Highmark Health has to review multiple providers on attributes such as quality of care, accessibility to membership, cost of care, etc. At Highmark, we have built a tool that does this optimization exercise algorithmically using internal and publicly available data. This talk will be a quick description of the problem we're trying to solve, our approach, and the value of such solutions to organizations like ours.

Monday, 8AM–9:15AM

MA18

CC - Room 123

Machine Learning in Healthcare

Flash Session

Session Chair

Agni Orfanoudaki, Saïd Business School, University of Oxford, Oxford, United Kingdom.

1 Analytics for Public Impact: Research Activities at The Public Impact Analytics Science Lab at Harvard

Soroush Saghafian, Harvard Univeristy, Cambridge, MA, Contact: soroush_saghafian@hks.harvard.edu

In this flash talk, we briefly overview various projects and research activities at the Public Impact Analytics Science Lab (PIAS Lab) at Harvard. We discuss our close collaboration with various stakeholders, the analytics science approaches used, and the data collection methods employed. We also shed light on the potential impact of these research activities as well as the broader lessons learned in conducting analytics-driven research that can have public impact.

2 Contextual Learning with Online Convex Optimization with Applications to Medical Decision-making

Esmaeil Keyvanshokooh[1], Mohammad Zhalechian[2], Cong Shi[2], Mark P. Van Oyen[2], Pooyan Kazemian[3], [1]Mays Business School, Texas A&M University, College Station, TX, [2]University of Michigan, Ann Arbor, MI, [3]Case Western Reserve University, Cleveland, OH, Contact: keyvan@tamu.edu

We formulate a new contextual multi-armed bandit model under a two-dimensional nested control in the context of medical decision-making. We develop a new contextual learning and optimization algorithm for this model and prove its regret. We illustrate the effectiveness of our methodology by using a case study on type-2 diabetes patients.

3 Quantifying The Benefits of Targeting for Pandemic Response

Sergio Camelo[1], Dragos Florin Ciocan[2], Dan Andrei Iancu[1], Xavier Warnes[3], Spyros Zoumpoulis[2], [1]Stanford University, Stanford, CA, [2]INSEAD, Fontainebleau, France; [3]Stanford University Graduate School of Business, Stanford, CA, Contact: spyros.zoumpoulis@insead.edu

We propose and implement a rigorous framework and algorithms to quantify the merits of targeted confinement interventions for pandemic response, and demonstrate them in a case study of COVID-19 in Île-de-France. We find that optimized interventions that differentiate based on both population groups and activities are interpretable, and achieve significantly better health and economic outcomes, while also reducing confinement time for each group, compared to less targeted interventions. Our framework highlights the significant benefits in explicitly and transparently modelling targeting and identifying the interventions that rigorously optimize overall societal welfare.

4 Managing The Risk of Readmission for Solid Organ Transplant Patients

Agni Orfanoudaki[1], Soroush Saghafian[2], [1]Saïd Business School, University of Oxford, Oxford, United Kingdom; [2]Harvard Univeristy, Cambridge, MA, Contact: agni.orfanoudaki@sbs.ox.ac.uk

Solid organ transplant patients are associated with a wide range of complications. In this study, we investigate the impact of routinely recorded risk factors and use machine learning to predict the 30-day risk of readmission. In addition, we present a reinforcement learning approach to derive interpretable prescriptive policies that account for unobserved confounding. We demonstrate that the proposed models lead to improved operational and patient outcomes compared to the standard of care. Our analysis includes real-world data from an online survey of human experts and the electronic health records of a major academic medical center based in the United States.

5 Deciphering Inpatient Procedure Heterogeneity with Multivariate Point Process Modeling

Fenglian Pan[1], Jian Liu[1], You Zhou[2], Nan Kong[2], [1]University of Arizona, Tucson, AZ, [2]Purdue University, West Lafayette, IN, Contact: nkong@purdue.edu

To improve the delivery of precision health, it is critical to decipher the heterogeneity among patients and further detect temporal associations for each type of patients. This research develops a multivariate point process model for discovering patients' latent temporal inpatient procedure patterns, which are represented as mutual-influencing mechanisms. An algorithm is developed to estimate the model parameters, based on which patients with different latent patterns are clustered. The proposed model can be used to predict the timing of procedures more accurately. The performance of proposed model is demonstrated by a read-world case study on opioid use disorder treatment with claims data.

6 Flash Paper

Kyra Gan, Carnegie Mellon University, Pittsburgh, PA

Will talk about the intersection of causal inference and reinforcement learning and its application in healthcare

7 Flash Paper

Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA

H2O: Holistic Hospital Optimization.

We present a successful application of machine learning and optimization to the Hartford healthcare system, the largest healthcare system in Connecticut, involving seven hospitals and more than 2000 beds for monitoring every patient in the system and optimizing the flow of patients in the system. We discuss the impact of the work and the lessons we learned.

Monday, 8AM–9:15AM

MA19

CC - Room 124

Model the Demand and Distribution of Vaccinations and Vaccine Hesitancy

Contributed Session

Session Chair

Marta J Ventura, Penn State, State College, PA

1 **Vaccine Demand Forecast Using Machine Learning Technique**

Abhijeet Kumar, Janeth Gabaldon, M A SHARIFUL AMIN, Javier RubioHerrero, Victor R. Prybutok, University of North Texas, Denton, TX, Contact: abhijeet.kumar@unt.edu

The demand for vaccines has significantly increased due to the occurrence of new infectious diseases. The recent outbreaks of coronavirus have added to the overall demand for vaccines. However, the growth in demand for vaccines has resulted in challenges related to the planning and management of the complex immunization supply chain. One of the key challenges is an accurate demand forecast for vaccines. While under-estimation of vaccine demand can lead to stock-outs, overestimation can lead to vaccine wastage. Therefore, this study aims to find a suitable model using machine learning techniques to forecast an appropriate demand for vaccines to avoid shortage and over-supply.

2 **Machine Learning Algorithms to Analyze Covid-19 Vaccine Hesitancy Behavior at The County Level in The U.S**

Hieu T. Bui, University of Arkansas, Fayetteville, AR

COVID-19 vaccine hesitancy (VH) has hindered the effectiveness of vaccination campaigns. We use open-access databases, and machine learning to (1) develop an effective measure of VH behavior; (2) determine the main factors contributing to changes in VH behavior at the county level over time; (3) explain the differences in VH of rural versus urban areas. The model identified political affiliation, Google search, and income per capita as some of the factors that impact VH behavior. These findings can help public health officials develop tailored strategies to address specific challenges leading to VH.

3 **Economic Impact of COVID-19 Vaccination on Healthcare Facilities**

Marta Ventura[1], Jose Antonio Ventura[2], Hui Yang[1], Adhithya Padmanabhan[1], [1]Penn State, State College, PA, [2]Pennsylvania State University, University Park, PA, Contact: mxv176@psu.edu

When vaccines became available, however, health officials had to face the challenging question of who should be vaccinated first and how to distribute the limited production of vaccines within their countries and all over the world. In addition, the limited logistics available to manage the manufacturing and distribution of vaccines led to new challenges. In this paper, we propose a mixed integer linear programming model to determine an optimal allocation of limited COVID-19 vaccines to reach herd immunity in a geographical area in an orderly manner while minimizing the overall cost, including the cost of building temporary medical facilities, travel cost of population to medical facilities, purchasing cost of vaccines, and inventory holding cost.

Monday, 8AM–9:15AM

MA20

CC - Room 125

Health Analytics

General Session

Session Chair

Mingfei Li, Bentley University, Waltham, MA

1 **Disease Progression in Alzheimer'S Disease Among US Veteran Population**

Ying Wang, Bentley University, Waltham, MA

Mild cognitive impairment (MCI) has become particularly attractive as it is considered to be the transitional state between normal aging and early Alzheimer's disease. However, not all MCI cases will progress to dementia or Alzheimer's. Some reverse to normal or near-normal conditions, some remain stable at MCI. Previous studies regarding the transitioning from MCI to AD relied on limited samples yield a wide range of estimations. This study described the disease progression from MCI to AD to death in a multistate framework from a large population of US veterans. The transition rates and probabilities between different disease phases were presented using the Markov multi-state modeling.

2 **Precision Public Health as a Strategy for Transforming Data into Actionable Information**

Ryan B. Simpson[1], Elena N. Naumova[2], [1]Tufts University Friedman School of Nutrition Science and Policy, Boston,

MA, [2]Tufts University, Boston, MA, Contact: ryan.simpson@tufts.edu

The recent paradigm shift towards Precision Public Health (PPH) aims to improve decision-making through evidence-based data-driven individualized health promotion, prevention, and control strategies. With the use of complex data, machine learning and artificial intelligence (AI), we are expanding PPH beyond a collection of tools for enhancing public health surveillance to a strategy for transforming data into actionable information. By examining global surveillance systems for infections with high pandemic potential, like WHO FluNET, we developed a framework for assessing time series records based on 5 principles (ACTOR: Availability, Capacity, Timeliness, Operability, and Reliability) accompanied by 25 standardized quantitative metrics.

3 Global Nutrition and Health Atlas: A Tool of Scientific Discovery

Bingjie Zhou, Elena N. Naumova, Tufts University Friedman School of Nutrition Science and Policy, Boston, MA, Contact: bingjie.zhou@tufts.edu

Public health and nutrition data are rapidly increasing in volume and complexity. Novel data visualization techniques offer a way to ease the user's cognitive load and improve comprehension, research reproducibility, and transparency. Using 4E principles: Evidence, Efficiency, Emphasis, and Ethics, we reviewed 13 highly utilized dashboards to examine their properties from users' perspectives. We created an open access data platform: Global Nutrition and Health Atlas (https://sites.tufts.edu/gnha/) to power innovation and research discovery with global data repositories with 26 themes and 500+ indicators from 190+ countries up to 30 years. We applied 'best practices in developing data portals, tutorials, and interactive visualization galleries.

4 Self-selecting No-pay Service Delivery Strategies: A Rising Tide that Lifts All Boats?

Omkar D. Palsule-Desai[1], Vikrant Vaze[2], Gang Li[3], Srinagesh Gavirneni[4], [1]Indian Institute of Management Indore, Indore, India; [2]Dartmouth College, Hanover, NH, [3]Bentley University, Waltham, MA, [4]Cornell University, Montreal, Canada. Contact: omkardpd@iimidr.ac.in

Services such as housing, food, and healthcare are expected to be universally accessible and affordable. Under rapidly increasing cost structures and income inequality, some organizations are implementing schemes under which customers can choose not to pay the required fees. We develop a mathematical model to characterize conditions under which service providers should adopt these strategies in a competitive environment. We show that the strategy of offering free services to the needy can, in addition to benefiting the firm, the consumer, and the society, also benefit the competitor. The underlying reasons are philanthropic amplification of paying customers' willingness to pay, non-paying customers' restriction-induced utility reduction, a faster transition of service professionals up the learning curve, and their appreciation for the societal contribution.

Monday, 8AM–9:15AM

MA21

CC - Room 126

Decision-making for Healthcare Policy

Flash Session

Session Chair

Sze-chuan Suen, University of Southern California, Los Angeles, CA

Session Chair

Amy Cohn, University of Michigan, Ann Arbor, MI

1 Reward Structure Design for Socially Optimal Ambulance Diversion Strategy

Hyun-Rok Lee[1], Taesik Lee[2], [1]Inha University, Incheon, Korea, Republic of; [2]KAIST, Daejeon, Korea, Republic of. Contact: hyunrok.lee@inha.ac.kr

To reduce overcrowding, an Emergency department (ED) may declare ambulance diversion (AD) status and divert arrivals of ambulances to other EDs. While AD is a logical strategy to pooling resources in an emergency medical service system, negative consequences, i.e. limited access to EDs for emergency patients, arise if excessively used by individual EDs. We model an ED network as a stochastic game and propose a reward structure design method to induce EDs to follow socially optimal AD strategies. This method guarantees that an equilibrium status is achieved under socially optimal operation. Numerical experiments are conducted to analyze the reward structure for socially optimal AD strategy.

2 A Subsidized One-Leader-Multiple-Follower Trauma Network Redesign Problem

Fangyuan Li, Purdue University

Ineffective emergency care for trauma injuries has been a serious healthcare problem in the U.S., which is partially caused by geographic maldistribution of trauma centers in the care network. We formulate this network redesign problem with a bilevel mixed-integer program, where the government as the leader allocates subsidies to each hospital system and each hospital system then follows to decide which hospital to downgrade and which to upgrade, and how to zone the potential trauma injury incidents. We apply a branch-and-bound solution technique and propose a multiway-branching method. We test the solution technique with a case study based on the US state of Indiana, and generate policy insights.

3 Sequential Allocation of Vaccine to Control An Infectious Disease

Isabelle J. Rao[1], Margaret L. Brandeau[2], [1]Stanford University, Stanford, CA, [2]Stanford University, Stanford, CA, Contact: isarao@stanford.edu

The vaccine allocation problem has broad applications in public health and has received renewed attention during the COVID-19 pandemic. We consider an SIR model with interacting population groups, an allocation over multiple time periods of limited vaccines and four objectives: minimize new infections, deaths, life years lost and quality-adjusted life years lost due to death. We develop intuitive and practical analytical conditions characterizing the optimal solution. We calibrate the model to the COVID-19 epidemic in New York and show that our method achieves near-optimal results. Our method highlights the need for more interpretable models over black-box models to aid in decision making.

4 Challenges in Diagnosing Staff Shortages in Healthcare Personnel Scheduling Problems

Daiwen Zhang, Amy Cohn, William Pozehl, Maocui Mu, University of Michigan, Ann Arbor, MI, Contact: dwzhang@umich.edu

Infeasibility is a common issue when solving personnel scheduling problems in healthcare. Most of those cases are caused by shortages of workforce in some sense. In particular, this means the current staffing supply cannot cover the needs of all time periods. In practice, it will be helpful to the decision maker if more information on the infeasibility can be diagnosed, e.g., which shifts cannot be covered at the same time, and how much the shortages are. We present algorithmic approaches to detecting the source and extent of infeasibility.

5 Utilizing a Systematic Approach to Predict Resource Allocation and Improve Intervention Success

Aparna Reddy, Makayla Roma, Emily Lindblad, Amy Cohn, Nithya Ramnath, University of Michigan, Ann Arbor, MI, Contact: aparnakr@umich.edu

Studies show lack of accurate resource allocation increases the likelihood of intervention failure. This study aims to improve intervention success by predicting accurate staffing and resource needs through a systematic method. Using a Lung Cancer Screening Program at the *VA Ann Arbor Health Care System* as a model, resource needs were determined from a predictive method. Utilizing process mapping, resource availability, and program goals, we developed a systematic method to calculate resource allocation. We outlined a systematic method to be applied in various contexts to promote efficient resource allocation, preempt future problems, and improve intervention success.

6 Using Simulations as Inputs

Sze-chuan Suen, University of Southern California, Los Angeles, CA

Markov decision processes (MDPs) rely on accurate state transition probabilities, stage rewards, and terminal rewards, but these values may be difficult to measure in health applications, where they may need to capture residual lifetime outcomes. Microsimulation models, stratified by demographic factors, may provide a good way to estimate these MDP inputs. I provide several examples of this process and discuss challenges and potential solutions.

7 Optimally Designing Cybersecurity Insurance Contracts to Encourage The Sharing of Medical Data

Yoon Lee[1], Anil Aswani[2], [1]UC Berkeley, Bellevue, WA, [2]UC Berkeley, Berkeley, CA

Though the sharing of medical data has the potential to lead to breakthroughs in health care, the sharing process itself exposes patients and health care providers to various risks. Patients face risks due to the possible loss in privacy or livelihood that can occur when medical data is stolen or used in non-permitted ways, whereas health care providers face risks due to the associated liability. As a result, health care providers are hesitant to share medical data. One possible solution to encourage health care providers to responsibly share data is through the use of cybersecurity insurance contracts. This paper studies the problem of designing optimal cybersecurity insurance contracts, with the goal of encouraging the sharing of the medical data.

8 Strategies for Efficient Funding of HIV Prevention Interventions to Achieve The Incidence Goals of The Ending The HIV Epidemic in The U.S. (EHE) Initiative

Evin Jacobson[1], Katherine A. Hicks[2], Justin Carrico[2], Paul Farnham[1], [1]CDC, Atlanta, GA, [2]RTI International, Durham, NC, Contact: wqm4@cdc.gov

We considered multiple strategies for efficiently funding HIV prevention interventions to meet 5-year and 10-year EHE annual incidence goals. Our results showed that these goals could be reached by proportionally scaling up current funding to all interventions by an additional 130%. We also used optimization methods to identify funding strategies that met EHE incidence goals with minimized annual funding across the interventions. Even when we required that 75% of current funding to each of the interventions be continued, optimizing the funding meant that the EHE incidence goals could be met with less total funding than was currently spent.

9 A Linear Model to Identify Optimal Hiv Prevention Funds Allocation Policy for Local Health Jurisdictions in The United States

Md Hafizul Islam, Centers for Disease Control and Prevention, Atlanta, GA, Contact: qla0@cdc.gov

Local U.S. health jurisdictions receive funds from different sources to implement HIV prevention interventions for appropriate populations at risk. We developed a linear programming model to identify the optimal allocation of the Centers for Disease Control and Prevention's HIV prevention funding for local health jurisdictions. The model allocates a given budget among prevention interventions and populations stratified by gender and risk groups to maximize the number of cases prevented. Inputs to the model include available budget and data on the costs and efficacy of HIV prevention programs for different subpopulations. Model solutions report the number of new cases prevented and the corresponding funding allocation to each prevention intervention for different subpopulations.

Monday, 8AM–9:15AM

MA24

CC - Wabash 1

Provalis Research / Gurobi Optimization

Technology Tutorial

2 Intro to Modeling

Alison Cozad[1], Juan Antonio Orozco Guzman[2], [1]Gurobi, Houston, TX, [2]Gurobi, Guadalajara, Mexico. Contact: cozad@gurobi.com

Join us and discover why gurobipy is our most popular interface and how it can help you to harness the power of mathematical optimization. In this tutorial, we'll walk through the modeling constructs and data structures that are necessary to translate a math formulation into a machine-readable format. Finally, we'll review some of the best practices —and a few pet peeves— for deploying optimization models in Python. Be sure to bring your laptop if you'd like to follow along with us!

Monday, 8AM–9:15AM

MA25

CC - Wabash 2

Supply Chain Resilience: Impact of Stakeholder Behavior and Trustworthy Information Sharing with a Case Study on Pharmaceutical Supply Chains

Tutorial Session

Session Chair

Mabel Chou, National University of Singapore, SG, SG, Singapore.

1 Supply Chain Resilience: Impact of Stakeholder Behavior and Trustworthy Information Sharing with a Case Study on Pharmaceutical Supply Chains

Ozlem Ergun, Jacqueline Griffin, Northeastern University, Boston, MA

Recent disruptions in many different supply chains have brought the critical issues of supply chain resilience into focus. Despite the notion that most economic markets should adjust to shifts in supply and demand through entry and exit of competitors, we have seen that even sectors that are not as heavily regulated, as the pharmaceutical sector, are vulnerable and prone to severe shortages. Although there are many aspect of a supply chain from design to last-mile logistics that impact resilience, in this chapter we highlight and focus on the importance of incorporating the concepts of (i) stakeholder behaviors and (ii) information availability in the future of OR/MS models focused on addressing supply chain resiliency. We present how the pharmaceutical industry, which has been plagued by supply chain shortages, is a strong case study for exploring these concepts. Further, within this context we present a research framework that incorporates these elements. Informed by the initial results with this framework we highlight important new research directions.

Monday, 8AM–9:15AM

MA26

CC - Wabash 3

SOLA Dissertation Award

Award Session

Session Chair

Yudai Honma, The University of Tokyo, Meguro-Ku, Japan.

Addressing Facility Workload Balancing in Coverage Problems

Jing Xu, University of California, Santa Barbara, Santa Barbara, CA

Coverage problems have been important location models and have been widely applied in practice. A major limitation of simple coverage problems is that they do not control allocation, which might lead to unreasonable facility workloads and workload imbalance. Previous studies have been dealt with facility workload related issues in coverage problems, with one of the most popular approach is to impose capacities and/or thresholds. However, capacities and thresholds cannot guarantee facility workload balance and have associated issues in application. This work seeks to evaluate existing approaches that consider workload balance in coverage problems and study alternative approaches to better address facility workload balance. The primary contribution of this research includes: better understanding and systematic evaluation of existing capacitated coverage approaches including their solution characteristics and commercial GIS performance, new modeling approaches explicitly considering facility workload balance in coverage problems that might be applied to other types of location problems, and efficient solution techniques for proposed multi-objective spatial optimization models.

A Discrete-continuous Approximation Model for Optimal Facility Location in Disaster Response Logistics

Diana Gineth Ramirez-Rios, University at Buffalo, Buffalo, NY

This work proposes a discrete-continuous facility location model that focuses on the identification of the optimal location of the points of distribution (PODs) in a continuous geographical region and the size of the districts served by the various PODs. Given the location of a distribution center where relief supplies are stored, the optimization model produces a districting plan for each POD that includes the POD's location inside each district and a post-disaster delivery strategy. The model computes the optimal location, number of PODs, and shapes of the districts, delivery frequencies and shipment sizes such that the total social costs, i.e., the summation of the logistics costs and the deprivation costs, are minimized. A set of continuous approximation functions that compute the total deprivation costs of typical districting shapes are integrated into the model.

Monday, 8AM–9:15AM

MA27

CC - Room 138

Interesting Topics in Retail Operations

General Session

Session Chair

Santiago Gallino, University of Pennsylvania, Philadelphia, PA

1 Inequity in Disaster Operations Management

Xabier Barriola[1], William Schmidt[2], [1]INSEAD, Fontainebleau, France; [2]Cornell University, Ithaca, NY, Contact: xabier.barriola@insead.edu

Responding to natural disasters requires a large and rapid deployment of resources to relieve the needs of the victims. Using a triple difference regression, we isolate the percentage change in prices paid by low-income versus high-income areas in disaster-affected versus unaffected areas, before and after a set of disasters. We show that affected low-income areas endure higher average percentage price increases within grocery categories compared to high-income areas. We find that low-income areas see a larger drop in price promotions, higher unit percent price increases, a larger decrease in offer sets of low-priced products, and a larger increase in substitution from low-priced items to high-priced items. Our results highlight how companies and agencies can use data to facilitate more targeted and equitable operational interventions in the aftermath of a disaster.

2 Order-based Trade Credits and Operational Performance in The Nanostore Retail Channel

Rafael Escamilla[1,2], Jan C. Fransoo[1], Santiago Gallino[3], [1]Tilburg University, Tilburg, Netherlands; [2]Kuehne Logistics University, Hamburg, Germany; [3]University of Pennsylvania, Philadelphia, PA, Contact: R.Escamilla@tilburguniversity.edu

Millions of nanostores sell basic items to bottom of the pyramid consumers in emerging markets. However, their suppliers struggle with high operational costs due to shopkeepers' cash constraints. In this setting, we empirically investigate whether order-based trade credits help improve operational performance in the supply chain. On the one hand, these credits can create efficiency gains in selling and distributing products to the nanostores. On the other hand, they are a risky endeavor, as shopkeepers might default on their credit lines. Using a difference-in-differences approach with nearest neighbor matching, we find that trade credits lead to substantial efficiency gains, while resolving important operational challenges for the supplier. We further investigate under what circumstances suppliers stand to gain from extending trade credits.

3 Monitoring Government Purchases to Reduce Public Spending: A Large Scale Field Experiment

Marcelo Olivares, Universidad de Chile, Santiago, Chile.

In most organizations, procurement decisions are typically delegated to local purchasing units who have a better understanding of actual needs. However, there can be misaligned incentives between these purchase units and the central organization, which leads to principal/agent problem that may increase procurement costs. This paper conducts a large field experiment using government purchases in Chile, implementing a novel monitoring system to track overspending of thousands of purchasing units, testing alternative informational designs to reduce public spending. Our results show that monitoring overspending coupled with informative feedback to buyers can significantly reduce overspending.

4 Inventory Record Inaccuracy Explains Price Rigidity Inperishable Groceries

Ioannis Stamatopoulos[1], Robert E. Sanders[2], Naveed Chehrazi[3], [1]The University of Texas at Austin, McCombs School of Business, Austin, TX, [2]UC, San Diego, Beverly Hills, CA, [3]Olin Business School, SAINT LOUIS, MO, Contact: yannis.stamos@mccombs.utexas.edu

Grocery retailers cannot engage in inventory-based pricing without physically auditing their shelves, because their inventory records are inaccurate and incomplete. We argue that this informational friction, known in the literature as inventory record inaccuracy (IRI), is much more powerful than physical menu costs in explaining price rigidity in perishable groceries.

Monday, 8AM–9:15AM

MA28

CC - Room 139

Balancing Supply & Demand in Retail Electricity Markets

General Session

Session Chair

Saed Alizamir, Yale University, New Haven, CT

Session Chair

Michael Blair, Yale University, New Haven, CT

1 Data-driven Clustering and Feature-based Retail Electricity Pricing with Smart Meters

N. Bora Keskin[1], Yuexing Li[2], Nur Sunar[3], [1]Duke University, Durham, NC, [2]Duke University, Durham, NC, [3]UNC, Chapel Hill, NC, Contact: bora.keskin@duke.edu

We consider an electric utility company that serves N customers over T periods. In each period, the company observes the customers' consumption and high-dimensional features on customer characteristics and exogenous factors. The space of features is partitioned into clusters based on similarity, and in each cluster, there is a distinct relationship between consumption and features. The company knows neither the underlying cluster structure nor the corresponding consumption models. We design a data-driven clustering-and-pricing policy to learn these elements on the fly and prove that our policy achieves near-optimal performance in terms of N and T. Through a case study on a real-life data set, we show that our policy significantly outperforms the historical decisions of the utility company.

2 When Should The Off-grid Sun Shine at Night? Optimum Renewable Generation and Energy Storage Investments

Christian Kaps[1], Simone Marinesi[2], Serguei Netessine[1], [1]The Wharton School, Philadelphia, PA, [2]WHARTON, Philadelphia, PA, Contact: ckaps@upenn.edu

Globally, 1.5 billion people live off the grid, their only access to electricity often limited to operationally-expensive fossil fuel generators. Solar power has risen as a sustainable and less expensive option, but its generation is variable during the day and non-existent at night. Thanks to recent technological advances, which have made large-scale electricity storage economically viable, a combination of solar generation and storage holds the promise of cheaper, greener, and more reliable off-grid power in the future. Still, it is not yet well-understood how to jointly determine optimal capacity levels for renewable generation and storage.

3 Electric Vehicles' Managed Home-Charging Programs

Ali Fattahi, Johns Hopkins University, Baltimore, MD

Experts estimate 20 million electric vehicles (EVs) will be on U.S. roads by 2030, and the majority (around 80%) of EV owners will perform home charging. Many utilities are designing managed charging programs to effectively integrate and manage the total EV load. We study a general case of an active managed home-charging program, in which a large number of non-homogeneous participants plug in their EVs at different times and indicate their required loads and charging windows. The utility is obligated to satisfy these requirements. We present a large-scale non-linear optimization model and an effective approximation method. We present the following managerial insights that are contrary to the utilities' common beliefs: a) increasing participation in managed charging programs may not be a cost-saving strategy, and b) higher charging frequency may increase the total cost.

4 Estimating The Impact of Climate Change: An Empirical Analysis of Smart Thermostat Data

Michael Blair[1], Saed Alizamir[1], Shouqiang Wang[2], [1]Yale University, New Haven, CT, [2]The University of Texas at Dallas, Richardson, TX, Contact: michael.blair@yale.edu

Using a rich micro-level dataset, we empirically analyze smart thermostat data to understand the relationship between households' thermostat settings and their ambient environment. We combine a variety of methodological tools including Dynamic Linear Models, random effects, and Bayesian Statistics, to develop models for short- and long-term behavior. Using established models we create realistic estimates of future weather conditions under a variety of climate change scenarios. We combine these scenarios with our statistical model to estimate the impact of climate change. Specifically, we predict future household behavior and investigate the resulting changes in consumption. The insights derived from our research provide a valuable framework to evaluate and design interventions such as smart nudging or demand response management programs.

Monday, 8AM–9:15AM

MA29

CC - Room 140

Optimizing Trials and Healthcare Operations

General Session

Session Chair

Aadhaar Chaturvedi, University of Auckland, AUCKLAND, New Zealand.

Session Chair

Philippe Chevalier, UCLouvain, Louvain La Neuve, Belgium.

1 Network Inventory Management for Clinical Trials

Philippe Chevalier[1], Alejandro Lamas[2], [1]UCLouvain, Louvain La Neuve, Belgium; [2]NEOMA Business School, Levallois-Perret, France. Contact: philippe.chevalier@uclouvain.be

Clinical trials are a critical step for the development of new drugs, both in cost (often in the order of billions of dollars) and in terms of elapsed time to bring the potential drug to the market. Since clinical trials are increasingly going global, optimizing the supply chain can bring huge benefits, in this research we model the inventory management problem between the central depot and the regional depots that will then supply the investigation sites. The main decision is when to resupply and how much inventory to send to each regional depot and as a consequence how much inventory will be left in the central depot for potential resupplies of other regional depots. The global network view is very important given that for regulatory reasons it is impossible to send products back to the central depot or between regional depots.

2 Learning Personalized Treatment Strategies with Predictive and Prognostic Covariates

Andres Alban[1], Stephen E. Chick[2], Spyros Zoumpoulis[2], [1]MGH Institute for Technology Assessment, Boston, MA, [2]INSEAD, Fontainebleau, France.

We consider the problem of sequentially allocating sample observations to learn personalized treatment strategies, motivated by the design of adaptive clinical trials that aim to learn the best treatment as a function of patient covariates. In such clinical settings, there may be knowledge of which covariates are predictive (they may interact with the treatment choice), and which are prognostic (they influence the outcome independent of treatment choice). We show how Bayesian sequential optimization techniques can be adapted to take advantage of such structural knowledge. We illustrate that such knowledge can improve the rate of inference relative to some existing approaches to adaptive contextual learning with a numerical experiment motivated by an application of clinical trial design to assess potential treatments of sepsis.

3 Emergency Care Access Vs. Quality: Uncovering Hidden Consequences of Fast-track Routing Decisions

Shuai Hao[1], Zhankun Sun[2], Yuqian Xu[3], [1]University of Illinois Urbana-Champaign, Champaign, IL, [2]City University of Hong Kong, Kowloon, Hong Kong; [3]UNC-Chapel Hill Kenan-Flagler Business School, Durham, NC, Contact: shuaih2@illinois.edu

Many hospitals have established a separate fast-track (FT) service line dedicated to patients with less urgent care needs to improve emergency department (ED) operational efficiency. However, so far, hospitals have not yet established consistent guidelines for determining which patients should be routed to the FT, possibly due to the lack of a comprehensive understanding of how FT routing decisions impact patient outcomes. Using data from two Canadian hospitals, we show that better-informed FT routing decisions can put the right patient in the right place at the right time, improving both the access to and the quality of emergency care.

4 Optimal Vaccine Allocation

Justin Goodson, Stephen Scroggins, Enbal Shacham, Tasnova Afroze, Saint Louis University, Saint Louis, MO, Contact: goodson@slu.edu

Allocation of limited vaccine supplies faces two main obstacles. First, classical models of disease spread struggle to incorporate the spatio-temporal factors that drive the person-to-person transmission of respiratory infection. Second, because these predictive models are difficult to integrate within a prescriptive optimization framework, the resulting allocation policies typically carry no guarantee of optimality. We show how to model disease spread that captures a population's mobility and location across time and space and that results in a tractable optimization model. We demonstrate how optimal allocation policies could have averted infections, deaths, and hospital costs during the first half of 2021, a period when vaccine supplies were low and COVID-19 was rampant. Our framework is a template for response to future outbreaks.

Monday, 8AM–9:15AM

MA30

CC - Room 141

iFORM: Risk Behaviors

General Session

Session Chair

Rong Li, Syracuse University, Syracuse, NY

Session Chair

Meng Li, University of Houston, Houston, TX

Session Chair

Rong Li, Syracuse University, Syracuse, NY

1 Risk Management Under Cognitive Bias: Overconfidence as a Psychological Hedge

Rong Li[1], Meng Li[2], Shuxiao Sun[3], [1]Syracuse University, Syracuse, NY, [2]University of Houston, Houston, TX, [3]Peking University, Beijing, China. Contact: rli138@syr.edu

Overconfidence (OC) and risk aversion (RA) are found as the most prevailing uncorrelated biases in managers. In the risk management literature, while RA is extensively examined, OC has never been studied. This paper is the first to study how OC affects risk management. Interestingly, we find that OC reduces RA in a linear fashion and thus can serves as a psychological hedge.

2 Managing Service Systems with Overconfident Customers

Na Zhang[1], Anand Paul[2], Xu Sun[2], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL

We study a service system where true service times are unknown and customers exhibit the cognitive bias of being overconfident (in particular, overprecise) in their beliefs about service times—customers underestimate the variability of service times. We examine the implications of overconfidence in both an unobservable queue and an observable queue. We further investigate the impact of queue length information in this setting and obtain qualitatively different results from the classical models.

3 Sell Now or Later? Regret with Price Volatility

Jingjing Weng[1], Yiwei Chen[1], Meng Li[2], [1]Temple University, Philadelphia, PA, [2]University of Houston, Houston, TX, Contact: jingjing.weng@temple.edu

Selling is of paramount significance in the trade, of which the most important aspect for a firm is to determine when to sell and how many quantities to sell. This is especially crucial under the dynamics of everchanging markets with price volatility, because firms often experience regret by both selling too soon and selling too late. In this paper, we employ dynamic programming to investigate a regret minimization firm's problem of allocating a fixed amount of capacity in a dynamic multi-period setting with price volatility.

4 Dynamic Moral Hazard with Adverse Selection

Feifan Zhang, Durham

We study the optimal incentive scheme for a long-term project with both moral hazard and adverse selection. The moral hazard issue is due to the fact that the agent's effort, which increases the arrival rate of a Poisson process, is not observable by the principal. In addition, the agent's effort cost, which needs to be reimbursed by the principal, is also the agent's private information.

Monday, 8AM–9:15AM

MA31

CC - Room 142

Analytics for Social Services

General Session

Session Chair

Vahideh Manshadi, Yale University, New Haven, CT

1 Increasing Charity Donations: A Bandit Learning Approach

Divya Singhvi[1], Somya Singhvi[2], [1]NYU Stern School of Business, New York, NY, [2]USC Marshall School of Business, Los Angeles, CA

We consider the problem of maximizing charity donations with personalized recommendations on crowd-sourcing platforms, when donor preferences are unknown. One salient feature of these platforms is that campaign recommendations do not always result in a donation. A donation is observed only when the campaign is selected and an eventual donation is made. We show that not accounting for this selection bias leads to sub-optimal recommendations. Hence, we propose the SSB algorithm to resolve the sample selection bias issue. We show that the SSB algorithm achieves near optimal rate of regret and considerably outperforms state-of-the-art learning algorithms in numerical experiments on synthetic as well as real world data sets.

2 Closing The Supply-demand Gap: Scheduling Policies for Volunteer Organizations

Mariana Escallon-Barrios, Karen Smilowitz, Northwestern University, Evanston, IL, Contact: marianaescallon2023@u.northwestern.edu

Recent research in volunteer management has explored how online scheduling platforms can be used to balance volunteer preferences with organizational needs. Strategically removing some scheduling options has been shown to improve supply/demand balance. In this talk, we explore how best to select those slots from the perspective of the staff or volunteers assigned. We proposed a max-min column generation solution approach and present a case study motivated by a disaster response volunteer-based organization to address the current coverage imbalances.

3 Combinatorial Exchange for Resource Sharing Among Nonprofits

Weixiao Huang[1], Jennifer A. Pazour[2], Alex Teytelboym[3], Andrew C. Trapp[1], [1]Worcester Polytechnic Institute, Worcester, MA, [2]Rensselaer Polytechnic Institute, Troy, NY, [3]University of Oxford, Austin, Contact: whuang2@wpi.edu

Nonprofit organizations (NPOs) often serve marginalized communities and resolve societal challenges, yet face a key barrier of severe resource limitations. We introduce a new auction-based mechanism that uses combinatorial optimization to catalyze resource exchanges among NPOs. We discuss rules of engagement, bidding languages, and nonprofit feedback toward facilitating collaboration.

4 Modeling Volunteer Response to Out-of-hospital Cardiac Arrest Cases

Pieter van den Berg[1], Shane Henderson[2], Caroline Jagtenberg[3], Hemeng Li[2], [1]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands; [2]Cornell University, Ithaca, NY, [3]Vrije Universiteit Amsterdam, Amsterdam, Netherlands. Contact: hl2359@cornell.edu

Out of hospital cardiac arrest (OHCA) requires immediate treatment and patient survival can be improved by combining traditional ambulance response with the dispatch of volunteers alerted via an app. In this talk, we explore volunteer dispatch strategies that use real-time information to determine which volunteers to alert and when, to maximize the survival rates while minimizing the total number of alerts. If time permits, we will also discuss how we model the presence of volunteers throughout a region as a Poisson point process and how we use the optimal volunteer location distribution that maximizes survival rates to guide the recruitment of volunteers.

Monday, 8AM–9:15AM

MA32

CC - Room 143

Sourcing, Production, and Distribution in Supply Chains

General Session

Session Chair

Sammi Tang, University of Miami, Coral Gables, FL

1 A Socio-technical Analysis of Blood Supply Chain Challenges in Nigeria

Temidayo Akenroye[1], Jamal El Baz[2], Femi Ogunremi[3], Olusola Olowoselu[4], [1]Liverpool Business School, Liverpool, United Kingdom; [2]Ibn Zohr University, Agadir, Morocco; [3]Monitor Healthcare Limited Nigeria, Laos, Nigeria; [4]University of Lagos, Lagos, Nigeria. Contact: T.O.Akenroye@ljmu.ac.uk

This paper examines Nigeria's blood supply chain challenges using socio-technical theory. Blood and blood products are scarce commodities in Nigeria because the demand for transfusion often exceeds supply availability. This unmet demand has contributed to increased mortality rates. Semi-structured interviews and consultation workshops were conducted to collect qualitative data from multiple stakeholders in Nigeria to examine the challenges associated with key operational activities. Different themes emerged from the thematic data analysis, which were further sub-categorized, to show the socio-technical challenges facing the blood supply chain.

2 Agricultural Subsidy Programs Under Decentralized Procurement and Deliberate Quality Degradation

Aysajan Eziz[1], Omkar D. Palsule-Desai[2], Srinagesh Gavirneni[3], [1]Ivey Business School, London, ON, Canada; [2]Indian Institute of Management Indore, Indore, India; [3]Cornell University, Ithaca, NY, Contact: aeziz@ivey.ca

The purpose of this study is to analyze two different types of farmer subsidies in India: price support scheme and price deficiency payment scheme. Given the guaranteed support price from the government under both subsidy programs, farmers are likely to engage in quality degradation behaviour to increase farm produce quantity, thus total revenue, by adding foreign particles or low-quality leftovers from previous years. We explicitly model such a degradation activity by the farmer. We systematically discuss under what conditions farmers decide to degrade and to what level. The factors considered include minimum support price, market price premium for high quality crops, farmer size, etc. We strive to gain insights for improvising/redesigning current farmer subsidy programs in India to improve the overall quality of crops while maintaining farmer support.

3 The Dynamcis of Distribution to Financially Constrained Nanostores

Zheyu Jiang[1], Harihara Prasad Natarajan[2], Nan Yang[2], [1]University of Miami, Coral Gables, FL, [2]University of Miami, Coral Gables, FL, Contact: zxj144@miami.edu

Nanostores, which account for a significant portion of fast-moving consumer goods (FMCG) market in developing countries, rely on regional distributors to replenish inventory. Take into consideration nanostores' financial constraints, we address the distribution problem for a regional distributor to supply multiple stores in a two-stage decision process. We characterize each nanostore's inventory decisions and the distributor's optimal delivery decision, which naturally decompose all stores into three mutually exclusive sets. The classification helps us to further investigate the impacts of two common levers, financial credits and retail pricing flexibility, on the distribution dynamics and all parties' profits in the supply chain.

4 Reshoring Under Tariff Uncertainty and Competition

Panos Kouvelis[1], Xiao Tan[2], Sammi Tang[3], [1]Washington University in St. Louis, St Louis, MO, [2]Washington University in St. Louis, St. Louis, MO, [3]University of Miami, Coral Gables, FL, Contact: ytang@miami.edu

Recent development in the U.S. tariff policies has forced companies to rethink their global operational strategies, particularly whether to add a domestic production location that is immune to tariffs. This paper formulates a three-stage model to analyze the global firm's reshoring capacity, output quantity, and production decisions. We examine how reshoring capacity investment is affacted by domestic competition and by tariff uncertainty at both the raw-material and finished-goods level.

Monday, 8AM–9:15AM

MA33

CC - Room 144

Socially Responsible and Sustainable Operations

General Session

Session Chair

Wei Wei, Isenberg School of Management, University of Massachusetts Amherst, Hadley, MA

1 Allocation of Funds in Bilevel Subsidy Welfare Programs

Wei Wei[1], Priyank Arora[2], Senay Solak[1], [1]University of Massachusetts Amherst, Amherst, MA, [2]University of South Carolina, Columbia, SC, Contact: wwei0@umass.edu

We analyze funds allocation problem in the subsidy welfare program (e.g., child care subsidy programs), wherein a funding agency allocates funds to multiple service agencies that make investments to enhance the quantity and quality of services received by beneficiaries at local service providers. We develop a bilevel, one-to-many, and forward-looking optimization model for the distribution of funds by taking into account: asymmetry of information (between entities at the two levels), equity consideration (by the funding agency), and service focus (of these programs). Our analysis reveals and explains how the funding agency can use funds allocation as a strategic lever to ensure the equitable social impact is generated by different agencies.

2 Examining The Impact of Leniency Bias on Supplier Audits

Tim Kraft[1], Xiaojin Liu[2], Robert Handfield[1], H. Sebastian

Heese[1], Balaji Soundararajan[1], [1]NC State - Poole College of Management, Raleigh, NC, [2]Virginia Commonwealth University, Richmond, VA, Contact: xliu22@vcu.edu

Auditing is a critical governance instrument that enables buyers to monitor suppliers and thus reduce corporate social responsibility (CSR) risk. However, auditing is not an exact science: audits are subject to potential biases that can impact their accuracy. In this study, we examine the impact of monitor leniency on facility CSR risk. Using a unique dataset consisting of historical, facility-level audits for a large global apparel brand, we find that monitor leniency in the current audit helps to reduce CSR risk. Further, we find that an increase in monitor leniency has a greater effect on facilities with low compliance ability, on facilities in developing countries, on facilities that have been audited a fewer number of times, and on facilities that experienced a greater positive change in leniency since their previous audit.

3 Delivery Terms for Voluntary Carbon Offsets

Vishal Agrawal[1], Gokce Esenduran[2], Safak Yucel[3], [1]Georgetown University, Washington, [2]Purdue University, West Lafayette, IN, [3]Georgetown University, Washington, DC, Contact: safak.yucel@georgetown.edu

A carbon offset represents one unit of reduction in greenhouse gas emissions that can be used to compensate for emissions that occur elsewhere. Companies purchase carbon offsets under two delivery terms: The first is prompt delivery, where a buyer orders offsets from a seller who has already invested in a project and generated offsets. The second is forward delivery, where a buyer orders offsets from a seller who has not yet invested. Given that the emissions reduction from the investment is uncertain, under forward delivery there is quantity risk---the seller may not generate sufficient offsets to fulfill the buyer’s order. In contrast, there is no quantity risk under prompt delivery. In this paper, we ask a fundamentally important question: Which delivery term should a buyer prefer and which one leads to a higher environmental benefit by leading to a higher investment?

Monday, 8AM–9:15AM

MA35

CC - Sagamore 1

Roundoff-Error Free Matrix Factorization Algorithms

General Session

Session Chair

Christopher Lourenco, US Naval Academy, Annapolis, MD

1 History and Background of Roundoff-error Free Factorization Algorithms

Erick Moreno-Centeno, Texas A&M University, College Station, TX

Solving sparse linear systems has a central role in solving linear programs and other optimization problems. Moreover, exactly solving linear programs and systems is necessary for some applications (e.g., theoretical results, feasibility problems, military applications, applications with hefty costs, ill-conditioned issues, etc.). To address this, we are developing the Sparse Exact (SPEX) Factorization Framework: a high-performance, well-documented, and extremely robust software package. This talk will focus on the history and the theoretical foundations of the package and companion talks on the recent developments.

2 Algorithms and Software to Solve Square Sparse Linear Systems Via Roundoff-error-free Lu and Cholesky Factorization

Christopher Lourenco, US Naval Academy, Annapolis, MD, Contact: lourenco@usna.edu

Square sparse linear systems are ubiquitous in optimization problems. For example, when solving linear programs, unsymmetric (simplex) or symmetric positive definite (interior point) linear systems must be solved. In this talk, we present algorithms and software which can exactly solve these sparse linear systems. Specifically, we present three factorizations which exactly solve the sparse linear system Ax=b in time proportional to arithmetic work---to date the only exact algorithms with this property. On the software front, we present a published software package which was shown to outperform competitor exact rational and exact iterative approaches. This software can be accessed either in C or via easy to use MATLAB and Python interfaces.

3 Roundoff-error-free QR Factorization

Lorena Mejia Domenzain, Texas A&M University, College Station, TX

QR factorization is a widely used tool in mathematics, computer science, and engineering. For example, QR factorization is regularly used to solve least squares problems. The QR factorization of matrix A is given by A=QR, where Q is an orthogonal matrix, and R is an upper triangular matrix. For some matrices, the round-off errors incurred when factorizing can lead to a loss in orthogonality. Thus, it is crucial to reduce or eliminate roundoff errors to reach the correct solution. This talk presents a roundoff-error-free (REF) QR factorization framework and algorithm. The REF QR factorization factors matrix A as A=QDR, where Q is a left orthogonal matrix, R is an upper triangular matrix, and D is a diagonal matrix. Every operation used to compute these factors is integral; thus, REF QR is guaranteed to be an exact orthogonal decomposition.

4 Exact Factorization Updates for Nonlinear Programming

Adolfo Raphael Escobedo, Arizona State University, Tempe, AZ

This talk introduces a novel approach for solving sequences of closely related systems of linear equations (SLEs) encountered in nonlinear programming efficiently and without roundoff errors. Specifically, it introduces rank-one update algorithms for the roundoff-error-free (REF) factorization framework, a toolset built on integer-preserving arithmetic that has led to the development and implementation of fail-proof SLE solution subroutines for linear programming (LP). Formal guarantees are established through the derivation of theoretical insights. Their advantages are supported with computational experiments, which demonstrate upwards of 75x-improvements over exact factorization run-times on fully dense matrices with over one million entries. An additional use of the featured algorithms for performing LP-related updates is also discussed.

Monday, 8AM–9:15AM

MA36

CC - Sagamore 2

Fair Learning and Optimization

General Session

Session Chair

Qing Ye, Blacksburg, VA

Session Chair

Weijun Xie, Virginia Tech, Blacksburg, VA

1 An Algorithmic Framework for Bias Bounties

Ira Globus-Harris, 1</sup

I will propose and analyze an algorithmic framework for "bias bounties": events in which external participants are invited to propose improvements to a trained model, akin to bug bounty events in software and security. This framework allows participants to submit arbitrary subgroup improvements, which are then algorithmically incorporated into an updated model. The algorithm has the property that there is no tension between overall and subgroup accuracies, nor between different subgroup accuracies, and it enjoys provable convergence to either the Bayes optimal model or a state in which no further improvements can be found by the participants. I will discuss the algorithm's analysis, experimental evaluation, and findings from a preliminary bias bounty event.

2 Strategic Manipulation Disparities in Fair Classification

Vijay Keswani, Yale University, New Haven, CT, Contact: vijay.keswani@yale.edu

In real-world classification settings, individuals respond to classifier predictions by updating their features to increase their likelihood of receiving positive decisions (at a certain cost), for instance, by opening multiple credit lines to improve credit scores. Yet, these kinds of strategic manipulations favor historically-advantaged groups and provide relatively fewer opportunities for socioeconomic minorities. Fair classification aims to address such disparities by constraining the classifiers to satisfy statistical fairness properties. However, we find that standard fair classifiers do not always eliminate strategic manipulation disparities. Addressing such biases requires novel analyses of connections between strategic cost functions and standard fairness metrics, and is necessary to construct models that provide equal opportunities.

3 Feamoe: Fair, Explainable, and Adaptive Mixture of Experts

Shubham Sharma[1,2], [1]University of Texas at Austin, Austin, TX, [2]University of Texas at Austin, Austin, TX, Contact: shubham_sharma@utexas.edu

Three key properties that are desired of trustworthy machine learning models deployed in high-stakes environments are fairness, explainability, and an ability to account for drift. While drift with respect to the accuracy of a model has been widely investigated, drift in regard to fairness metrics remains largely unexplored. We propose FEAMOE, a mixture of experts framework aimed at learning fairer, more interpretable models that can also rapidly adjust to drifts in both the accuracy and fairness of a classifier. We illustrate our framework for three popular fairness measures and demonstrate how drift can be handled with respect to these fairness constraints, while producing a more interpretable model. We also show that models trained on the large-scale HMDA dataset demonstrate drift with respect to both accuracy and fairness, and show that FEAMOE can handle these drifts.

4 Fermi: Fair Empirical Risk Minimization Via Exponential Renyi Mutual Information

Sina Baharlouei, University of Southern California, Los Angeles, CA, Contact: baharlou@usc.edu

Despite the success of large-scale empirical risk minimization (ERM) at achieving high accuracy across a variety of machine learning tasks, fair ERM is hindered by the incompatibility of fairness constraints with stochastic optimization. In this talk, we propose fair empirical risk minimization via the exponential R\'enyi mutual information (FERMI) framework. FERMI is built on a stochastic estimator for exponential R\'enyi mutual information (ERMI), an information divergence measuring the degree of the dependence of predictions on sensitive attributes. Theoretically, we show that ERMI upper bounds existing popular fairness violation metrics, thus controlling ERMI provides guarantees on other commonly used violations. Empirically, we show that FERMI is amenable to large-scale problems with multiple (non-binary) sensitive attributes and non-binary targets.

Monday, 8AM–9:15AM

MA37

CC - Sagamore 6

Recent Advances in Distributionally Risk-Receptive and Risk-Averse Programs

General Session

Session Chair

Sumin Kang, Virginia Polytechnic Institute and State University, Blacksburg, VA

Session Chair

Manish Bansal, Virginia Tech., Blacksburg, VA

1 Solution Approaches for Distributionally Robust Mixed-integer Programs

Sumin Kang[1], Manish Bansal[2], [1]Virginia Polytechnic Institute and State University, Blacksburg, VA, [2]Virginia Tech., Blacksburg, VA, Contact: suminkang@vt.edu

We introduce cutting-planes based solution approaches for solving distributionally robust mixed-integer programs with general ambiguity sets. We also present results of our computational experiments to showcase the effectiveness of these approaches.

2 TTRrisk: Tensor Train Decomposition Algorithm for Risk Averse Optimization

Akwum Onwunta, Lehigh University, Bethlehem, PA, Contact: ako221@lehigh.edu

We present a new algorithm to solve high-dimensional risk-averse optimization problems governed by differential equations under uncertainty. We focus on Conditional Value at Risk (CVaR), but the approach is equally applicable to other coherent risk measures. The algorithm is based on low rank tensor approximations of random fields discretized using stochastic collocation. We propose an adaptive strategy to select the width parameter of smoothed CVaR to balance the smoothing and tensor approximation errors. Moreover, unbiased Monte Carlo CVaR estimate can be computed by using the smoothed CVaR as a control variate. We introduce an efficient preconditioner for the optimality system in a full space formulation. The numerical experiments demonstrate that the proposed method enables accurate CVaR optimization constrained by large-scale discretized systems.

3 Bayesian Decision Models for Adversarial Forecasting Under Incomplete Information and Uncertainty

Tahir Ekin[1], William Nicholas Caballero[2], Roi Naveiro[3], [1]Texas State University, San Marcos, TX, [2]US Air Force Academy, Colorado Springs, CO, [3]Institute of Mathematical Sciences (ICMAT-CSIC), Madrid, Spain. Contact: t_e18@txstate.edu

Forecasting methods typically assume clean and legitimate data streams. However, adversaries may attempt to influence data and alter forecasts, which in turn may impact decisions. This talk presents a Bayesian decision theoretic approach for adversarial forecasting. Proposed adversarial risk analysis based framework allows incomplete information and adversarial perturbations on the forecasting output. We solve the adversary's poisoning decision problem where he manipulates batch data being fed into forecasting methods. Adversarial autoregressive and hidden Markov models are demonstrated with examples using real world data. The findings show the vulnerability of forecasting models under adversarial activity. We discuss potential defender strategies to improve the security of existing decision frameworks that use forecasting method outputs.

4 Distributionally Risk-receptive and Risk-averse Network Interdiction Problems with General Ambiguity Set

Manish Bansal[1], Sumin Kang[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Polytechnic Institute and State University, Blacksburg, VA, Contact: bansal@vt.edu

We consider a distributionally risk-receptive network interdiction problem (DRR-NIP) where a leader maximizes a follower's minimal expected objective value for the best-case probability distribution belonging to a given set of distributions (referred to as ambiguity set). The DRR-NIP is applicable for network vulnerability analysis where a network user (or follower) seeks to identify vulnerabilities in the network against potential disruptions by an adversary (or leader) who is receptive to risk for improving the expected objective values. We present exact and approximation algorithms for solving DRR-NIP and distributionally robust NIP with a general ambiguity set. We also provide conditions for which these approaches are finitely convergent along with our computational results.

Monday, 8AM–9:15AM

MA38

CC - Sagamore 7

Applications and Theory of Robust and Stochastic Programs

General Session

Session Chair

Nan Jiang, Virginia Tech, Blacksburg, VA

Session Chair

Weijun Xie, Virginia Tech, Blacksburg, VA

1 The Analytics of Robust Satisficing

Melvyn Sim[1], Qinshen Tang[2], Minglong Zhou[1], Taozeng Zhu[3], [1]National University of Singapore, Singapore, Singapore; [2]Nanyang Techonological University, Singapore, Singapore; [3]Institute of Supply Chain Analytics, Dongbei University of Finance and Economics,, Dalian, China. Contact: qinshen.tang@ntu.edu.sg

We propose a new prescriptive analytics model based on robust satisficing that incorporates a prediction model to determine the here-and-now decision that would achieve a target expected reward as well as possible under both risk ambiguity and estimation uncertainty. The reward function of the decision model depends on some observable parameters whose future realizations are uncertain, and their outcomes may be influenced by some observable factors or the decision made. We feature two applications and use real data in their case studies and elucidate the benefits of our robust satisficing model over the predict-then-optimize approach; when evaluated on the true distribution, the robust satisficing models yield solutions with lower risks, and with suitably chosen targets, they could also achieve higher expected reward.

2 Data-driven Distributionally Robust Optimization with Multiple Datasets: Applications to The Optimal Power Flow Problem

Adrián Esteban-Pérez[1], Yves Rychener[2], Juan M. Morales[1], Daniel Kuhn[3], [1]University of Málaga, Malaga, Spain; [2]Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland; [3]Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, Switzerland. Contact: adrianesteban@uma.es

We study data-driven distributionally robust optimization (DRO) problems where multiple datasets are available to the decision maker. Under standard assumptions on the cost function, we show that these problems can be reformulated as convex optimization problems in a DRO framework. We argue that these reformulations are useful in the Optimal Power Flow problem under ambiguity about the probability distribution of the wind power forecast error.

3 Two-stage Stochastic Program with Mixed Integer Recourse for Relay-based Network Design

Onkar Kulkarni, Mathieu Dahan, Benoit Montreuil, ISyE Georgia Tech, Atlanta, GA, Contact: onkar.kulkarni@gatech.edu

In this work, we study a two-stage stochastic program to design relay-based transportation networks. We position and size relay hubs in the first stage, while we schedule trucks for transporting commodities upon realization of commodity demand uncertainty in the second stage. Due to commodity consolidation considerations, the second stage contains integer decision variables, which makes the problem challenging to solve. To alleviate the issue, we propose algorithm(s) based on Benders-decomposition to provide good quality solutions. In order to test our approach, we apply the developed methodology to design a relay-hub network for a major car manufacturing company to be used for car deliveries.

4 An Active-set Method for Two-stage Stochastic Quadratic Programming

Niloofar Fadavi, Harsha Gangammanavar, Southern Methodist University, Dallas, TX

In this talk, we examine two-stage stochastic quadratic programming problems. The first and second stage problems are convex programs with quadratic objective functions and affine constraints. We model the uncertainty that affects the right-hand sides and variable bounds in the second stage using random variables with finite support. We provide exact and inexact proximal bundle algorithms to deal with these problems. In the inexact variation of the algorithm, we use approximate second-stage solutions to alleviate the computational difficulties associated with the exact approach. Using the relationship between the partitions generated from a primal-dual active-set method and observations of random variables, we compute approximate solutions by solving (reduced) linear systems. We present the convergence and numerical analysis of these algorithms.

Monday, 8AM–9:15AM

MA39

CC - Room 201
Industry Applications of Black-box Optimization Techniques
General Session

Session Chair
Shreyas Subramanian, Amazon Web Services, Herndon, VA

1 **Using Genetic Algorithms to Optimize Scheduling**
Greg Sommerville, AWS, New York, NY
Genetic algorithms are an efficient way to find optimal solutions within a large solution space. GAs use concepts from nature like genetic crossover, genetic mutation, and survival of the fittest to evolve a solution to a problem. In this talk, we'll introduce genetic algorithms, discuss how they work, and apply them to solve an example scheduling problem that runs with AWS SageMaker.

2 **Optimization of Robot Trajectory Planning with Nature-inspired Algorithms**
Martin Schuetz[1], Kyle Brubaker[1], Mauricio C. Resende[2], Helmut Katzgraber[3], [1]Amazon, Bellevue, WA, [2]Amazon.com, Inc., Bellevue, WA, [3]Amazon Web Services, Kirkland, WA
We solve robot trajectory planning problems at industry-relevant scales. Our end-to-end solution integrates highly versatile random-key algorithms with model stacking and ensemble techniques, as well as path relinking for solution refinement. Through a distinct separation of problem-independent and problem-dependent modules, we achieve an efficient problem representation, with a native encoding of constraints. The core optimization module consists of a biased random-key genetic algorithm. We show that generalizations to alternative algorithmic paradigms such as dual annealing are straightforward. We provide numerical benchmark results for industry-scale data sets. Our approach is found to consistently outperform greedy baseline results.

3 **Efficient Global Optimization Algorithm Using Neural Network-based Prediction and Uncertainty**
Laurel Barnet[1], Leifur Leifsson[2], Kenneth Bryden[1], [1]Iowa State University, Ames, IA, [2]Purdue University, West Lafayette, IN, Contact: labarnet@iastate.edu
Surrogates are important for global modeling and search in large engineering and science data sets. The efficient global optimization (EGO) algorithm uses the surrogate uncertainty estimator to guide the selection of the next sampling point. Gaussian process regression (or Kriging) provides an uncertainty estimate and is widely used in EGO or EGO-like algorithms. Here, an EGO-like algorithm, called the efficient global optimization with neural network-based prediction and uncertainty (EGONN), is described which uses two neural networks, one for prediction and the other modeling the prediction uncertainty. Given a set of initial data, one for each neural network, the algorithm proceeds in cycles and selects the next sampling point based on the expected improvement. EGONN is demonstrated on analytical functions and physics-based problems.

4 **How to Optimize for Emerging Mobility Solutions at Scale?**
Apoorv Maheshwari, Ernst & Young, Glenmont, NY
Several emerging mobility concepts such as flying cars, autonomous vehicles, and electric vehicles, are envisioned to be ubiquitous in future mobility ecosystem. Realizing the vision of large-scale adoption requires efficiently solving complex optimization problems, for example, placement of EV charging stations. These optimization formulations need not only account for a diverse set of data layers but also need to have somewhat explainable solutions to inform policy decisions. Additionally, given the wider applicability, the framework needs to be scalable. In this presentation, we will discuss application of a scalable optimization framework to some of these emerging transportation problems.

Monday, 8AM–9:15AM

MA40

CC - Room 202
Quantum Optimization
General Session

Session Chair
Ramin Fakhimi, Lehigh University

1 Improving QAOa with Various Warm-Start Strategies

Bryan Gard[1], Swati Gupta[2], Creston Herold[1], Greg Mohler[1], Jai Moondra[3], Reuben Tate[3], [1]Georgia Tech Research Institute, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, [3]Georgia Institute of Technology, Atlanta, GA, Contact: rtate30@gatech.edu

We discuss a warm-started variant of Quantum Approximate Optimization Algorithm (QAOA), i.e., the initial quantum state is an arbitrary separable state. In addition to changing the initial state, we change the mixing Hamiltonian in a way that aligns with adiabatic principles. Experiments suggest that even at low circuit depth, this approach is robust against noise and yields superior cuts compared to Goemans-Williamson and standard QAOA. This talk is joint work with Bryan Gard, Swati Gupta, Creston Herold, Greg Mohler, and Jai Moondra.

2 Error Mitigation for Quantum Optimization by Leveraging Problem Symmetries

Ruslan Shaydulin, JPMorgan Chase & Co., New York, NY

Hardware errors are the central obstacle to the success of the Quantum Approximate Optimization Algorithm (QAOA). We introduce an application-specific approach for mitigating the errors in QAOA evolution by performing parity checks that leverage the symmetries of the objective function to be optimized. We develop a theoretical framework for analyzing this approach under local noise and derive explicit formulas for fidelity improvements on problems with global $_2$ symmetry. We numerically investigate the symmetry verification on the MaxCut problem and identify the error regimes in which this approach improves the QAOA objective, which align well with the error rates present in near-term hardware. We further demonstrate the efficacy of symmetry verification on an IonQ trapped ion and IBM Quantum superconducting quantum processors.

3 How to Improve The Performance of The QAOA

Ramin Fakhimi[1], Hamidreza Validi[2], Illya V. Hicks[2], Tamás Terlaky[1], Luis F. Zuluaga[1], [1]Lehigh University, Bethlehem, PA, [2]Rice University, Houston, TX, Contact: raf318@lehigh.edu

QAOA is one of the promising quantum algorithms for solving combinatorial optimization problems. We investigate different derivative-free optimization algorithms for finding optimal parameters. We also examine the impact of quadratic unconstrained binary optimization (QUBO) models on the associated QAOA in this study. Notably, we explore the effect of the penalty coefficients. We propose two QUBO models with tight penalty coefficients for the max k-cut problem. We show how different models affect the quality of solutions concerning the feasibility and the objective value. For at least 60% of test instances, the computational experiments show the superiority of the tight models over naive ones in terms of the quality of feasible solutions. Finally, we investigate how tight penalty coefficients can mitigate the effect of intrinsic noise of quantum computers.

4 Solving The Semidefinite Relaxation of QUBOs in Matrix Multiplication Time, and Faster with a Quantum Computer

Brandon Augustino, Lehigh University, Landing, NJ

Recent works on quantum algorithms for solving semidefinite optimization problems have leveraged a quantum-mechanical interpretation of positive semidefinite matrices to obtain quantum speedups with respect to the dimension n and sparsity measure s. While their dependence on other parameters suggests no overall speedup, some quantum SDO solvers provide speedups in the low-precision regime. We present an iterative refinement scheme for the Hamiltonian Updates algorithm of Brandão et al. (Quantum 6, 625 (2022)) to exponentially improve the dependence of their algorithm on precision. As a result, we obtain a classical algorithm to solve the semidefinite relaxation of Quadratically Unconstrained Binary Optimization problems in matrix multiplication time, and in time $\tilde{\Ocal} (n^{1.5} s^{0.5 + o(1)})$ with a quantum computer.

Monday, 8AM–9:15AM

MA41

CC - Room 203

Recent Advances in Nonconvex Optimization II

General Session

Session Chair

Salar Fattahi, University of Michigan, Ann Arbor, MI

Session Chair

Cedric Josz, Columbia University, Le Kremlin-Bicetre, France.

Session Chair

Richard Zhang, UC Berkeley, Berkeley, CA

1 Non-convex Optimization in Unsupervised Learning

Kaizheng Wang, Columbia University, New York, NY

This talk concerns non-convex optimization in unsupervised learning.

2 Comparing Solution Paths of Sparse Quadratic Minimization with a Stieltjes Matrix

Ziyu He[1], Shaoning Han[2], Andres Gomez[2], YING CUI[3], Jong-Shi Pang[2], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, [3]University of Minnesota, Minneapolis, MN, Contact: ziyuhe@usc.edu

This paper studies several solution paths of sparse quadratic minimization problems as a function of the weighing parameter of sparse regularizer. Three such paths are considered: the “ℓ_0-path” which is exact but computationally expensive; the “ℓ_1-path” where the ℓ_1-function provides a convex surrogate; and the “capped ℓ_1-path” where the capped ℓ_1-function aims to enhance the convex approximation. Our study of the capped ℓ_1-path is the first of its kind as the path pertains to computable directionally stationary solutions of a parametric nonconvex nondifferentiable problem. A major conclusion of this paper is that a capped ℓ_1 directional stationary path offers interesting theoretical properties and practical compromise between the ℓ_0 and the ℓ_1-paths.

3 Presenter

Rahul Mazumder, Massachusetts Institute of Technology, Cambridge, MA

4 Rational Generalized Nash Equilibrium Problems

Jiawang Nie[1], Xindong Tang[2], Suhan Zhong[1], [1]UCSD, San Diego, CA, [2]The Hong Kong Polytechnic University, Hong Kong, Hong Kong.

This talk discusses generalized Nash equilibrium problems that are given by rational functions. Rational expressions for Lagrange multipliers and feasible extensions of KKT points are introduced to compute generalized Nash equilibria (GNEs). We give a hierarchy of rational optimization problems to solve rational generalized Nash equilibrium problems. The existence and computation of feasible extensions are studied. The Moment-SOS relaxations are applied to solve the rational optimization problems. Under some general assumptions, we show that the proposed hierarchy can compute a GNE if it exists or detect its nonexistence. Numerical experiments are given to show the efficiency of the proposed method.

Monday, 8AM–9:15AM

MA42

CC - Room 204

Diversity, Equity, and Inclusion: Examples of Best Practices at Universities in the US

Panel Session

Session Chair

Juliane Mueller, Lawrence Berkeley National Lab, Berkeley, CA

1 Diversity, Equity, and Inclusion: Examples of Best Practices at Universities in The US

Juliane Mueller, Lawrence Berkeley National Lab, Berkeley, CA, Contact: juliane.mueller2901@gmail.com

Diversity, Equity, and Inclusion (DEI) are key ingredients that enable organizations to reach their goals. They are critical for building successful and highly performing teams who work together toward meaningful outcomes. Our panelists will discuss how DEI is supported at their universities, what impact DEI have had on their research and careers, and what specific actions you can take to support DEI at your organization. Please join us for this exciting discussion and bring your questions.

2 Panelist

Victoria C. P. Chen, The University of Texas at Arlington, Arlington, TX

3 Panelist

Susan E. Martonosi, Harvey Mudd College, Claremont, CA

4 Panelist

Michael P. Johnson, University of Massachusetts Boston, Boston, MA, Contact: michael.johnson@umb.edu

5 Panelist

Candace Arai Yano, University of California-Berkeley, Berkeley, CA, Contact: yano@ieor.berkeley.edu

Monday, 8AM–9:15AM

MA43

CC - Room 205

Accelerated Algorithms for Linear and Quadratic Programs

General Session

Session Chair

DongDong Ge, Shanghai University of Finance and Economics, Shanghai, China.

Session Chair

Zikai Xiong, Massachusetts Institute of Technology, Cambridge, MA

1 Continuous-time Analysis of AGM Via Conservation Laws in Dilated Coordinate Systems

Jaewook J. Suh, Gyumin Roh, Ernest Ryu, Seoul National University, Department of Mathematical Sciences, Seoul, Korea, Republic of. Contact: jacksuhkr@snu.ac.kr

We analyze continuous-time models of accelerated gradient methods through deriving conservation laws in dilated coordinate systems. Namely, instead of analyzing the dynamics of $X(t)$, we analyze the dynamics of $W(t)=t^\alpha(X(t)-X_c)$ for some α and X_c and derive a conserved quantity in this dilated coordinate system. Through this methodology, we recover many known continuous-time analyses in a streamlined manner and obtain novel continuous-time analyses for OGM-G, an acceleration mechanism for efficiently reducing gradient magnitude that is distinct from that of Nesterov. Finally, we show that a semi-second-order symplectic Euler discretization in the dilated coordinate system leads to an $\mathcal{O}(1/k^2)$ rate on the standard setup of smooth convex minimization, without any further assumptions such as infinite differentiability.

2 An ADMM-Based Interior-Point Method for Conic Optimization

Joachim Dahl, Cardinal Operations, Denmark.

We consider an ADMM-based interior-point method conic optimization. We consider both symmetric and non-symmetric cones, and we give preliminary computational results for a selection of large-scale problems.

3 From An Interior Point to a Corner Point: Smart Crossover

Chengwenjian Wang, ETH Zurich, Zurich, Switzerland.

The crossover in solving linear programs is a procedure to recover an optimal corner/extreme point from an approximately optimal inner point generated by classical interior-point methods or emerging first-order methods. Unfortunately, the computation time of this procedure can be much longer than the time of the former stage. Our work shows that this bottleneck can be significantly improved if the procedure smartly takes advantage of the problem characteristics and implements customized strategies. Specifically, we design smart crossover algorithms for the problem with the network structure and the problem with a large optimal face. The comparison experiments with state-of-art commercial LP solvers on classical linear programming problem benchmarks, network flow problem benchmarks, and MINST datasets exhibit their considerable advantages in practice.

4 DRSOM: A Dimension-Reduced Second-Order Method

Chuwen Zhang, Shanghai University of Finance and Economics, Shanghai, China. Contact: chuwen@shanshu.ai

We introduce a Dimension-Reduced Second-Order Method (DRSOM) for convex and nonconvex unconstrained optimization. Under a trust-region-like framework our method preserves the convergence of the second-order method while only using Hessian-vector products in two directions. Moreover, the computational overhead remains comparable to the gradient descent method. We show that the method has a complexity of $O(\square^{-3/2})$ to satisfy the first-order and second-order conditions in the subspace. The applicability of DRSOM is exhibited by various computational experiments in logistic regression, L_2-L_p minimization, sensor network localization, and neural networks. For neural networks, our method gains computational advantages in terms of iteration complexity over state-of-the-art first-order stochastic methods, such as ADAM.

Monday, 8AM–9:15AM

MA44

CC - Room 206

Networks and Deep Learning

General Session

Session Chair

Lingxun Kong, The Dow Chemical Company, Lake Jackson, TX

1 Using Weighted Behavioral Co-expression Networks for Deception Detection

Xinran Wang[1], Steven Pentland[2], [1]University of Arizona, Tucson, AZ, [2]Boise State University, Boise, ID, Contact: xinranwang@arizona.edu

Human behavior involves the simultaneous coordination of multiple channels (e.g., face, voice). Most deception research treats these separately, failing to capture the interactions between channels. We view the human body as a coordinated system and apply network science methodologies to deception detection tasks. Specifically, we construct weighted behavioral co-expression networks (CoNets) which represent patterns of correlation among nonverbal behaviors. We test the hypothesis that deceivers and truthtellers differ in their behavioral coordination and that these differences manifest as different network properties. We employ node embeddings to represent CoNets for predicting deception. Preliminary results show that deception detection performance using CoNets node embeddings outperforms methods that aggregate features independently.

2 Distributed and Asynchronous Multi-task Learning

Lingzhou Hong, Alfredo Garcia, Texas A&M University, College Station, TX

The ever-growing size and complexity of data create scalability challenges for storage and processing. In certain application domains, data streams are spatially distributed and their underlying models are not necessarily the same. We consider a distributed asynchronous Multi-Task Learning scheme that accounts for heterogeneous and correlated data streams. We assume that nodes can be partitioned into groups corresponding to different learning tasks and are connected in a directed network. Each node estimates a linear model asynchronously and is subject to local (within-group) regularization and global (across groups) regularization terms targeting noise reduction and generalization performance improvement. We provide a finite-time characterization of convergence and illustrate the scheme's general applicability in real-world examples.

3 Design and Operations for Complex Site Product Network Integration Under Uncertainty

Yixin Ye[1], Lingxun Kong[1], Scott Bury[2], [1]The Dow Chemical Company, Lake Jackson, TX, [2]The Dow Chemical Company, Midland, MI, Contact: lkong1@dow.com

Unplanned events, such as equipment failures or raw material shortages, are major challenges faced by highly integrated chemical manufacturing sites due to the large number of critical points and the propagation effect on the manufacturing network. At Dow, we built a web-based application to provide algorithmic traversing of such manufacturing network graphs for impact analyses of the unplanned events. In addition, a MILP model was developed to generate optimal inventory reallocation solutions. With minimal adaption effort, this app also allows decision makers to proactively study the impact of planned events (e.g., maintenance) and adjust inventory and production plans. On the design level, we use an AI agent-based approach to establish a bottleneck identification procedure for the site considering asset reliability as well as supply/demand scenarios.

Monday, 8AM–9:15AM

MA45

CC - Room 207

Advances in Optimization for Machine Learning

General Session

Session Chair

Kayhan Behdin, Massachusetts Institute of Technology, Cambridge, MA

1 Rank-Constrained Optimization Problem

Yongchun Li, Weijun Xie, Virginia Tech, Blacksburg, VA, Contact: liyc@vt.edu

We study the rank-constrained convex optimization problem. We prove necessary and sufficient conditions under which a convex relaxation is equal to the convex hull of the feasible region.

2 PARS-Push: Personalized, Asynchronous and Robust Decentralized Optimization

Mohammad Taha Toghani[1], Soomin Lee[2], Cesar A. A. Uribe[3], [1]Rice University, Houston, TX, [2]Yahoo! Research, Sunnyvale, CA, [3]Rice University, Houston, TX, Contact: mttoghani@rice.edu

We study the multi-step Model-Agnostic Meta-Learning (MAML) framework where a group of n agents seeks to find a common point that enables "few-shot" learning (personalization) via local stochastic gradient steps on their local functions. We formulate the personalized optimization problem under the MAML framework and propose PARS-Push, a decentralized asynchronous algorithm robust to message failures, communication delays, and directed message sharing. We characterize the convergence rate of PARS-Push for smooth and strongly convex and smooth and non-convex functions under arbitrary multi-step personalization. Moreover, we provide numerical experiments showing its performance under heterogeneous data setups.

3 Integer Programming for Subspace Clustering with Missing Data

Akhilesh Soni, Jeff T. Linderoth, Jim R. Luedtke, Daniel Pimentel Alarcon, University of Wisconsin-Madison, Madison, WI, Contact: soni6@wisc.edu

In the Subspace Clustering with Missing Data (SCMD) problem, we are given a collection of points where each of the points is observed partially, and the points are assumed to lie in the union of a small number of low-dimensional subspaces. The goal is to identify clusters of vectors belonging to the same subspace and learn the corresponding basis.
We propose a mixed-integer nonlinear programming framework that is based on dynamically determining a set of candidate subspaces and optimally assigning points to selected subspaces. We propose a Benders' decomposition approach for solving the LP relaxation and integrate it with a column-generation approach for generating new subspaces. An empirical study shows that our framework achieves better clustering accuracy than state-of-the-art methods when the data is high rank or the percentage of missing data is high.

4 On Distributed Exact Sparse Linear Regression over Networks

Tu Nguyen[1], Cesar A. Uribe[2], [1]Rice University, Houston, TX, [2]Rice University, Houston, TX, Contact: tan5@rice.edu

In this work, we propose an algorithm for solving exact sparse linear regression problems over a network in a distributed manner. Particularly, we consider the problem where data is stored among different computers or agents that seek to collaboratively find a common regressor with a specified sparsity k. The main novelty in our proposal lies in showing a problem formulation with zero duality gap for which we adopt a dual approach to solve the problem in a decentralized way. This sets a foundational approach for the study of distributed optimization with explicit sparsity constraints. We show theoretically and empirically that, under appropriate assumptions, where each agent solves smaller and local integer programming problems, all agents will eventually reach a consensus on a sparse optimal regressor.

Monday, 8AM–9:15AM

MA46

CC - Room 208

Crowdsourced Last-Mile Delivery

General Session

Session Chair

He Wang, Georgia Tech, Atlanta, GA

Session Chair

Adam Behrendt, Georgia Tech, Atlanta, GA

1 Dynamic Pricing Under a Ridesharing Network: A Tighter Upper Bound than Fluid Approximation

Yiming Jiang[1,2], [12]Georgia Institute of Technology, Atlanta, GA

Motivated by ridesharing platforms like Uber, we study dynamic pricing problem under a closed queuing network. Due to the exponentially large state space, fluid approximation was proposed to deal with the computational intractability. Different from fluid approximation which generates static pricing policy, we propose a dynamic pricing policy which utilizes both the information from origin and destination in each trip. We prove that our model yields a tighter upper bound than fluid approximation. And the gap between these two upper bounds is provided. Moreover, we demonstrate how to use value function approximation to reduce problem size. Computational experiments with synthetic data show that our dynamic pricing policy outperforms static policy generated by fluid approximation.

2 Gamifying Learning in Mathematical Optimization: The Burrito Optimization Game

Lawrence V. Snyder, Lehigh University, Bethlehem, PA

The Gurobi Burrito Optimization Game is a new educational game designed to introduce learners to the power of optimization. Players choose locations for burrito trucks on a city map to maximize their revenue. The free web-based game can be used in OR, data science, or other courses, or as a standalone app. The game teaches users why optimization is valuable and important, why it's difficult, and why solvers and other optimization algorithms are. In this talk, I will introduce the game and discuss learning outcomes that can emerge, including teachable moments such as the tradeoff between fixed costs and variable revenues, directional changes in the optimal solution as the data change, and why enumeration is not a practical approach.

3 Two-echelon Prize-collecting Vehicle Routing with Time Windows and Vehicle Synchronization: A Branch-and-price Approach

I. Edhem SAKARYA[1], Milad Elyasi[2], Sonja Rohmer[3], Örsan Özener[2], Ali Ekici[2], Tom Van Woensel[4], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Ozyegin University, Istanbul, Turkey; [3]HEC Montreal, Montreal, QC, Canada; [4]Eindhoven University of Technology, Mb Eindhoven, Netherlands. Contact: i.e.sakarya@tue.nl

Traffic congestion and air and noise pollution in urban areas are aggravating due to the increasing rate of urbanization and the resulting tendency toward utilizing e-commerce in grocery delivery in cities. Adverse health effects linked to this pollution demand the implementation of appropriate countermeasures that reduce the number of vehicles and mitigate the environmental impact of logistics within cities. One possible solution is the use of cargo bikes and large vehicles simultaneously. An integrated planning approach presents opportunities by allowing to replenish the cargo bikes from the inventory of the larger-sized vehicles without having to return to a depot location. In this context, we propose a branch-and-price algorithm to solve 2E-PC-VRP with Time Windows and Vehicle Synchronization and obtain promising results in comprehensive numerical studies.

4 Courier Coordination Policies for Crowdsourced Delivery with a Hybrid Fleet of Couriers

Adam Behrendt, Georgia Tech, Atlanta, GA

Crowdsourced delivery platforms operate as an intermediary between consumers who place orders and couriers who make deliveries; both of which are uncertain. Crowdsourced delivery platforms have begun to utilize multiple courier types (i.e., a hybrid system) with the hope of reaping the advantages of each. In this paper, we address the challenge of managing two types of couriers at both the planning and operational level. We present fluid models for fleet sizing and order pricing that establish the superiority of a hybrid system over each system individually. Furthermore, we study order allocation policies between the two systems and study order pooling and splitting policies in depth. In our online experiments we find that a look ahead splitting policy outperforms pooling and batching policies by 2.4% while being more robust uncertainty.

Monday, 8AM–9:15AM

MA47

CC - Room 209

OR Operations and Simulations

General Session

Session Chair

V. Varadarajan, Norfolk Southern, Suwanee, GA

1 EVALUATING PEAK VOLUME RECOVERy in HUMP YARDs with ANYLOGIC SIMULATION

Jiaxi Zhao[1], Tyler Dick[2], [1]University of Illinois at Urbana Champaign, Urbana, IL, [2]U of Illinois at Urbana-Champaign, Urbana, IL, Contact: jiaxiz3@illinois.edu

As freight transportation demand continues to increase worldwide, great stress has been given to the classification yards to ensure accurate and efficient operations to sort freight to their destinations. Seasonal and unplanned surges in freight demand and disruptions from incidents and maintenance activities add to congestion in yards and even affect the mainline network. Quantifying the influence and recovery patterns of peak demands has been challenging due to the limitation to implement experiments in the field. This research developed a novel hump yard simulation model using AnyLogic software and conducted various experiments to study the impact of the extents of volume increment and the duration of volume peak on the recovery pattern of hump yards in terms of the change in railcar average dwell time.

2 ANALYTICAL MODELs on YARD CAPACITY

V. Varadarajan, Norfolk Southern, Suwanee, GA

A review of analytical models on yard capacity will be presented and potential variations will be discussed along with the insight we gain for congestion modeling using analytical approaches.

3 An Integrated Approach for Social Distancing and Revenue Optimization in Long Distance Passenger Trains

MD Tabish Haque, Faiz Hamid, Indian Institute of Technology Kanpur, Kanpur, India. Contact: tabish@iitk.ac.in

The present study aims to develop an integrated model that minimizes the spread of COVID-19 through multi-dimensional social distancing rules and maximizes train operator revenue via a quantity-based revenue strategy in a post-pandemic world. The seating plan incorporates a group seat reservation policy where social distancing rules are relaxed within the same group. This is due to a shallow risk of virus spread within a group and increased capacity utilization. A mixed-integer linear program (MILP) is proposed to build a seating plan. Several classes of valid inequalities are also employed to strengthen the MILP model. The validity of the model and the efficacy of valid inequalities have been tested on real-life instances. The computational results illustrate a significant improvement in both the objectives compared to the present practice observed by operators.

4 Tools for Predicting Decarbonization Impacts for the Rail Freight Industry

George F. List, NC State, Raleigh, NC

Identifying low cost decarbonization pathways for the rail freight industry is critical to achieve goals of net zero carbon emissions. The industry is a major consumer of diesel fuel. However, freight railroad operations are complex, the power demands are significant for individual trains, and the distances between refueling locations are long. For technologies like battery power and hydrogen fuel cells, there are also challenges about tying recharging stations to the power distribution grid. This presentation describes a set of tools being developed to allow analysts to explore ways in which the rail freight industry's use of diesel fuel can be reduced or eliminated. Included are modules for identifying decarbonization pathways, future rail freight demand, energy consumption by national region, supporting recharging technology, interfaces with the power grid, and costs.

Monday, 8AM–9:15AM

MA48

CC - Room 210

Intelligent Intersection Management and Control with Emerging technologies

General Session

Session Chair

Yiheng Feng, Purdue University

1 Learning The Max Pressure Control for Urban Traffic Networks Considering The Phase Switching Loss

Xingmin Wang[1], Yafeng Yin[1], Yiheng Feng[2], Henry Liu[3], [1]University of Michigan, Ann Arbor, MI, [2]Purdue University, West Lafayette, IN, [3]University of Michigan, Ann, MI, Contact: xingminw@umich.edu

This work proposes a novel framework that utilizes reinforcement learning algorithms to optimize a max pressure controller considering the phase switching loss. We extend the max pressure control by introducing a switching curve and prove that the proposed control method is throughput-optimal in a store-and-forward network. Then the theoretical control policy is extended by using a distributed approximation and position-weighted pressure so that the policy-gradient reinforcement learning algorithms can be utilized to optimize the parameters in the policy network. The proposed framework combines the strengths of the data-driven method and the theoretical control model; it is also of great significance for real-world implementations because the proposed control policy can be generated in a distributed fashion based on local observations.

2 Cvlight: Decentralized Learning for Adaptive Traffic Signal Control with Connected Vehicles

Wangzhi Li[1], Zhaobin Mo[2], Yongjie Fu[3], Kangrui Ruan[2], Sharon Di[2], [1]Purdue University, West Lafayette, IN, [2]Columbia University, New York, NY, [3]Columbia University, New york, NY, Contact: li4444@purdue.edu

This paper develops a decentralized reinforcement learning (RL) scheme for multi-intersection adaptive traffic signal control (TSC), called "CVLight", that leverages data collected from connected vehicles (CVs). A novel algorithm, Asymmetric Advantage Actor-critic (Asym-A2C), is proposed where both CV and non-CV information is used to train the critic network, while only CV information is used to execute optimal signal timing. Experiments show the superiority of CVLight over state-of-the-art algorithms under a 2-by-2 synthetic road network with various traffic demand patterns and penetration rates. A case study further demonstrated the effectiveness of CVLight under real-world scenarios. Compared to other baseline models, the trained CVLight agent can efficiently control multiple intersections solely based on CV data and achieve the best performance.

3 Real-time Network-level Signal and Trajectory Optimization in Mixed-autonomy Environments

Ali Hajbabaie, Ramin Niroumand, Leila Hajibabai, North Carolina State University, Raleigh, NC

This study develops a real-time framework for the network-level integrated signal and trajectory optimization in mixed autonomy environments. The network-level problem is decomposed into intersection-level sub-problems and embedded into a coordination scheme via information exchange to push the intersection-level solutions toward the network-level optima. Each intersection uses a bi-level architecture to solve the joint problem. An efficient shooting heuristic is developed to optimize the trajectories of connected-automated vehicles (CAVs) while the trajectories of connected human-driven vehicles (CHVs) are estimated using a customized car-following model with a given set of signal timing plans in the lower level. The upper level enumerates all the feasible signal timing plans and selects the one with the best objective function to be implemented.

Monday, 8AM–9:15AM

MA49

CC - Room 211

Coordination and Collaboration in Freight Logistics

General Session

Session Chair

Bram De Moor, KU Leuven, Leuven, Belgium.

1 The Hidden Costs of Not-so-friendly Ghost Lanes

Angela Acocella, Tilburg University, Tilburg, Netherlands. Contact: a.j.acocella@tilburguniversity.edu

Shippers' procurement of truckload transportation is a costly process. Shippers adopt a coverage strategy to secure contracted capacity upfront to reduce potential administrative and search costs later on if and when volume materializes. However, this strategy leads to unnecessary costs and inefficiencies when lanes are procured that do not end up being used. In fact, 70% of shippers' procured lanes are never utilized. These ghost lanes cause network imbalances for carriers. Using a large transaction dataset, we demonstrate that a high rate of ghosting from a shipper in one year contributes to a carrier inflating contract prices the following year for that shipper. We characterize lanes most likely to be ghosted before they occur, demonstrate how these potential ghost lanes tend to underperform, and show ways to reduce the rate - and negative effects - of ghosting.

2 A Statistical Approach for Design of a New Facility Based on Horizontal Collaboration

Dilhani Shalika Marasinghe, Clemson University, Clemson, SC, Contact: dmarasi@g.clemson.edu

This study presents a new type of facility in a future logistics system based on horizontal collaboration. These facilities organize and reroute pallets or similar-sized containers. Freight rerouting decisions are made dynamically based on last-minute information about inbound pallets, and limited storage is available in the facility to temporarily store a few pallets. A pallet assignment model (PAM) is introduced to determine the decisions in a single period that minimizes the penalty. The model is then used to experimentally investigate the impact of the amount of storage. The number of pallets sent to storage across many scenarios is described by a Gamma - Poisson distribution. Further, an experimental approach is taken that centers on parameters critical to the design of these facilities. A factorial design was performed to determine the effect of design parameters.

3 The (s,m,S) Policy: Increasing Truck Efficiency Through Collaborative Shipping

Bram De Moor[1], Robert N. Boute[2,3,4], Stefan Creemers[5], [1]Netherlands; [2]KU Leuven, Leuven, Belgium; [3]Vlerick Business School, Leuven, Belgium; [4]Flanders Make, Leuven, Belgium; [5]IESEG School of Management, Lille, France.

Collaborative shipping can reduce truck usage in today's supply chains. To orchestrate collaborative shipping, ordering policies from the joint replenishment problem can be used. However, these policies often make abstraction of capacity constraints of the shared transport mode. In this paper, we propose a novel joint replenishment policy that takes capacity constraints into account: the *(s,m,S)* policy, with *(s,S)* the traditional reorder point and order-up-to level, and *m* the minimum order quantity for which a company is willing to join a replenishment. We develop an optimization procedure and benchmark our policy against other (capacitated) joint replenishment policies. Furthermore, we demonstrate how our policy can be used to engage with freight sharing platforms, on which companies are offered spare truck capacity at certain moments in time.

Monday, 8AM–9:15AM

MA50

CC - Room 212
E-Business and Online Platforms
General Session

Session Chair
Changseung Yoo, McGill University, Montreal, QC, Canada.

1 Device Targeting in Mobile Search Advertising

Sai Soundarya Gorthi[1], Kartik Ganju[2], Alain Pinsonneault[1], [1]McGill University, Montreal, QC, Canada; [2]University of Minnesota, Minneapolis, MN, Contact: sai.gorthi@mail.mcgill.ca

We examine if the paid information search results(ads) received on mobile devices are tailored to the model of the user device. We emulated different models of Apple mobile devices to collect the ads they receive for the search term "buy baby toys." Comparing the average first two and first three ad (maximum number of ads visible on a mobile screen) prices across the devices indicates that the latest models of mobile devices have a significantly higher average ad price compared to older models. Our preliminary analysis also indicates that the latest model receives ads of a higher price more frequently than older models. Our results show that targeting is possible without socio-demographic data about the user, calling into question the efficacy of recent regulations restricting targeting to advertisements based on user characteristics.

2 An Unintended Consequence of Platform Dependence: Empirical Evidence from IT-enabled Food-delivery Platforms

Varun Karamshetty[1], Michael Freeman[2], Sameer Hasija[2], [1]National University of Singapore, Singapore, Singapore; [2]INSEAD, Singapore, Singapore. Contact: varun.karamshetty@nus.edu.sg

Digital food-delivery platforms increase restaurants' catchment area and reduce search costs for customers. Larger catchment area allows restaurants to pool their risks and decreases noise in demand, whereas reduced search costs increases competition and noise. Overall, it is unclear how these competing factors affect restaurants' ability to forecast demand - a critical factor for operational efficiency and profitability. We empirically investigate the impact of food-delivery platforms on demand forecast error in restaurants. We find that a 10 percentage point increase in dependence on delivery platforms leads to a 2.83% increase in overall forecast error. We also find that the majority of increase is due to increase in the error associated with forecasting intra-day demand pattern, and a smaller portion is due to error in forecasting inter-day demand amplitude.

3 Ways to Have Successful Self-improvement Activities: An Empirical Study of Reminder Effects for Different Types of Procrastinators

Kyung Pyo Kang, Jaehong Park, Kyung Hee University, Seoul, Korea, Republic of. Contact: kpkang0646@khu.ac.kr

While many people have self-growth activities, not all people are equally motivated nor do they keep their goal commitment over time. For example, while some people routinely get involving their activities (i.e., non-procrastinators), other people tend to procrastinate their self-growth activities (i.e., procrastinators). To support people's goal achievements, previous studies have investigated various strategies (e.g., providing reminders). However, they overlooked the different effects of such strategies depending on the type of who you are. This study aims to reveal how differently reminders (push-alarm) affect people's goal achievements depending on whether the people procrastinate their activities or not. We expect this paper will expand the understanding of successful self-growth activities associated with people's behavior of procrastination.

4 Where Do You Want to Buy a Game Item? Empirical Study of The Price Fluctuation of a Game Item at Used Market

SeungMin Hong, GaHyeon Jeong, JaeHong Park, Kyung Hee University, Seoul, Korea, Republic of. Contact: seungmin.h9748@gmail.com

Online game users frequently make transactions in the RMT (Real Money Trading) market to strengthen their game characters easily instead of the in-game purchases. Weempirically examine how the shock from the game (e.g., the release of the game update patch) influences the price of game items traded at the RMT market using DID (Difference-In-Differences) methods. In particular, we classify items to the game item categories (e.g., weapons, armors, etc.) as the patch is often related to the game items such as the power balance of weapons. We initially found that the release of game patch raises the average item price at RMT market, and such effect varies depending on game item purposes. Thus, this study will contribute to the game item price design as this finding can provide an understanding of the role of the RMT market in the game economy.

Monday, 8AM–9:15AM

MA51

M - Santa Fe

Daniel H. Wagner Prize

Award Session

Session Chair

Margret V. Bjarnadottir, University of Maryland, College Park, MD

Session Chair

Andrew S. Wasser, Carnegie Mellon University, Pittsburgh, PA

1 AI vs. Human Buyers: A Study of Alibaba's Inventory Replenishment System

Jiaxi Liu[1], Shuyi Lin[1], Linwei Xin[2], Yidong Zhang[1], [1]Alibaba Group, Hangzhou, China; [2]University of Chicago, Chicago, IL

Inventory management is one of the most important components of Alibaba's business. Traditionally, human buyers make replenishment decisions: although AI algorithms make recommendations, human buyers can choose to ignore and make their own decisions. The company has been exploring a new replenishment system in which algorithmic recommendations are final. The algorithms combine state-of-the-art deep reinforcement learning techniques with the framework of fictitious play. By learning the supplier's behavior, we are able to address an important endogeneity issue of lead time and fill rate on order quantity, which has been ignored in the extant literature of stochastic inventory control. We present evidence that our algorithms outperform human buyers in terms of reducing out-of-stock rates and inventory levels. More interestingly, we have seen additional benefits amid the pandemic. Over the last two years, cities in China have (partially) intermittently locked down to mitigate COVID-19 outbreaks. We have observed panic buying from human buyers during lockdowns, leading to the bullwhip effect. By contrast, panic buying and the bullwhip effect can be mitigated under our algorithms, due to their ability to capture the change in the supplier's behavior during lockdowns.

2 Generalized Synthetic Control for TestOps at ABI: Models, Algorithms, and Infrastructure

Tianyi Peng[1], Foncea Patricio[1], Vivek Farias[2], Ivo Montenegro[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT, Cambridge, MA, [3]Portugal. Contact: tianyi@mit.edu

We describe a novel approach to learning from experiments in the world of physical retail, and an associated platform, TestOps, implemented by ABI and MIT. TestOps leverages a recent theoretical breakthrough to learn from experiments when treatment effects are small, the environment is noisy and non-stationary, and adherence problems are commonplace, resulting in ~100x increase of experimental power relative to alternatives. TestOps currently runs experiments impacting ~135M USD in revenue every month and routinely identifies interventions that result in a 1-2% increase in sales volume.

Monday, 8AM–9:15AM

MA52

M - Lincoln
Project Scheduling
General Session

Session Chair
Norbert Trautmann, Switzerland.

1 A Novel Mixed-integer Linear Programming Model for The Multi-mode Resource-constrained Project Scheduling Problem

Nicklas Klein, Department of Business Administration, Bern, Switzerland. Contact: nicklas.klein@unibe.ch

In many projects, there are tradeoffs between the resource requirements and durations of activities. These tradeoffs can be represented via multiple execution modes of the activities, which is considered in the multi-mode resource-constrained project scheduling problem (MRCPSP). Given are precedence-related activities whose durations and resource requirements depend on the chosen execution mode. Sought are the activities' start times and modes to minimize the project makespan. We present a novel MILP model that uses two kinds of sequencing variables to detect which activities are executed in parallel. A numerical comparison indicates that the novel model outperforms the state-of-the-art models on instances with relatively long activity durations.

2 Multi-site Project Scheduling Under Resource Constraints

Tamara Bigler, Mario Gnaegi, Norbert Trautmann, University of Bern, Bern, Switzerland. Contact: norbert.trautmann@unibe.ch

The execution of a project often requires resources which are distributed among multiple sites, and therefore transportation times must be considered for moving some mobile resource units or the output of some precedence-related activities. Example applications arise in hospital clusters that are sharing pools of medical personnel and medical devices, and in a make-to-order production that is carried out by several partners in a supply chain. We present a MILP-based approach for minimizing the duration of such a project subject to completion-start precedence and renewable-resource constraints.

3 Efficient Algorithms for Project Scheduling with Autonomous Learning

Alessandro Hill[1], Thomas Vossen[2], [1]California Polytechnic State University, San Luis Obispo, CA, [2]University of Colorado-Boulder, Boulder, CO, Contact: ahill29@calpoly.edu

We study a class of novel project scheduling problems that incorporate autonomous learning. In these models, certain jobs can be completed in a reduced amount of time if scheduled after jobs that lead to acquiring relevant experience. We consider single-and multi-predecessor learning and present corresponding learning mechanisms. We discuss the structure and complexity of these combinatorial problems and devise polynomial algorithms to solve them. In a computational analysis, we quantify the potential scheduling benefits that can be obtained when integrating learning compared to classical project scheduling.

4 Further Revisions to The Pert Model with Lognormal Activity Times

Eric Logan Huggins[1], Ivan G. Guardiola[2], [1]Fort Lewis College, Durango, CO, [2]Fort Lewis College, Durango, CO, Contact: huggins_e@fortlewis.edu

We consider the PERT model but with activity times that follow lognormal distributions rather than the traditional PERT-Beta distributions. The lognormal distribution has an infinite right tail which allows for activities to be delayed indefinitely, requiring the project planner to determine how confident they are when estimating pessimistic times. We develop a model for the project completion time using a single lognormal distribution using approximation methods. We also consider a Bayesian model for the project completion time that can be updated while the project is ongoing.

Monday, 8AM–9:15AM

MA53

M - Denver
Analytical Issues in Service Science
General Session

Session Chair
Varun Gupta, Penn State Erie, The Behrend College, Erie, PA

1 Data-driven Condition-based Maintenance for Perpetual Systems

Sandun Perera[1], Varun Gupta[2], Hongwei Long[3], Xiaohang Yue[4], [1]College of Business, University of Nevada, Reno, Reno, NV, [2]Penn State Erie, The Behrend College, Erie, PA, [3]Florida Atlantic University, Boca Raton, FL, [4]University of Wisconsin-Milwaukee, Milwaukee, WI

We consider an IOT-based smart system where the past performance of the system is monitored in real-time and is used to derive the operational control bands to optimize its performance over time. In particular, we show that the optimal maintenance policy for this smart system is to follow a “two-band control” on the current performance level. The smart system autonomously switches to a prearranged backup system when its performance is detected to be unacceptable (not in control) and immediately transmits an IoT-enabled Kanban signal to the maintenance crew. When the maintenance order is completed, the backup system switches back to the original system. This paper not only proves the optimal policy is a two-band control policy but also provides efficient ways to approximate the optimal policy as well as the underlying performance of the system.

2 Multi-product Dynamic Upgrades

Xiao Zhang, Saint Louis University, Saint Louis, MO

Upgrades in travel industry are often static and offered either at the booking time or at the check-in time. In this paper, we study dynamically offered upgrades by a multi-product firm via notifications (e.g., emails) between the booking and the check-in times.

Monday, 8AM–9:15AM

MA54

M - Marriott 1
Causal Inference
General Session

Session Chair
Christina Yu, [1]</sup

1 Network Interference in Micro-randomized Trials

Shuangning Li, Stanford University, Stanford, CA, Contact: lsn@stanford.edu

The micro-randomized trial (MRT) is an experimental design that can be used to develop optimal mobile health interventions. Often, mobile health interventions have a social media component; an individual’s outcome could thus depend on other individuals’ treatments and outcomes. In this paper, we study the micro-randomized trial in the presence of such interference. We model the interference with a network interference model. Assuming the dynamics can be represented as a Markov decision process, we analyze the behavior of the outcomes in large sample asymptotics and show that they converge to a mean-field limit when the sample size goes to infinity. We then give characterization results and estimation strategies for various causal estimands including the short-term direct effect of a binary intervention, its long-term direct effect and its long-term total effect.

2 Graph Agnostic Randomized Experimental Design Under Heterogeneous Network Interference

Christina Lee Yu, Cornell University, Ithaca, NY

Randomized experiments are widely used to estimate causal effects across many domains, however classical approaches to experimental design rely on critical independence assumptions that are violated by network interference. We consider heterogeneous linear and polynomial potential outcomes models for network interference, under which we propose simple estimators for the total treatment effect that output unbiased estimates with low variance under simple randomized designs. Our solution and statistical guarantees do not rely on restrictive network properties, allowing for highly connected graph structures. When the network is completely unknown, we provide a simple unbiased and efficient estimator under a staggered rollout randomized design, showing that the flexibility from additional measurements over time can relax requirements of network knowledge.

3 Counterfactual inference in sequential experimental design

Raaz Dwivedi, Harvard and MIT, Cambridge, MA

We consider the problem of counterfactual inference insequentially designed experiments wherein a collection of N units each undergoa sequence of interventions for T time periods, based on policies thatsequentially adapt over time. We introduce a suitable latent factor model wherethe potential outcomes are determined by exogenous unit and time level latentfactors. Under suitable conditions, we show that it is possible to estimate themissing (potential) outcomes using a simple variant of nearest neighbors.First, assuming a bilinear latent factor model and allowing for an arbitraryadaptive sampling policy, we establish a distribution-free non-asymptoticguarantee for estimating the missing outcome of any unit at any time; undersuitable regularity conditions, this guarantee implies that our estimator isconsistent. Second, for a generic non-parametric latent factor model, weestablish that the estimate for the missing outcome of any unit at time Tsatisfies a central limit theorem as T goes to infinity, under suitableregularity conditions. Finally, en route to establishing this central limit theorem,we prove a non-asymptotic mean-squared-error bound for the estimate of themissing outcome of any unit at time T. Our work extends the recently growingliterature on inference with adaptively collected data by allowing for policiesthat pool across units and also compliment the matrix completion literaturewhen the entries are revealed sequentially in an arbitrarily dependent mannerbased on prior observed data.

4 Time Series Versus Cross-Sectional Patterns in Panel Data

Dennis Shen, UC Berkeley, Berkeley, CA

A central goal in social science is to evaluate the causal effect of a policy. One dominant approach is through panel data analysis in which the behaviors of multiple units are observed over time. The information across time and space motivates two general methods: (i) horizontal regression (i.e., unconfounedness), which exploits time series patterns, and (ii) vertical regression (e.g., synthetic controls), which exploits cross-sectional patterns. Although conventional wisdom asserts that the two are fundamentally different, we prove that they yield numerically identical point estimates under several standard settings. Within this regime, we study properties of the estimator from three model-based perspectives with randomness stemming from (i) time series patterns, (ii) cross-sectional patterns, and (iii) both patterns. For each model, we construct corresponding confidence intervals that offer new approaches to inference. The juxtaposition of our results articulates how the choice of randomness relates to the estimand. We show that these insights carry over to the design-based framework as well.

Monday, 8AM–9:15AM

MA55

M - Marriott 2

Theory and Applications of Flexible Servers Systems

General Session

Session Chair

Yuan Zhong, 1</sup

1 Stability and Instability of Parameter Agnostic Policies in Parallel Server Systems

Gorkem Unlu, Yuan Zhong, Booth School of Business, Chicago, IL

We consider the X-Model parallel server system and examine its stability properties under parameter agnostic policies. Parameter agnostic policies are attractive because they require only the queue size information. However, they can lead to instability for relatively low system loads. For the X-Model system, we show that switching curve policies, where each server makes the service decision according to a non-decreasing function of queue sizes, can lead to instability. We conjecture that there does not exist a parameter agnostic policy that stabilizes all underloaded parallel server systems.

2 Detecting Service Rate Slowdown in Service Systems

Gal Mendelson, Stanford University, Palo Alto, CA, Contact: galmen@stanford.edu

In this talk I will discuss the interplay between control and statistical analysis in service systems. The choice of the control mechanism is key for obtaining desired performance, and fast, online detection of changes to system parameters such as servers' service rates is key to maintaining desired service quality and availability. I will demonstrate that the choice of control has a substantial impact on the nature of the data that is being generated and consequently changes how it should be used. I will discuss the limitations of using state data (e.g. queue lengths) for detection and present a new statistic, namely action data, and demonstrate that it can be very powerful. This is joint work with Kuang Xu (Stanford).

3 Parallel Server Systems Under An Extended Heavy Traffic Condition

Rami Atar[1], Eyal Castiel[2], Martin I. Reiman[3], [1]Technion, Haifa, Israel; [2]Georgia Tech, Atlanta, GA, [3]Columbia University, Maplewood, NJ, Contact: castieleyal@yahoo.fr

The goal of this presentation is to talk about recent developments in the heavy traffic analysis of parallel server systems. The typical asymptotically optimal policies require an assumption that a static resource allocation linear program has a unique solution giving only one reasonable resource allocation for the system controller. This solution determines the graph of basic activities, which identifies the set of activities that are used. This talk will outline the weakness of this assumption and how to get rid of it by focusing on the simplest non-trivial example. A policy is constructed and proved to be asymptotically optimal in a diffusion scaling. The design of the policy relies on the solution to a non-linear differential equation (HJB equation) and the scaling limit is a controlled diffusion process. Finally, we will see how to generalize this result

4 Size-based Scheduling in Many-server Queues with Impatient Customers and Noisy Service Time Estimates

Jing Dong[1], Rouba Ibrahim[2], [1]Columbia University, New York, NY, [2]University College London, London, United Kingdom.

Size-based scheduling policies, such as shortest-job-first (SJF), have been extensively studied, for decades, yet almost exclusively in single-server queues with infinitely patient jobs and under exact job-size information. Motivated by applications to service systems, we analyze the performance of size-based scheduling in multiserver queues with abandonment and inexact job-size information. We propose appropriate measures of job-size estimation noise and prove that noisy SJF maximizes, asymptotically, the system throughput. We also show that the noisy SJF queue is asymptotically equivalent to a two-class priority queue where customers with short predicted service times (below a threshold) are served without waiting, and customers with long predicted service times (above a threshold) abandon without service.

Monday, 8AM–9:15AM

MA56

M - Marriott 3

Stochastic Models in the Sharing Economy

General Session

Session Chair

Mojtaba Abdolmaleki, University of Michigan, Ann Arbor, MI

Session Chair

Xiuli Chao, University of Michigan, Ann Arbor, MI

1 Ergodic Control of Bipartite Matching Queues with Class Change and Matching Failure

Xin Liu[1], Amin Khademi[2], [1]Amazon, Seattle, WA, [2]Clemson University, Clemson, SC, Contact: xinliu@alumni.unc.edu

We study a bipartite matching queue with multi-class customers and multi-type resources. Customers may change their classes or abandon the system while waiting in queue, and they may decline the offered resource units which results in matching failure. We are interested in designing efficient instantaneous matching policies that allocate resources upon arrival to waiting customers. Under a suitable stability condition, we construct a simple linear program (LP) which serves as a lower bound for the original stochastic control problem under any admissible policy. We then propose a randomized matching policy based on the solution of the LP and show that the proposed policy is asymptotically optimal under both the long-run average and ergodic cost criteria.

2 Dynamic Pricing, Matching and Empty Vehicle Relocation Policies in Ride-sourcing Systems

Mojtaba Abdolmaleki, Xiuli Chao, Tara Radvand, Yafeng Yin, University of Michigan, Ann Arbor, MI, Contact: mojtabaa@umich.edu

With the development of shared mobility there is a growing interest in design and optimization, such as pricing and empty vehicle relocation, to maximize system utility. Impatience of passengers during waiting is an important feature of such systems, but it has been neglected due to its complexities. We develop a provably near-optimal dynamic pricing and empty vehicle relocation policy for a ride-sourcing system with limited passenger patience. We solve three open questions: (i) the performance of our dynamic policy converges to that of the true optimal value exponentially fast in time when the market size is large; (ii) the passenger loss of our policy decreases to zero exponentially fast when demand size increases; and (iii) using empty vehicle relocation, our dynamic policy can balance supply utilization and customer waiting times under the Square Root Safety (SRS) rule.

3 Platform Competition in Two-sided Networks

John R. Birge[1], Emin Ozyoruk[2], [1]University of Chicago, Chicago, IL, [2]University of Chicago, CHICAGO, IL

Platforms for ridesharing, contract work, hospitality, entertainment, etc., involve network externalities in matching supply and demand. The form of the externalities has implications for competition among platforms and potential market segmentation. Understanding these interactions can inform market design and policies that encourage efficiency. In this study, we focus on ridesharing platform competition and propose a model for externality effects and equilibrium among platforms. After using queueing theory and heavy traffic approximations to derive the key performance metrics, we analyze relationships among geography, population density, and external market competition in the form of equilibria and overall efficiency.

4 Pricing in On-demand (and One-way) Vehicle Sharing Networks

Xiaobing Shen, Saif Benjaafar, University of Minnesota, Minneapolis, MN, Contact: shen0341@umn.edu

We consider the dynamic pricing problem that arises in the context of an on-demand vehicle sharing system with one-way trips. We provide an alternative approach to bounding the performance of static pricing policies. Our approach is startlingly simple, producing, upon the application of a well-known recursive relationship that relates system availability in a system with K vehicles to one with K-1 vehicles, a sequence of bounds that are increasingly tight. The worst of these bounds is given by K/(N + K - 1 + /μ), where is the total demand rate and 1/ μ is the average trip travel time, implying a convergence rate that is at least of order 1- O(1/K) in the number of vehicles for fixed /μ. The same recursive relationship can be used to obtain a bound that is independent of /μ given by 1-O(1/K^(1/2)).

Monday, 8AM–9:15AM

MA57

M - Marriott 4

Machine Learning for Quality Assurance and Decision-making

General Session

Session Chair

Yinan Wang, Virginia Tech, Blacksburg, VA

Session Chair

Wenbo Sun, University of Michigan Transportation Research Institute, Ann Arbor, MI

1 Online Monitoring of Heterogeneous Partially Observable Data Streams Based on Q-learning

Haoqian Li[1], Honghan Ye[2], Kaibo Liu[3], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Woodbury, MN, [3]UW-Madison, Madison, WI, Contact: hli788@wisc.edu

With the rapid advances in Internet of Things (IoT) technology and computational infrastructure, heterogeneous data streams are becoming common in various manufacturing applications. Meanwhile, the resource constraints often restrict the observability of data streams. In this article, diverging from conventional heuristic approaches, we propose a new algorithm based on Q-learning to monitor and quickly detect mean shifts occurring to heterogeneous data streams in the context of limited resources, where only a subset of observations is available at each acquisition time. In particular, we integrate Q-learning with a global threshold learned through a nonparametric cumulative sum (CUSUM) procedure to effectively detect a wide range of possible mean shifts when data streams follow arbitrary distributions.

2 A Bayesian Optimization Framework for Personalized System Design Based on Computer Experiments

Jiacheng Liu[1], Wenbo Sun[2], Jionghua Jin[3], Jingwen Hu[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan Transportation Research Institute, Ann Arbor, MI, [3]University of Michigan, Ann Arbor, MI, Contact: liujc@umich.edu

It is increasingly important to consider human variation in optimizing a personalized system design based on individual characteristics. Most available optimization methods for personalized design are only developed for observational and fixed samples, and thus are not directly applicable to the computer-simulation-based optimal design that can sequentially add new computer simulation runs with a flexible selection of sample size and inputs. In this study, we proposed a new Bayesian-Optimization-based method that searches for the optimal personalized design policy to optimize the expected system responses over the whole population by sequentially introducing informative computer simulation runs. Both a numerical example and a case study on the vehicle restraint system will be presented to demonstrate the effectiveness and robustness of the proposed method.

3 Real-time Process Monitoring and Closed-loop Laser Power Control in Powder Bed Fusion

Rongxuan Wang, Blacksburg, VA

Laser powder bed fusion still suffers from the printing accuracy issue, especially for small features such as the tips of a turbocharger compressor. Heat accumulation is the main reason and results from using constant laser power. This work develops a closed-loop control system to regulate the laser power based on real-time thermal monitoring. The desired control target is found by correlating the printing error with the thermal signatures from a set of thin line printing trails. The control system is built upon a self-designed multi-sensing laser powder bed fusion platform. The result shows the laser power can be successfully controlled with 2 kHz, and a significant improvement in small feature printing accuracy has been observed by both microscopic imaging and 3D scanning. The controller can also prevent the lack of fusion and swelling problems due to improper power input.

4 Transfer Learning for Predictive Quality in Laser-based Micro-machining

Mengfei Chen, Weihong Guo, Rutgers, The State University of New Jersey, Piscataway, NJ, Contact: wg152@rutgers.edu

Machine learning methods are increasingly used to provide unprecedented opportunities towards smart manufacturing. However, traditional machine learning models are challenged with data availability and high training effort in the event of changes in the manufacturing process. In this work, we address this challenge by introducing transfer learning (TL) into manufacturing. We demonstrate the potentials and benefits of TL in a case study for predictive quality in laser-based micro-machining processes across different materials (steel and aluminum), different dielectric liquid (water and oil), and different process parameters (laser speed, laser power, and repetition frequency). The proposed TL framework is expected to adapt to such process changes and deliver accurate predictions on the quality of the channels machined without the need to re-train the model.

Monday, 8AM–9:15AM

MA58

M - Marriott 5

QSR Student Introduction and Interaction Session

Panel Session

Session Chair

Wenmeng Tian, Mississippi State University, Mississippi State, MS

Session Chair

Ruizhi Zhang, University of Georgia, Athens, GA

Session Chair

Xiaolei Fang, North Carolina State University, Raleigh, NC

Session Chair

Hao Yan, Arizona State University, Tempe, AZ

1 Student Introduction and Interaction

Xiaolei Fang, North Carolina State University, Raleigh, NC

The Student Introduction and Interaction Session is designed for QSR student members to build their professional network, show up their talents, and learn from invited guests. In this session, each student will be given two minutes to deliver an elevator speech about his/her research interests and accomplishments; Senior QSR members, junior faculty members, and industry guests are invited to interact with all attendees.

2 Panelist

Junzi Zhang, Amazon.com Services LLC, Albany, CA

3 Panelist

Eunshin Byon, University of Michigan, Ann Arbor, MI

4 Panelist

Ana Maria Estrada Gomez, Purdue University, West Lafayette, IN

Monday, 8AM–9:15AM

MA59

M - Marriott 6

Data-driven Diagnosis and Analytics for Engineering Systems

General Session

Session Chair

Yuxuan Li, Oklahoma State University, Stillwater, OK

Session Chair

Chenang Liu, Oklahoma State University, Stillwater, OK

1 Hierarchical Deep Learning with Generative Adversarial Network for Automatic Diagnosis of ECG Signals

Zekai Wang[1], Bing Yao[2], [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Stillwater, OK, Contact: zekai.wang@okstate.edu

Cardiac disease is the leading cause of death in the US. Routine use of electrocardiogram (ECG) is the most common method for physicians to assess the electrical activities of the heart and detect possible abnormal cardiac conditions. In this paper, we propose a two-level hierarchical deep learning framework with Generative Adversarial Network (GAN) for automatic diagnosis of ECG signals. The first-level model is composed of a Memory-Augmented Deep auto-Encoder with GAN (MadeGAN), which aims to differentiate abnormal signals from normal ECGs. The second-level learning aims at robust multi-class classification for different arrhythmias identification, which is achieved by integrating the transfer learning technique to transfer knowledge from the first-level learning with the multi-branching architecture to handle the data-lacking and imbalanced data issue.

2 Collaborative Online Learning for a Heterogeneous Population of Units Under Resource Constraints

Tanapol Kosolwattana[1], Huazheng Wang[2], Ying Lin[3], [1]University of Houston, Houston, TX, [2]Oregon State University, Corvallis, OR, [3]University of Houston, Houston, TX, Contact: tkosolwa@CougarNet.UH.EDU

Adaptive monitoring of a large population of dynamic processes enables cost-effective process control under limited resources. However, existing adaptive monitoring models either ignore the dependency among processes or overlook the uncertainty in process modeling. To design an optimal monitoring strategy that accurately monitors the processes with poor health conditions and actively collects information for uncertainty reduction, a novel combinatorial bandit with a dependent and dynamic arms method is proposed in this study. The efficiency of the proposed method is demonstrated through both theoretical analysis and an empirical study of adaptive monitoring for degrading batteries.

3 A Simulation-optimization Framework for Food Supply Chain Network Design to Ensure Food Accessibility Under Uncertainty

Mengfei Chen[1], Mohamed Kharbeche[2], Mohamed Haouari[2], Weihong Guo[3], [1]Rutgers, The State University of New Jersey, PIscataway, NJ, [2]Qatar University, Doha, Qatar; [3]Rutgers, The State University of New Jersey, Piscataway, NJ

How to ensure accessibility to food and nutrition while the global food supply chain suffers from disruptive forces like COVID and natural disasters is an emerging and critical issue. A food accessibility evaluation index is proposed in this work to quantify how nutrition needs are met. The proposed index is then embedded in a multi-objective optimization problem to determine the optimal supply chain design to maximize food accessibility and minimize cost. Considering uncertainty in demand and supply, the multi-objective optimization problem is solved in a two-stage simulation-optimization framework where Green Field Analysis is used to determine supply chain configuration and then Monte Carlo simulation is used to determine supply chain operations by solving a stochastic programming problem. Model parameters are estimated from historical data and real-time data.

4 Collaborative Discrimination-enabled Generative Adversarial Network (cod-gan) for Data Augmentation in Imbalanced Classification

Ziyang Zhang, Yuxuan Li, Chenang Liu, Oklahoma State University, Stillwater, OK, Contact: jan.zhang@okstate.edu

This study aims to modify GAN to optimize data augmentation when data from two classes is imbalanced. Hence, a creative and effective GAN structure, collaborative discrimination-enabled generative adversarial network (CoD-GAN) is proposed. The main novelty lies in integrating multiple discriminators to improve the robustness of its discrimination and the diversity of the synthetic samples. The effectiveness of the proposed method is validated by simulation data and real-world dataset.

Monday, 8AM–9:15AM

MA60

M - Marriott 7
QSR Flash Session
Flash Session

Session Chair
Xiaowei Yue, Virginia Tech, Blacksburg, VA

1 Applying Wassestein-based Policy Optimization to Hvac Problems

Chaoyue Zhao, University of Washington, Seattle, WA

Model-free RL methods have been exploited to address HVAC problems, but their performances are not ideal for real-world implementation. One major concern is most of these work limits the policy to a particular parametric distribution class and optimizing over such distributions results in local movements in the action space and thus leads to a sub-optimal solution. This framework will replace the untrustworthy probabilistic assumptions of policy gradient methods with an ambiguity set that covers all permissible distributions. A practical on-policy actor-critic algorithm is proposed. Experiments show that our approach demonstrates the stability and solution optimality.

2 Knowledge-constrained Machine Learning for Modeling and Prediction of Complex Systems

Hao Yan[1], Jiayu Huang[2], Yongming Liu[1], Jing Li[3], Frank Setzer[1], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Chandler, AZ, [3]Georgia Institute of Technology, Tempe, AZ, Contact: haoyan@asu.edu

Incorporating knowledge into machine learning models for uncertainty quantification is an important topic for the modeling of complex systems. Traditionally, the prior regularization method is often used to control the model complexity via specific prior knowledge. However, it is hard to incorporate these prior distributions in the black-box Bayesian machine learning models. Here, we propose two works on incorporating domain knowledge into the black-box Bayesian machine learning models, such as Bayesian neural networks. Case studies such as solar PV plant modeling, trajectory prediction and image segmentation will be used to illustrate the advantage of the proposed methods.

3 The Application of Transfer Learning in Tellurene Manufacturing

Yueyun Zhang, Jorge Loria, Jing Jiang, Wenzhuo Wu, Zachary Hass, Arman Sabbaghi, Purdue University, West Lafayette, IN

As a solution-grown product, tellurene can be manufactured through a scalable process. It is critical to learn the effects of process factors on the production yield and dimensions. We apply transfer learning in the analysis of tellurene manufacturing under new process B based on the established linear regression model under old process A. It is done by incorporating the equivalent effect of a lurking variable in terms of an observed factor into the linear regression model. Process A and process B can be distinguished by different settings of lurking variables. We use a blocked Gibbs sampler to compute the posterior of equivalent effect conditional on direct draws of mean and variance parameters. With the validation data from the proposed experimental design, we model TEA and incorporate the TEA model in the base model to complete the model transfer.

4 GAN-assisted Data Analytics and Modeling to Advance Complex Engineering Systems

Yuxuan Li, Chenang Liu, Oklahoma State University, Stillwater, OK

As many advanced engineering systems become complex, it also becomes common that the collected data have high dimensionality and inherent complexity, leading to more technical challenges in data analytics. Thus, to improve the power of data analytics and further advance the complex engineering systems using data, advanced techniques are critically needed. Inspired by the emerging generative adversarial network (GAN), this talk will present a GAN-assisted methodological framework to thoroughly address these issues, which has been validated under various scenarios.

5 Posterior Regularized Bayesian Neural Network

Jiayu Huang[1], YUTIAN PANG[1], Yongming Liu[1], Hao Yan[2], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, AZ

Traditional NNs often lack the ability for uncertainty quantification. Bayesian NNs(BNNs) could help measure the confidence level by using distributions in NNs modeling. Besides, knowledge is commonly available and could improve the performance of BNNs if it can be properly incorporated. In this work, we propose a novel Posterior-Regularized BNN(PR-BNN) model by incorporating soft and hard constraints as a posterior regularization term. We also propose an augmented Lagrangian method and stochastic optimization algorithm for efficient updating via Monte Carlo sampling. The simulations and case studies have shown the performance improvement of the proposed model over traditional BNNs.

6 Tensor Dirichlet Process Multinomial Mixture Model with Graphs Clustering for Passenger Trajectory Clustering

Ziyue Li, University of Cologne, Cologne, Germany. Contact: zlibn@wiso.uni-koeln.de

Existing passenger clustering cannot easily cluster the passengers due to the hierarchical structure of the passenger trip information. Furthermore, existing approaches rely on an accurate specification of the clustering number. Finally, existing methods do not consider spatial semantic graphs such as geographical proximity and functional similarity between the locations. In this paper, we propose a tensor Dirichlet Process Multinomial Mixture model with graphs, which can preserve the hierarchical structure of the multi-dimensional trip information and cluster them in a unified one-step manner with the ability to determine the number of clusters automatically. The spatial graphs are utilized in community detection to link the semantic neighbors. We further propose a tensor version of Collapsed Gibbs Sampling method with a minimum cluster size requirement.

7 VLP: A Visual Language Processing Modeling Framework Via An Attention-on-attention Mechanism

Xiaoyu Chen[1], Ran Jin[2], [1]University of Louisville, Louisville, KY, [2]Virginia Tech, Blacksburg, VA, Contact: xiaoyu.chen@louisville.edu

Quantitatively understanding human visual searching process in interactive and intelligent systems will not only advance the knowledge preservation of human expertise, but also enhance the AI modeling performance by imitating the human visual searching process. A general visual language processing (VLP) modeling framework is proposed to provide computational attention on visual attention (AonA) based on eye movements. This VLP modeling framework is expected to explain visual searching decisions via AonA even for counter-intuitive scenarios when cognitive threats bias human decision making.

8 Flash Paper

Abdallah A. Chehade, University of Michigan-Dearborn, Canton, MI

Leveraging AI/ML for scaled assessment of safety and reliability of AI-driven systems in autonomous vehicles

9 Task Allocation and Coordinated Motion Planning for Autonomous Multi-robot Optical Inspection Systems

Yinhua Liu[1], Xiaowei Yue[2], [1]University of Shanghai for Science and Technology, Shanghai, China; [2]Virginia Tech, Blacksburg, VA, Contact: xwy@vt.edu

Numerous methods for path planning and robotic coordination have been developed but they may not work for autonomous multi-robot optical inspection due to fast computation requirements, end-effector orientations, and complex surfaces. This paper proposes a novel method for coordinated motion planning of multi-robot inspection. A local robust task allocation is proposed to achieve efficient and well-balanced measurement assignment among robots; collision-free path planning and coordinated motion planning are developed via dynamic searching. A case study shows that it can mitigate the risk of collisions, resolve conflicts among robots, and reduce the cycle time.

19 Change Detection in Spatio-temporal Processes: Applications in Smart Manufacturing Systems

Satish Bukkapatnam, Texas A&M University, College Station, TX

This flash talk presents an overview of the key challenges in, and the methods employed for tracking changes in spatio-temporal dynamics underlying real world manufacturing processes and systems.

Monday, 8AM–9:15AM

MA61

M - Marriott 8

Energy Infrastructure Network Resilience

General Session

Session Chair

Subhojit Biswas, 1</sup

1 Flexibility Management in Economic Dispatch with Dynamic Automatic Generation Control

Lei Fan, University of Houston, Houston, TX

As the installation of renewable energy resources grows rapidly in power systems, system frequency maintenance and control become challenging problems to maintain the system reliability in bulk power systems. As two of the most important frequency control actions in the control centers of independent system operators and utilities, the interaction between Economic Dispatch and Automatic Generation Control attracts more and more attention. In this paper, we propose a robust optimization based framework to measure the system flexibility by considering the interaction between two hierarchical processes. We propose a cutting plane algorithm with the reformulation technique to obtain seven different indices of the system. In addition, we study the impacts of several system factors and show numerically how these factors can influence the system flexibility.

2 Battery bidding under uncertainty considering practical market situations

Weihang Ren, Yongpei Guan, University of Florida, Gainesville, FL, Contact: renw@ufl.edu

Storing off-peak electricity and supplying for peak demand is advantageous in terms of energy production, social impact, and environmental preservation. The potential gain from the bidding spread for the battery owner motivates multiple methods of energy storage. In this paper, we use stochastic programming to investigate optimized bidding methods under market uncertainty. From the standpoint of a battery owner, we create efficient algorithms to create strategies for three common energy market settings. We present one-time validation for our proposed strategies in each market setting, as well as an analysis of the structural feature of each strategy that reveals the underlying logic. We then improve our solution approaches to a rolling horizon method for better fit in practice. We run numerical experiments to demonstrate the empirical performance of our solutions.

3 Electric Grid and Market Impact from Transportation Electrification: A Case Study of Heavy-duty Freight Electrification in The Atlanta-ChattanoogaRegion

Zhi Zhou, Lusha Wang, Vincent Freyermuth, Natalia Zuniga, Olcay Sahin, Monique Stinson, Argonne National Laboratory, Lemont, IL, Contact: zzhou@anl.gov

The decarbonization of the electric grid happens in both generation and demand sides. One of the major sources on the demand side is the shift of fuel from gas to electricity in the transportation sector. This will change the shape of electricity demand profiles, and the change will be different from time and regions. In this study, we investigate the impact of charging demand on grid operations in a day-ahead electricity market clearing context, which is based on a mixed integer program formulated unit commitment and economic dispatch problem. We applies the model to a case study of heady-duty freight electrification in the Atlanta-Chattanooga region, with a number of charging demand profiles from different future electrification scenarios.

4 Climate-Resilient Power System Expansion Planning

Amelia Musselman[1], Jean-Paul Watson[1], Tomas Valencia Zuluaga[2], [1]Lawrence Livermore National Laboratory, Livermore, CA, [2]University of California Berkeley, Berkeley, CA

Climate change, through not only more frequent extreme weather events but also shifts in routine weather patterns, is increasingly impacting power systems. Factors such as increased temperatures, droughts, changing wind patterns, and solar irradiance shifts can impact generator, storage, and transmission efficiencies, production, and lifetimes. We analyze the impact of climate change on power systems via a novel climate-resilient capacity expansion planning model, which seeks to minimize costs while ensuring power system resilience and reliability under a changing climate. We apply our model to a case study of California, initially varying temperature, wind speed, and irradiance. Climate data from the CMIP6 model repository is leveraged.

Monday, 8AM–9:15AM

MA62

M - Marriott 9

Modeling Deep Decarbonization in the Power Sector

General Session

Session Chair

Qingyu Xu, Princeton University, Baltimore, MD

1 Incorporating Forward-looking Projections into Present-day Electric Sector Decisions with Long-run Marginal Emission Rates

Pieter Gagnon, National Renewable Energy Laboratory, Golden, CO

Emissions factors are widely used to estimate how various interventions would influence emissions from the electric sector. The ongoing evolution of the electric grid, however, calls into question the usage of retrospective or short-run emissions factors, which do not incorporate how changes in electricity demand can influence the structure of the grid (the building and retiring of capital assets, such as generators). This talk will address how long-run marginal emission rates can, in a modeling environment, outperform other common emissions metrics at comprehensively anticipating the consequences of an intervention, and discuss the implications of this finding for policy and technology evaluation.

2 Informing Energy Storage Solutions to Decarbonize Electricity

Audun Botterud[1], Jonghwan Kwon[2], Neal Mann[1], Zhi Zhou[3], Todd Levin[4], [1]Argonne National Laboratory, Lemont, IL, [2]Argonne National Laboratory, LEMONT, IL, [3]Argonne National Laboratory, Argonne, IL, [4]Argonne National Laboratory, Lemont, IL, Contact: abotterud@anl.gov

We present a detailed capacity expansion model (CEM) for the U.S. power system, accounting for multiple expansion stages and chronological operations. We use the model to compare four pathways for full electricity decarbonization by 2035 with different levels of technology innovation and public acceptance. In particular, we focus on the role of energy storage. We find that the optimal level of energy storage expansion and technology choice differ substantially between the four pathways. We also illustrate the importance of energy storage representation within CEMs for the results of decarbonization analysis.

3 Optimizing Transmission Expansion for Renewable Energy Development Considering Existing Rights-of-Way

Fikri Kucuksayacigil[1], Michael R. Davidson[2], [1]University

of California San Diego, San Diego, CA, [2]University of California, San Diego, La Jolla, CA, Contact: fkucuksayacigil@ucsd.edu

Models of large-scale renewable energy development typically expand transmission infrastructure to accommodate heterogeneous geographic resources. Yet, planning new transmission lines is complicated due to permitting, land use and other constraints. Upgrading existing rights-of-way emerges as a promising alternative due to reduced costs (when accounting for more accurate cost structures) and simplified process of land acquisition and construction. In this study, we develop a capacity expansion model with operational details and integer transmission expansion decisions corresponding to voltage upgrade options for the Western United States. Our research reveals that upgrade significantly substitutes new line building, capacities of proposed lines are insufficient, and lines from wind-dominated zones to major demand centers should be massively upgraded.

4 No-regrets Capacity Expansion Planning Model for New York City Considering Key Uncertainties: Prices & Policies for Natural Gas & Hydrogen

Stephanie Wilcox, Johns Hopkins University, Baltimore, MD

In recent years, a growing number of cities have banned natural gas in new construction. Restrictions directly impact energy reliability, infrastructure investments, electricity and fuel prices, and energy access. However, few studies evaluate the technical, environmental, and economic effects of natural gas legislation at the city-level. The U.S. EPA's City-based Optimization Model for Energy Technologies (COMET) will be extended to analyze the future of natural gas, hydrogen, and distributed energy resources in cities under various natural gas policy scenarios.

Monday, 8AM–9:15AM

MA63

M - Marriott 10

Trustworthy Reinforcement Learning for Energy Systems

General Session

Session Chair

Ming Jin, Virginia Tech, Blacksburg, VA

Session Chair

Harshal D. Kaushik, Virginia Tech, Blacksburg, VA

1 Dynamic Pricing with Non-stationary Demand Using Reinforcement Learning

Sadegh Kazemi[1], Mahdi Kazemi[2], [1]University of Houston, Houston, TX, [2]Yazd University, Yazd, Iran, Islamic Republic of.

In this study, we investigate how the pricing policy of an online retailer is influenced by customers' time-varying willingness to pay (WTP). We model customers' changing WTP with a linear recursion and use reinforcement learning to enable the retailer to learn the time-varying demand. We show that by using reinforcement learning, the retailer can optimize its pricing strategy. We solve the pricing problem based on fixed and dynamic pricing strategies. We use simulation to make performance comparisons between the two pricing strategies and provide managerial insights.

2 Toward Effective Human-system Integration in Customized Vehicle Automation

Jundi Liu, Linda Boyle, Ashis Banerjee, University of Washington, Seattle, WA, Contact: jundiliu@uw.edu

It is crucial to continuously improve human-system integration to realize human-aware and responsive automation. In this work, we proposed to improve vehicle automation by customizing it to driving styles. Specifically, we adopted an Inverse Reinforcement Learning (IRL) approach for customizing vehicle automation to driving styles identified from naturalistic driving data by using Multivariate Functional Principal Component Analysis (MFPCA) and clustering analysis. As a follow-up, we leveraged real-time trust modeling for further trust calibration considerations. We designed an online driving simulator study to collect trust dynamics data while interacting with vehicle automation and developed a clustering-based State Space Model for real-time trust prediction. Our proposed framework has implications for the design of future vehicle automation.

3 Demand-side Energy Resources as Virtual Batteries: A Learning-based Approach

Junjie Qin, Purdue University, West Lafayette, IN

Diverse demand-side energy resources can provide valuable grid services. Bringing these resources to electricity markets requires an interoperable representation of their dynamics and constraints, which may depend on exogenous stochastic processes like weather and building occupancy. Virtual battery models have been proposed as a standardized representation of dynamic demand-side flexible energy resources. In this work, we propose a learning-based framework for the identification and real-time control of virtual battery models for diverse demand-side flexible resources (eg., building thermostatistic loads and electric vehicle charging loads) while providing performance and reliability guarantees.

Monday, 8AM–9:15AM

MA64

M - Indiana A

Mechanisms for Emerging Forms of Democratic Participation

General Session

Session Chair

Paul Goelz, 1</sup

1 **Auditing and Designing for Equity in Resident Crowdsourcing**

Zhi Liu[1], Nikhil Garg[2], [1]Cornell, New York, NY, [2]Cornell Tech, New York, NY, Contact: ngarg@cornell.edu

Modern governance relies on crowdsourcing to identify problems such as downed trees. A major concern is that residents do not report problems at the same rates, leading to inefficient and inequitable allocation of government resources. However, measuring under-reporting is difficult---we do not observe unreported incidents. Thus, distinguishing between low reporting rates and ground-truth incident rates is challenging. First, we develop a method to identify reporting rates, without using external ground truth data. We apply our method to over 100,000 resident reports made to the NYC Department of Parks and Recreation, finding that there are substantial spatial and socio-economic disparities in reporting rates. Second, I'll overview work in redesigning inspection decisions to improve system efficiency and equity.

2 **Liquid Democracy in Practice: An Empirical Analysis of Its Epistemic Performance**

Manon Revel, Massachusetts Institute of Technology, Cambridge, MA, Contact: mrevel@mit.edu

Increasing distrust in democratic institutions leads scholars to re-think how we make decisions in democracies. Proposals often include involving more lay citizens in decisions to reduce the biases in the compositions of the representative bodies. One idea is to use liquid democracy to allow all to participate in the nomination of representatives through transitive delegations. While liquid democracy promises to identify more competent representatives, little is known about how the system would unfold in practice. Theoretical models have studied the mathematical guarantees under which liquid democracy outperforms direct democracy on closed questions for which there exists a ground truth. Herein, we test these theories through a series of 10 experiments on liquid democracy and find those delegation behaviors are consistent with those identified in theory.

3 **Liquid Democracy with Ranked Delegations**

Ulrike Schmidt-Kraepelin, TU Berlin

Liquid democracy is a novel paradigm for collective decision-making that gives agents the choice between casting a direct vote or delegating their vote to another agent. We consider a generalization of the standard liquid democracy setting by allowing agents to specify multiple potential delegates, together with a preference ranking among them. This generalization increases the number of possible delegation paths and enables higher participation rates because fewer votes are lost due to delegation cycles or abstaining agents. In order to implement this generalization of liquid democracy, we need to find a principled way of choosing between multiple delegation paths. We call such functions delegation rules, and analyze their space from axiomatic, empirical, and algorithmic viewpoints.

4 **Supporting Democratic Innovation: Fairness, Representativeness, and Transparency for Citizens' Assemblies**

Paul Gölz, Harvard University, Boston, MA

One of the most exciting developments in democracy are citizens' assemblies, panels of randomly constituents that contribute to questions of policy. Since panels should be representative of the population, and since each constituent should have a fair chance of being randomly selected to the panel, the selection process poses challenges of fairness, efficiency, and transparency. I describe how we support nonprofit organizations in running citizens' assemblies using algorithms and mathematical modeling.

Monday, 8AM–9:15AM

MA65

M - Indiana B

Innovations in Auction Design

General Session

Session Chair

Benjamin Lubin, Boston University, Boston, MA

Session Chair

Sven Seuken, University of Zurich, Zuerich, Switzerland.

1 **Bidder Feedback in First-Price Video Ad Auctions**

Sébastien Lahaie, Google Research, New York, NY

The display advertising industry has recently moved to first-price auctions as its main mode of ad allocation and pricing. To inform buyers' bidding algorithms, these ad auctions typically send the minimum-bid-to-win as feedback to buyers after the auction: the second-highest bid for the winning bidder, and the highest bid for losing bidders. For ads in video streams, the minimum-bid-to-win concept does not have a clear generalization as the auctions are combinatorial. Buyers can bid to show ads of various lengths and in different positions within the stream. We propose practical generalizations of the minimum-bid-to-win concept to combinatorial auctions, drawing on connections to cost sharing and cooperative game theory, and investigate the bidding dynamics induced by various feedback policies.

2 **Monotone-Value Neural Networks: Exploiting Preference Monotonicity in Combinatorial Assignment**

Jakob Weissteiner, University of Zurich, Zürich, Switzerland.

Many resource allocation problems involve the combinatorial assignment of items, e.g., auctions or course allocation. Because the bundle space grows exponentially in the number of items, preference elicitation is a key challenge. Recently, researchers have proposed ML-based mechanisms that outperform traditional mechanisms while reducing elicitation costs. However, previously used ML algorithms disregard important prior knowledge about agents' preferences. To address this, we introduce monotone-value neural networks (MVNNs), which are designed to capture combinatorial valuations, while enforcing monotonicity and normality. We prove that MVNNs are universal and provide a MILP to make solving MVNN-based WDPs practically feasible. Our results show that MVNNs improve the prediction performance and they yield state-of-the-art allocative efficiency.

3 **Within-Instance Mechanism Design**

Maria Florina Balcan, Siddharth Prasad, Tuomas Sandholm, Carnegie Mellon University, Pittsburgh, PA

There has been significant work on a subfield of automated mechanism design where the designer only has samples from the valuation distribution, initiated by Likhodedov and Sandholm (2004). This has been used to design high-revenue auctions, pricing schemes, and many other mechanisms. We present applications to multi-item, multi-bidder revenue maximization (for limited supply) when such samples are not available. First, we present a learning-within-an-instance mechanism that generalizes and improves upon prior random-sampling mechanisms for unlimited supply, and prove revenue guarantees for it. Second, we show how to design an auction that is robust to market shrinkage and uncertainty: if there is a fixed population of buyers known to the seller, but only some random (unknown) fraction of them participate, how much revenue can the seller guarantee?

UNREGISTERED MA65 - Presenter

Oleg V. Baranov, University of Colorado-Boulder, Boulder, CO

Monday, 8AM–9:15AM

MA66

M - Indiana C

Optimization for Sustainable Chemical and Energy Systems I

General Session

Session Chair

Alexander Dowling, 1</sup

Session Chair

Bridgette Befort, University of Notre Dame

Session Chair

Nicole Cortes, University of Notre Dame

1 **Enabling Process-materials Co-optimization Via Surrogate Modeling for Adsorption-based Gas Separations**

Xiangyu Yin[1], Lorenz T. Biegler[2], Chrysanthos E. Gounaris[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: xiangyuy@andrew.cmu.edu

This work proposes methodologies to learn and incorporate MOF surrogate models within PSA process models, making it possible to directly co-optimize the PSA process and the materials for gas separation applications. The first step is to develop an automatic workflow for learning algebraic surrogate models from user-defined MOF structure files. After that, a fidelity-tunable PSA column model is created within the IDAES-PSE framework. The surrogate-integrated process model enables simultaneous simulations and optimizations in both the material and the process design space.

2 Machine Learning Surrogates with OMLt and IDAEs for Improved Design and Analysis of Energy Systems

Bashar L. Ammari[1], Carl Laird[1], Ruth Misener[2], Alexander Thebelt[2], Calvin Tsay[2], Michael Lee Bynum[3], Joshua Haddad[4], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Imperial College London, London, United Kingdom; [3]Purdue University/Sandia National Laboratories, Albuquerque, NM, [4]University of Florida, Gainesville, FL, Contact: bammari@andrew.cmu.edu

Increased interest in integrating machine learning and optimization has warranted development of a framework to efficiently represent data driven models in algebraic modeling languages. In this presentation, we introduce the Optimization and Machine Learning Toolkit (OMLT) which integrates trained neural networks and gradient boosted trees in Pyomo. OMLT uses ONNX interoperability features to support machine learning models from packages such as Keras, PyTorch, Tensorflow, and Scikit-Learn. As a demonstration, we include two IDAES examples - a neural network surrogate of an auto-thermal reformer and a machine learning application to flexibility analysis.

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Acknowledging OMLT contributions from Jordan Jalving.

3 Optimal Design of Integrated Energy Systems Using First-principle and Machine Learning Models

Jaffer Ghouse[1], Jordan Jalving[2], Bernard Knueven[3], Xian Gao[4], Xinhe Chen[4], Damian Agi[4], Nicole Cortes[4], John Siirola[5], David Miller[1], Alexander Dowling[4], [1]National Energy Technology Laboratory, Pittsburgh, PA, [2]KPMG, Albuquerque, NM, [3]National Renewable Energy Laboratory, Golden, CO, [4]University of Notre Dame, Notre Dame, IN, [5]Sandia National Laboratories, Albuquerque, NM, Contact: jaffer.ghouse@netl.doe.gov

Integrated energy systems (IES) produce electricity, store thermal/electrical energy, and/or produce hydrogen/chemicals that allows for greater flexibility when operating in a grid with increased variable renewable energy penetration. The optimal design and operation of an IES needs to incorporate the interaction with the bulk power market. This study will present novel, multi-scale computational approaches to co-optimize the design and operation of an IES while capturing the bulk power market as machine learning surrogates and the candidate energy system as physics-based models. The data for generating the market surrogates consists of 64,000 simulations obtained by varying generator characteristics that are the decision variables in the optimization problem. The results show that the proposed approach outperforms the conventional price-taker assumption.

4 Improved Characterization of Membrane Transport Properties Through Data Analytics

Xinhong Liu[1], Jonathan Ouimet[1], Laurianne Lair[1], William Phillip[1], Alexander Dowling[2], [1]University of Notre Dame, Notre Dame, IN, [2]University of Notre Dame, Notre Dame, IN, Contact: xliu27@nd.edu

We recently proposed the Diafiltration Apparatus for high-Throughput Analysis (DATA), which enables a 10-times reduction in the time necessary to characterize membrane transport properties. In this talk, we apply Fisher information matrix (FIM) analysis and model-based design of experiments (MBDoE) techniques to further improve DATA. We show that modeling the start-up process leverages additional data to elucidate the underlying physics, improve the parameter precision, and bring insights to design a time-varying applied pressure in DATA. A time correction for permeate product collected is also introduced to improve the model predictions. Moreover, our framework, which integrates data analytics and instrumentation design can be applied to investigate concentration-dependent membrane performance to further accelerate the development of materials.

Monday, 8AM–9:15AM

MA67

M - Indiana D

Frontiers in Online Resource Allocation

General Session

Session Chair

Rajan Udwani, UC Berkeley, Berkeley, CA

1 Single-leg Revenue Management with Advice

Santiago Balseiro[1], Christian Kroer[1], Rachitesh Kumar[2], [1]Columbia University, New York, NY, [2]Columbia University, New York, NY

Single-leg revenue management is a foundational problem of revenue management that has been particularly impactful in the airline and hotel industry: Given n units of a resource and a stream of sequentially-arriving customers segmented by fares, what is the optimal online policy for allocating the resource. Previous work focused on designing algorithms when forecasts are available, which are not robust to inaccuracies in the forecast, or online algorithms with worst-case performance guarantees, which can be too conservative. In this work, we look at the single-leg revenue management problem through the lens of the algorithms-with-advice framework, which attempts to incorporate predictions into online algorithms in a manner that optimally trades off consistency (performance when advice is accurate) and competitiveness (performance when advice is inaccurate).

2 A New Class of Revenue Management Problems with Overbooking and No-shows: Shoring up Trust Between Shippers and Carriers in Maritime Container Shipping

Jacob Feldman[1], Panos Kouvelis[2], Yunzhe Qiu[3], [1]Olin Business School, Saint Louis, MO, [2]Washington University in St. Louis, Clayton, MO, [3]Washington University in St. Louis, St. Louis, MO

In this work, we propose and study a deposit-based booking system that draws inspiration from current practices that have been shown to be successful in mitigating no-show behavior and overbooking in the container shipping industry. Our main algorithmic finding is the development of a simple and easy to implement booking policy, which we show to be 1/4th-competitive against a clairvoyant benchmark that knows the full sequence of deposits.

3 Online Algorithms for Matching Platforms with Multi-channel Traffic

Vahideh Manshadi, Yale University, New Haven, CT

Two-sided platforms rely on their recommendation algorithms to help visitors successfully find a match. However, on platforms such as VolunteerMatch -- which has facilitated millions of connections between volunteers and nonprofits -- a sizable fraction of website traffic arrives directly via an external link, thus bypassing the platform's recommendation algorithm. We study how such platforms should account for this *external traffic* in the design of their recommendation algorithms. We model the platform's problem as a special case of online matching, and we propose a new algorithm (Adaptive Capacity) which accounts for matches differently based on whether or not they originate from external traffic. We establish theoretical guarantees on the performance of our algorithm, and we demonstrate its strong performance in a case study motivated by VolunteerMatch data.

4 Online Bin Packing with Known T

Shang Liu, Xiaocheng Li, Imperial College Business School, London, United Kingdom. Contact: s.liu21@imperial.ac.uk

In this paper, we revisit the online bin packing problem under a setting where the total number of items T is known in advance (also known as *closed*). We study both the stochastic model and the random permutation model. We develop and analyze an adaptive algorithm that solves an offline bin packing problem at geometric time intervals as guidance. Under both models, we show that the algorithm achieves $C\sqrt{T}$ regret, where C is a universal constant (≤13). We develop a new approach to analyzing the packing dynamic using exchangeable random variables. The approach is used to analyze both the algorithm performance and the benchmarks related to the bin packing problem. Our analysis provides an alternative treatment and tightens the analysis of the asymptotic benchmark of the stochastic bin packing problem.

Monday, 8AM–9:15AM

MA68

M - Indiana E

Online Advertising & Revenue Management

General Session

Session Chair

John G. Turner, University of California - Irvine, Irvine, CA

1 Serving Online Ads with Reach and Frequency Requirements on a Moving Time Window

John G. Turner[1], Ali Hojjat[2], [1]University of California - Irvine, Irvine, CA, [2]University of Michigan - Ann Arbor, Ann Arbor, MI, Contact: john.turner@uci.edu

We propose and study a new form of online advertising contract in which ad exposures are counted over a moving time window (e.g., a 24-hour time interval) that shifts forward as the time passes. We model a user's ad exposure as a birth-and-death Markov process. Then we derive a closed-form ad serving policy that can achieve a desired frequency distribution for an online ad campaign and characterize the necessary and sufficient conditions for such a policy to exist.

2 Strawberry or Vanilla This Week? How to Optimize Tailored Assortments for Variety-Seeking/Avoiding Consumers

Dorothee Honhon[1], ismail KIRCI[2], Sumit Kunnumkal[3], Sridhar Seshadri[4], [1]University of Texas at Dallas, Richardson, TX, [2]UIUC, champaign, IL, [3]ISB, India, India; [4]University of Illinois, Champaign, IL, Contact: kirci.ismail@gmail.com

We consider the problem of a retail personalizing an assortment to a consumer who is variety-seeking or variety-avoiding, that is, less or more likely to buy the same product as in the previous period. We characterize the structure of the optimal assortment in single- and multi-period settings.

3 Dynamic Two-part Pricing and Bidding for Display Ad Campaigns on Advertising Exchanges

Naren Agrawal[1], Sami Najafi-Asadolahi[2], Stephen A. Smith[3], [1]Santa Clara University, Santa Clara, CA, [2]Santa Clara University, Morgan Hill, CA, [3]Santa Clara University, Saratoga, CA, Contact: snajafi@scu.edu

We consider an ad agency that manages multiple ad campaigns by bidding for campaigns targeted viewers on an ad exchange and charging campaigns based on a two-part pricing scheme: a part that is charged upfront (upfront fee) and a part that is charged each time a viewer is shown an ad (the CPM price). The agency faces a delay cost for each undelivered impression per unit time as well as a terminal penalty proportional to the number of undelivered impressions. We formulate the problem as a Markov Decision Process and determine the optimal dynamic bidding policy to serve campaigns as well as the optimal dynamic policies for the upfront fee and the CPM price (given the remaining periods and the remaining number of impressions that are waiting to be delivered to campaigns). We show the counterintuitive result that the upfront fees can increase as the time approaches the terminal period.

Monday, 8AM–9:15AM

MA69

M - Indiana F

Data-Driven Retail Operations

General Session

Session Chair

Chloe Kim Glaeser, University of North Carolina at Chapel Hill Kenan-Flagler Business School, Chapel Hill, NC

1 Inferring Customers' Consideration Sets from Heat-map Data

Zahra Ziaei[1], Adam J. Mersereau[1], Seyedmorteza Emadi[2], [1]University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]University of North Carolina-Chapel Hill, Chapel Hill, NC, Contact: zahra_ziaei@kenan-flagler.unc.edu

In this research, we study the application of heatmap data from a brick-and-mortar store for improving the modeling and prediction of customer purchase behavior. We demonstrate how heatmap data, along with aggregate sales data, can be used to infer customer consideration sets, while estimating the effects of covariates influencing consideration of a product or/and utility of a product.

2 Omnichannel Fulfillment in Grocery Retail

Chloe Kim Glaeser[1], Ken Moon[2], Xuanming Su[2], [1]University of North Carolina at Chapel Hill Kenan-Flagler Business School, Chapel Hill, NC, [2]University of Pennsylvania, Philadelphia, PA, Contact: chloe_glaeser@kenan-flagler.unc.edu

We partner with an online grocery retailer to answer the practice-based question of the optimal mix of delivery zones and fulfillment options using data-driven analytics. We investigate how consumers respond to the locally tailored fulfillment options made available to them by the online grocer. We employ a geographical regression discontinuity design to find the causal effect of delivery introduction. Based on this empirical evidence, we build and estimate a structural model and perform a counter-factual analysis to estimate the revenue increase from additionally offering delivery. We examine how the retailer can leverage data to customize locally available fulfillment options while scaling operations.

3 Store Closures and Online Shopping: Evidence from a Natural Experiment

Ragip Gurlek[1], Diwas S. Kc[1], Paolo Letizia[2], [1]Emory University, Atlanta, GA, [2]University of Tennessee, Knoxville, TN, Contact: rgurlek@emory.edu

We examine the impact of retail store closures on omnichannel sales and consumer shopping behavior. We utilize the business closure shocks caused by COVID-19 pandemic to empirically identify omnichannel effects of retail store closures. Using data from a fashion retailer on store closures due to COVID-19 shocks, we find that when a store is closed, the volume of online orders originating from its location increases by 29%. Furthermore, even after store reopening, store locations with temporary closures continue to generate greater online sales proportional to the duration of the closure. For instance, a 30-day temporary closure leads to 49% increase in the post-closure online sales right after the reopening and 37% increase 60 days after the reopening. Omnichannel total sales (offline + online), on the other hand, decrease by 5.5% if the retailer closes 10% of the stores.

4 Inventory Record Inaccuracy Explains Price Rigidity in Perishable Groceries

Ioannis Stamatopoulos[1], Robert E. Sanders[2], Naveed Chehrazi[3], [1]The University of Texas at Austin, McCombs School of Business, Austin, TX, [2]UC, San Diego, Beverly Hills, CA, [3]Olin Business School, St. Louis, MO

Grocery retailers cannot engage in inventory-based pricing without physically auditing their shelves, because their inventory records are inaccurate and incomplete. We argue that this informational friction, known in the literature as inventory record inaccuracy (IRI), is much more powerful than physical menu costs in explaining price rigidity in perishable groceries.

Monday, 8AM–9:15AM

MA70

M - Indiana G

Machine Learning for Discrete Optimization

General Session

Session Chair

Mikhail Bragin, University of California, Riverside, CA

Session Chair

Bing Yan, Rochester Institute of Technology, Rochester, NY

1 An Optimization Method-assisted Ensemble Deep Reinforcement Learning Algorithm to Solve Unit Commitment Problems

Jingtao Qin, Yuanqi Gao, Mikhail Bragin, Nanpeng Yu, University of California-Riverside, Riverside, CA, Contact: jqin020@ucr.edu

Unit commitment (UC) is a fundamental problem in the day-ahead electricity market. It is critical to solve the UC problems in a computationally efficient manner. Recent advances in artificial intelligence have demonstrated the capability of reinforcement learning to solve UC problems. Unfortunately, the existing research on solving UC problems with RL suffers from the curse of dimensionality when the size of UC problems grows. To address these issues, we propose an optimization method-assisted ensemble deep reinforcement learning algorithm, where UC problems are formulated as a Markov Decision Process (MDP) and solved by multi-step deep Q-learning in an ensemble framework. The proposed algorithm establishes a candidate action set by solving tailored optimization problems to ensure a relatively high performance and the satisfaction of operational constraints.

2 An Innovative Formulation Tightening Approach for Job-shop Scheduling

Bing Yan, Rochester Institute of Technology

Job shops are an important production environment for low-volume high-variety manufacturing. Its scheduling has been formulated as a Mixed-Integer Linear Programming (MILP) to take advantage of popular MILP methods. With a large number of parts, MILP methods may experience difficulties. To address this, a critical but overlooked issue is formulation tightening, i.e., if constraints can be transformed to delineate the convex hull, then a solution can be obtained by linear programming methods. In this talk, an innovative and systematic approach is presented to tighten formulations of individual parts by innovatively linking integer and binary variables with potential machine learning-based parameterization. Results show significant benefits in solution quality and computational efficiency. The approach also applies to other MILP problems with similar features.

3 Learning for Power Systems Optimization with MIPLearn and UnitCommitment.jl

Alinson Xavier, Argonne National Laboratory, Argonne, IL

With the increased adoption of renewables and other modern grid elements, the computational performance of existing tools for power systems optimization has become a critical bottleneck. The computational challenge often comes from having to solve a large number of closely-related problems to optimality. In this talk, we first introduce MIPLearn, an open-source general-purpose framework that accelerates, under this scenario, the performance of conventional MIP solvers using machine learning. We then illustrate its usage with UnitCommitment.jl, an open-source Julia/JuMP library of state-of-the-art unit commitment solution methods and formulations.

4 Synergistic Integration of Machine Learning and Mathematical Optimization for Unit Commitment

Jianghua Wu[1], Peter B. Luh[1], Yonghong Chen[2], Bing Yan[3], Mikhail Bragin[4], [1]University of Connecticut, Storrs, CT, [2]Midcontinent ISO, Carmel, IN, [3]Rochester Institute of Technology, Rochester, NY, [4]University of California, Riverside, Riverside, CA

Unit Commitment (UC) is important for power system operations. With increasing challenges, e.g., growing intermittent renewables and intra-hour net load variability, traditional mathematical optimization could be time-consuming. Machine learning (ML) is a promising alternative. However, directly learning good solutions is difficult in view of the combinatorial nature of UC. In this work, we synergistically integrate ML within our recent decomposition and coordination method of Surrogate Lagrangian Relaxation to learn “good enough” subproblem solutions of deterministic UC. Compared to the original UC, a subproblem is much easier to learn. Nevertheless, predicting good-enough subproblem solutions is still challenging because of the “jumps” of binary decisions and many types of constraints. To overcome these issues, subproblem dimensionality is reduced via aggregating multipliers. Multiplier distributions are novelly specified based on “jumps” for effective learning. Loss functions are innovatively designed to improve prediction qualities. Ordinal Optimization and branch-and-cut are used as a backup for unfamiliar cases. Furthermore, online self-learning is seamlessly integrated with offline learning to exploit solutions from daily operations. Results on the IEEE118-bus system and the Polish 2383-bus system demonstrate that continual learning keeps on improving the subproblem-solving process with near-optimality of the overall solutions maintained. Our method opens a new direction to solving complicated UC.

Monday, 8AM–9:15AM

MA71

M - Arizona

New Approximations to Hard Discrete Optimization Problems

General Session

Session Chair

Jean Pauphilet, London Business School, London, United Kingdom.

1 Approximation and Hardness for Submodular Linear Ordering Problems

Majid Farhadi[1], Swati Gupta[2], Shengding Sun[3], Prasad Tetali[4], Michael Wigal[3], [1]Georgia Tech, Georgia, GA, [2]Georgia Tech, Atlanta, GA, [3]Georgia Tech, Georgia, GA, [4]Carnegie Mellon University, Pittsburgh, PA, Contact: wigal@gatech.edu

The minimum linear ordering problem (MLOP) asks to minimize an aggregated cost of a given set function f with respect to an ordering of the base set. Various special cases have been previously studied, for example, the minimum linear arrangement problem, when f is the cut function of a graph. In this talk, we will show how both graphic matroid MLOP (when f is the rank function of a graphic matroid) and minimum latency vertex cover (MLVC) are NP-hard. With techniques from scheduling theory, we will also give a randomized 4/3 approximation algorithm for the MLVC problem. Previously, Iwata, Tetali, and Tripathi gave 2 - 1/(1 + |E|) approximation for monotone submodular MLOP. Using the theory of principal partitions, we give a refinement to this bound, which as a corollary leads to a 2 - (1 + f(E))/(1 + |E|) approximation algorithm for graphic matroid MLOP. We will end with open questions.

2 Sparse PCa with Multiple Components

Ryan Cory-Wright[1,2], Jean Pauphilet[3], [1]IBM Research, Cambridge, MA, [2]Imperial College Business School, London, United Kingdom; [3]London Business School, London, United Kingdom.

Sparse PCA is a cardinal technique for obtaining combinations of features that explain the variance in high-dimensional datasets in an interpretable manner. Most works either analyze the single principal component case, assume that all PCs share the same support or are fully disjoint, which allows the orthogonality constraint to be omitted and simplifies the problem dramatically. By reformulating sparse PCA as a sparsity and rank constrained optimization problem, we design exact, approximate, and feasible methods and second-order cone and semidefinite relaxations that collectively obtain bound gaps on the order of 5% for real-world datasets with 100s or 1000s of features, and demonstrate that considering the orthogonality and sparsity constraints simultaneously can lead to improvements in the Area Under the ROC curve of 14%-20% compared to deflation methods.

3 A Level-set Approach for Solving Nonlinear Discrete Optimization Problems

Ryan Killea[1], Andrew C. Trapp[2], [1]Worcester Polytechnic Institute, Worcester, MA, [2]Worcester Polytechnic Institute, Worcester, MA, Contact: rbkillea@wpi.edu

There are many discrete optimization problems that must be regularly solved, some of which involve unknown resource vectors. We propose a novel method to solve nonlinear discrete optimization problems parameterized over right-hand side vectors within a bounded region. Our approach is based upon constructing level-sets of the value function. We employ a tree-based data structure that supports efficient queries and, upon completion, the ability to rapidly reason over the region of interest. Our approach leverages problem structure and combines bounding with incremental solution construction to avoid excess computation arising from repeated solves. We test the scalability of our algorithm using a set of computational experiments, obtaining promising performance.

4 Warm-Starting Benders Decomposition with Inner and Outer Approximation

Arnaud Robin[1], Alexandre Jacquillat[2], Jean Pauphilet[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Sloan School of Management, Cambridge, MA, [3]London Business School, London, United Kingdom. Contact: arobin@mit.edu

Many companies need to routinely solve large-scale two-stage stochastic optimization problems (e.g., inventory allocation, facility location, traffic management). However, decomposition methods like Benders' decomposition (BD) are notoriously slow in high dimension. In a data-driven setting, we accelerate the convergence of BD via a two-step procedure. First, we use historical instances to generate multiple valid cuts. Second, we apply an optimization-based cut-selection algorithm to select a small subset of these cuts to use as an efficient warm start. We demonstrate the computational benefits on capacitated facility location instances and report an overall 10-40% reduction in computational time.

Monday, 8AM–9:15AM

MA72

M - California

Topics in Social Media Analytics

General Session

Session Chair

Theodore T. Allen, Ohio State University, Columbus, OH

1 Interpretable AI Modeling of the Probabilities New Cyber Vulnerabilities Have Exploits

Tu Feng[1], Enhao Liu[2], Theodore Allen[3], John McCarty[3], [12]University of Maryland, Hanover, MD, [3]Ohio State University, Columbus, OH

Cyber vulnerabilities within recent time windows with exploits are critical intelligence for all types of organizations. We review methods for scraping and feature generation involving Twitter and open-source databases. We also describe the tradeoffs for exploit prediction associated with interpretability.

2 A Decision-Tree Framework for Automatic Classification of Tweets

Evelyn Arrey[1], Enhao Liu[2], Theodore Allen[1], [1]Ohio State University, Columbus, OH, [2]University of Maryland, Hanover, MD

Classifying social media posts continues to have many applications. Yet, doing classification in an interpretable way can help all stakeholders participate in the relevant processes including diagnosing the sources of model errors. We propose a framework for feature engineering and classification and use language identification as an example.

3 New Methods for Deep Learning Hyperparameter Tuning Applied to Misinformation Classification

Mehdi Mashayekhi[1], Maha Yazbeck[2], Theodore Allen[2], [1]Columbus, OH, [2]Ohio State University, Columbus, OH

We consider 12 standard datasets and one additional dataset relating to the BERT reddit COVID misinformation. We show how our proposed extension of the R-BEESE simulation optimization leads to improved model accuracy compared with four alternatives. The insights about COVID misinformation are reviewed.

4 A Framework for Modeling the Effects of Strategic Information Sharing on Sentiments and Misinformation on Social Media

Theodore T. Allen[1], Richie Vanderburgh[1], Antor Rashid[2], [1]Ohio State University, Columbus, OH, [2]FactSpread, Columbus, OH

We are all concerned about the spread of misinformation and political polarization. One important option to consider is the deployment of transparently and well-sourced factual information to reduce the effects of misinformation and depolarize discourse. This presentation proposes the steps needed to develop an optimized system for low-cost information interventions on social media with measurable benefits.

Monday, 8AM–9:15AM

MA73

M - Colorado

Empirical Service Operations

General Session

Session Chair

Mohamad Soltani, University of Alberta, Edmonton, AB, Canada.

Session Chair

Hessam Bavafa, Wisconsin School of Business, Madison, WI

1 How Schedule Flexibility Affects Job Applications

Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL

Struggling to attract talent, companies are scrambling to offer schedule flexibility. Analyzing data from a major job-search platform, we investigate how offering or requiring worktime flexibility affects worker attraction.

2 Racial and Gender Biases in Customer Satisfaction Surveys: Evidence from The Restaurant Industry

Masoud Kamalahmadi[1], Qiuping Yu[2], Yong-Pin Zhou[3], [1]University of Miami, Miami, FL, [2]Scheller College of Business, Georgia Tech, Atlanta, GA, [3]University of Washington, Seattle, Seattle, WA

We explore whether customers exhibit any racial or gender biases when evaluating workers' performance in a racially diverse and *female-dominated occupation*. Specifically, we analyzed over 260,000 customer satisfaction surveys and 1.5 million transactions at a U.S. national casual dining restaurant chain. We found that customers were biased against female servers despite female being the majority. This contradicts the *taste-based* and *statistical discrimination* theories in the economic literature which predict biases against men in female-dominated industry. Our further analysis showed that biases against female workers could be explained by *status-based gender biases*. We also found customer biases against racial minority servers, which were driven by *statistical discrimination* rather than *taste-based or status-based discriminations*.

3 Impact of Physicians' Workstyles on EHR Workload

Umit Celik[1], Sandeep Rath[2], Bradley R. Staats[3], Saravanan Kesavan[4], [1]UNC Kenan Flagler Business School, Chapel Hill, NC, [2]University of North Carolina at Chapel Hill - Kenan Flagler, Chapel Hill, NC, [3]University of North Carolina at Chapel Hill, Chapel Hill, NC, [4]UNC Chapel Hill, Guangzhou, China. Contact: Umit_Celik@kenan-flagler.unc.edu

Physicians spend a significant amount of time on Electronic Health Records (EHR). Time spent on EHR affects physician burnout, operational productivity, the degree of quality of care, and the workload of physicians. We obtain data on EHR usage by 74 primary care physicians under a large health care system. With this data, we show that in addition to clinical complexity, physician work style impacts the amount of time the physicians spend on EHR. We used instrumental variables, probit, and OLS estimation approaches in our empirical analyses. We find that performing EHR work before an appointment is efficient for the total EHR workload. Moreover, performing EHR work after the appointment is efficient, and helps to decrease the end-of-day EHR workload. In the light of these results, we recommend that an EHR break during the day helps physicians perform more efficient EHR work.

Monday, 8AM–9:15AM

MA74

M - Florida

Blockchain in Finance and Insurance

General Session

Session Chair

Andreea Minca, Cornell University, Ithaca, NY

Session Chair

Hamed Amini, Georgia State University, Atlanta

1 Cryptocurrency Venues: Segmentation, Fees, and Tax Policies

Kerry Back[1], Oğuzhan Çelebi[2], Ali Kakhbod[1], Max Reppen[3], [1]Jesse H. Jones School of Business, Houston, TX, [2]MIT, Cambridge, MA, [3]Questrom School of Business, Boston, MA

We study interactions between cryptocurrency trading venues, traders, and taxation in which the venues differ in technology. This market is distinguished from markets like equities because each venue clears trades separately from one another. We show that trading fees rise when the venues are technologically differentiated. Improvements in the lower tech venue is associated with greater trading volumes, whereas improvements in the higher tech venue has an ambiguous impact. When the two venues have similar technologies, differentiation has a positive effect on trading volumes. Our welfare analysis suggests that in equilibrium, the tax rate to optimize tax revenue depends only on trader preferences, and it is thus independent of the venue properties and competition. With other government welfare weights, the aggregate welfare can have a maximum for nontrivial tax rates

2 Decentralized Payment Clearing Using Blockchain

Hamed Amini[1], Maxim Bichuch[2], Zachary Feinstein[3], [1]Georgia State University, Atlanta, [2]Johns Hopkins University, Baltimore, MD, [3]Stevens Institute of Technology, Hoboken, NJ

In this talk, we construct a decentralized clearing mechanism which endogenously and automatically provides a claims resolution procedure through blockchain. In so doing, we provide an algorithm which constructs the blockchain so as to guarantee the payments can be verified and the miners earn a fee. We, additionally, consider the special case in which the blocks have unbounded capacity to provide a simple equilibrium clearing condition for the terminal net worths. Finally, we consider the optimal bidding strategies for each firm in the network so that all firms are utility maximizers with respect to their terminal wealths. The implications of these strategies, and more broadly blockchain, on systemic risk are considered.

3 Blockchain Adoption and Optimal Reinsurance Design

Hamed Amini[1], Romain Deguest[2], Andreea Minca[3], Engin Iyidogan[4], [1]Georgia State University, Atlanta, GA, [2]IESEG School of Management, Paris la Defense, France; [3]Cornell University, Ithaca, NY, [4]SKEMA Business School, Paris, France. Contact: r.deguest@ieseg.fr

We study blockchain adoption in a reinsurance market. Unlike standard operational costs related to claim processing that scale linearly with claim volume, blockchain operating costs per firm are independent of claim volume and decrease with the adoption rate since verification and storage costs are distributed among the adopters. In a consortium of insurance firms, we quantify how the equilibrium adoption decisions depend on the reinsurance contract characteristics, the risk aversions of insurance companies, the distributions of their potential losses and the blockchain cost structure. When a reinsurance firm acts as a central planner in the blockchain consortium, the optimal adoption rate from planner's viewpoint is higher than the Nash equilibria adoption rate. We observe that this gap widens when the blockchain cost becomes more sensitive to the adoption level.

Monday, 8AM–9:15AM

MA75

M - Illinois

Statistical Inference on Hidden Structures and Beyond

General Session

Session Chair

Dana Yang, 1</sup

1 Kernel Feature Selection: Automatic Sparsity without l_1 Regularization

Feng Ruan[1], Michael Jordan[2], Keli Liu[3], [1]Northwestern, Evanston, IL, [2]University of California, Berkeley, Berkeley, CA, [3]Stanford University, Stanford, CA, Contact: fengruan@berkeley.edu

Kernel feature selection is an important tool in nonparametric statistics. In this talk, I am going to describe a surprising property about the (non-convex) kernel feature selection objective: all stationary points of the objective are automatically sparse in finite samples without use of known regularization techniques, e.g., l_1 penalization and early stopping.

2 Optimality of Approximate Message Passing

Alex Wein[1], Andrea Montanari[2], [1]UC Davis, Davis, CA, [2]Stanford, Stanford, CA

The approximate message passing (AMP) framework has been widely successful at producing algorithms with provable guarantees for a variety of high-dimensional statistical inference tasks. In some settings, AMP is conjectured to be optimal in the sense that no computationally efficient estimator can achieve a better mean squared error (MSE) than AMP. In a simple "signal plus noise" model (spiked Wigner), we prove a variant of this conjecture by showing that AMP has the best possible MSE within the class of so-called "low-degree polynomial algorithms." This result is sharper than existing low-degree lower bounds, matching AMP's exact asymptotic MSE (given by the replica symmetric formula). The proof sheds some light on what makes AMP optimal for some problems but not others.

3 Random Graph Matching in Geometric Models

Haoyu Wang[1], Yihong Wu[1], Jiaming Xu[2], Israel Yolou[1], [1]Yale University, New Haven, CT, [2]Duke University, Durham, NC, Contact: haoyu.wang@yale.edu

We study the problem of matching two graphs with edge weights correlated through latent geometries. Given a random permutation π and n iid pairs of correlated d-dimensional Gaussian vectors $\{X_{\pi(i)},Y_i\}$ with noise parameter □, the edge weights are given by $A_{ij}=\langle X_i,X_j\rangle$ and $B_{ij}=\langle Y_i,Y_j\rangle$. The goal is to recover the hidden vertex correspondence π based on the observation of A and B. We focus on the low-dimensional regime of d=o(log n) wherein the underlying geometry is most evident. We derive an approximate MLE, which provably achieves, with high probability, perfect recovery of π when □=$o(n^{-2/d})$ and almost perfect recovery when □=$o(n^{-1/d})$. Furthermore, these conditions are information-theoretically optimal even when the latent coordinates are observed, complementing the recent results of Kuniskty-Niles Weed in geometric models of the planted bipartite matching problem.

4 Tensor-on-tensor Regression: Riemannian Optimization, Over-parameterization, Computational Barriers, and Their Interplay

Yuetian Luo, University of Wisconsin-Madison

We propose the Riemannian gradient descent and the Riemannian Gauss-Newton methods to solve tensor-on-tensor regression without prior knowledge of the intrinsic rank and cope with the challenge of unknown rank by studying rank over-parameterization. We show RGD and RGN converge linearly and quadratically to a statistical optimal estimator in both rank correctly/over-specified settings. Our theory reveals Riemannian optimization adapts to rank over-parameterization. Our results improve upon the existing results of over-parameterized matrix trace regression. We also give the first evidence for the computational barrier in scalar-on-tensor regression under the low-degree polynomials framework and reveal a blessing of computational barriers phenomenon in the over-parameterized tensor-on-tensor regression when the tensor order is at least three.

Monday, 8AM–9:15AM

MA76

M - Michigan

Emerging Topics in Supply Chain Risk Management

General Session

Session Chair

Piyal Sarkar, Ryerson University, Canada, Toronto, Canada.

1 Risks in Global Supply Chain Management

Amulya Gurtu, Cofrin School of Business, University of Wisconsin-Green Bay, Green Bay, WI, Contact: gurtua@uwgb.edu

Globalization increased the complexities and risks in supply chain management (SCM). Global supply chains heavily rely on efficiencies across the systems. Digitization improves SCM performance, but it makes SCM vulnerable. COVID-19 and the Russia-Ukraine conflict have presented many new dimensions of risks in SCM. The cost of managing these risks affects financial performance. Building resilience and reducing risks in SCM provides competitive advantages. The sources of risks are evolving. The risk assessment and mitigation strategies need to be expanded to include new risks because the influence and impact of modern risks in SCM are potentially catastrophic. There is a need to explore supply chain risks in the contemporary context.

2 Design of Weather Rebate Sharing Contract

Piyal Sarkar[1], Mohamed Wahab Mohamed Ismail[2], Liping Fang[2], [1]Ryerson University, Canada, Toronto, ON, Canada; [2]Ryerson University, Toronto, ON, Canada. Contact: piyal.sarkar@ryerson.ca

To address weather risk in supply chains, we propose a class of contract that performs better than a traditional revenue sharing contract. Contract parameters are designed to consider the risk aversion attitude of supply chain members. Conditional Value at Risk (CVaR) is used as the risk measure. The new class of contract combines a Cooling Degree Days (CDD)-based rebate structure with financial risk hedging. This class of contract can be utilized for administering supply chains of weather-sensitive products.

3 DISRUPTION MITIGATIOn and PRICING FLEXIBILITY

Florian Lucker[1], Oben Ceryan[2], [1]Bayes Business School, City University of London, London, United Kingdom; [2]City, University of London, London, United Kingdom.

We study a firm that is exposed to random supply chain disruptions. We focus on the optimal use of pricing to mitigate disruptions, i.e. the option to increase prices during the disruption to better match available supply with demand (referred to as pricing option). We find that the pricing option often complements other operational mitigation strategies such as holding additional inventory or reserving capacity that can be used during the disruption. In other words, when a firm has the pricing option, it may be incentivized to hold larger quantities of inventory and reserve capacity.

Monday, 8AM–9:15AM

MA77

M - Texas

Behavioral Supply Chain Management

General Session

Session Chair

Andrew M. Davis, Cornell University

1 Presenter

Anna Devlin[1], Jatinder N. J. Gupta[2], [1]Drexel University, Philadelphia, PA, [2]University of Alabama Huntsville, Huntsville, AL

Many landlords opt to hire property management (PM) firms to manage their properties, creating a principal-agent scenario. These relationships are governed by contracts with rent-based fees such as a payment to the PM firm for filling vacancies or extending leases. These fees incentivize appropriate short term behavior from the PM firm, but can be in direct conflict with a landlord's long term profits. This research studies an analytical model to investigate how contract terms should be set to incentivize effort from PM firms and maximize a landlord's long-term profits. Taking into account vacancy rates and effort finding high-quality renters, we examine long-term profits for landlords and PM firms under a contract with fees that increase as renters stay longer. Implications on rent increases due to landlord cost savings and landlord/PM relationships are also discussed.

2 Full Quantity or Full Credit? Choosing The Right Buyback Policy for a Boundedly-Rational Retailer

Yinghao Zhang[1], Peiwen Yu[2], Tianjun Feng[3], [1]University of Cincinnati, Cincinnati, OH, [2]Chongqing University, Chongqing, China; [3]Fudan University, Shanghai, China. Contact: zhang5y7@ucmail.uc.edu

We compare two forms of buyback policies - a traditional full-quantity partial-credit (FQ) buyback contract and an alternative full-credit partial-quantity (FC) contract. Through lab experiments, we find that retailer's orders are influenced by behavioral tendencies such as loss aversion, prospective accounting, and inventory error. Taking into account the retailer's behavioral biases, a supply firm should adopt the FC contract when the wholesale price is endogenously set and when the production cost is high. On the other hand, when the wholesale price is exogeneous or when the production cost is low, the supplier should adopt the FQ policy.

3 Sourcing Under Supplier-induced Risks: A Behavioral Investigation

Junhao Vincent Yu[1], Karen L. Donohue[2], Karthik V. Natarajan[2], [1]NC State University, Raleigh, NC, [2]University of Minnesota, Minneapolis, MN, Contact: jyu37@ncsu.edu

Various types of supplier-induced risks occur in supply chains. In this study, we compare risks that disrupt product supply and that influence consumer demand. We combine modeling and experimental methods to investigate buyers' sourcing behaviors and associated profit implications when facing suppliers with different types and levels of risks.

Monday, 8AM–9:15AM

MA78

M - Utah

Presenting, Using, and Managing Information

General Session

Session Chair

Jingchuan Pu, Pennsylvania State University, State College, PA

1 How to Sell Your Crypto Art? Evidence from Non-fungible Token Art Drops

Yuan (Lucy) Zhang[1], Kenny Cheng[1], Liangfei Qiu[2], [1]University of Florida, Gainesville, FL, [2]University of Florida Warrington College of Business Administration, Gainesville, FL

Crypto art is an early use case for NFT because of the ability of blockchain technology to assure the unique signature and ownership of the artwork. While artists see opportunities in the fast-growing NFT collectible market, little is known about the NFT release and sales strategies. In this study, we use one of the earliest NFT art collection datasets to empirically investigate the effect of NFT drop mechanisms and promotional strategies on the price of NFT arts. As one of the first empirical studies investigating NFT drop mechanisms and NFT characteristics' influence on NFT value, we provide meaningful investment insights on crypto art and stimulate further research on NFT releasing and trading in different contexts.

2 Informational Efficiency of Cryptocurrency Markets

Mariia Petryk, 1</sup

Our study investigates price discovery in the cryptocurrency markets by analyzing the evolution and determinants of their (in)efficiency. First, we compare the informational efficiency of cryptocurrencies to regulated stocks using time series estimates of variance ratios. We find that stocks are more efficient than cryptocurrencies. We also find that "mildly regulated" cryptocurrencies are more efficient than unregulated ones. Our results point to the role of regulation on price efficiency. We further investigate the factors that contribute to cryptocurrency market (in)efficiency, including social media activity and type of technology. Our findings will be interesting for policymakers and cryptocurrency trading platforms to design policies that control investment risks.

Monday, 8AM–9:15AM

MA79

JWM - Room 201

Crowds, Platforms, and Innovations

General Session

Session Chair

Brian Lee, Pennsylvania State University, University Park, PA

1 Anchoring Search: An Investigation of The Role of Abstraction and Traversal in Creative Problem Solving

Shi-Ying Lim[1], Tian Chan[2], [1]National University of

Singapore, Singapore, Singapore; [2]Emory University, Atlanta, GA, Contact: sylim@nus.edu.sg
Conceptualizing creative problem-solving as a search process that may involve individuals navigating between a problem space and a solution space, we theorize on the dual roles of abstraction (which expands the search area) and traversal (in terms of the total number of ideation steps and the jumps between the problem to solution-space) affect problem-solving. Using a data set of users' creative modification of IKEA products, we document evidence that creative problem-solving involving 1. changes in the levels of abstraction (concrete vs. abstract), 2. increased number of ideation steps, and 3. reduced number of traversals between the problem and the solution spaces, can lead to more successful problem-solving.

2 Product Development in Crowdfunding: Theoretical and Empirical Analysis

Sidika Tunc Candogan[1], Philipp Benjamin Cornelius[2], Bilal Gokpinar[3], Ersin Korpeoglu[1], Christopher S. Tang[4], [1]University College London, London, United Kingdom; [2]Rotterdam School of Management, Rotterdam, Netherlands; [3]UCL School of Management, London, United Kingdom; [4]University of California-Los Angeles, Los Angeles, CA, Contact: sidika.tunc.16@ucl.ac.uk
We analyze an entrepreneur's product development and improvement decisions in crowdfunding. We show that both the chances of campaign success and the likelihood of product improvement first increase but then decrease with the product's level of enhancement. We also characterize the initial enhancement level that maximizes the entrepreneur's profit.

3 CDC Announcements and User Participation

Lijia Ma[1], Xue Tan[2], Yingfei Wang[1], Yong Tan[1], [1]University of Washington, Seattle, WA, [2]Indiana University, Bloomington, IN, Contact: lijiam@uw.edu
In the COVID-19 pandemic, the overabundance of information makes it hard to find trustworthy sources and reliable guidance. An important role of the CDC is to promote healthy and safe behaviors, communities, and the environment. Its social media channel also allows conversations (in the comment section) for people to exchange information and possibly refine their beliefs. Our study seeks to analyze the relationship between the official announcement (e.g. CDC)and the discussion it sparks. To be more specific, we would like to answer the two research questions: How does the content CDC posts affect the conversation? How does the influence vary with the political orientation of readers? To answer these questions, we collect data from both the CDC and the state-level health departments on a social media platform. Our results provide managerial implications for policymakers.

4 Automation, Productivity, and It Workforce: The Case of ContainerTechnology

Yutong Liu[1], Wei Chen[2], Muhammad Taqi Raza[1], [1]The University of Arizona, Tucson, AZ, [2]The University of Arizona, Tucson, AZ, Contact: yutong@email.arizona.edu
This study investigates the impact of adopting container technology in organizations as process automation in software development. We separate container-adopted and non-container-adopted organizations to assess how the organizational productivity and IT workforce change after adopting container technology. Our findings suggest that the adoption of container technology positively affects both productivity and the size of the IT workforce. In addition, we find that the pre-adoption size of the organization attenuates the effect of container adoption, while the complexity of the development environment amplifies it. The implication is that the encapsulation of application dependencies in containers automates the creation of software development environments and furthers a cross-machine consistency for better collaboration.

Monday, 8AM–9:15AM

MA80

JWM - Room 202

Human, Machines, and Algorithms Session 3

General Session

Session Chair

Siyuan Liu, Penn State University

1 A Tale of Two Tasks: The Imperative of Goal Adjustment in Fairness-aware Machine Learning

Heng Xu[1], Nan Zhang[2], [1]American University, Washington, DC, [2]University of Florida, Gainesville, FL
Numerous efforts in machine learning (ML) have been devoted to develop what are now known as fairness-aware ML algorithms. Most existing such algorithms were designed as drop-in replacements for ranking or selection tasks in practice. This paper demonstrates that a seemingly minor adjustment on this problem definition, specifically a modification of the weights assigned to false positives and false negatives, can help address some longstanding obstacles facing fairness-aware ML, such as

the intrinsic conflict between different fairness definitions. Our results suggest that assigning ML with a carefully designed optimization goal, rather than as a straightforward replacement of existing ranking/selection tasks, can enable fairness-aware ML to reach a considerably better tradeoff between predictive accuracy and fairness in practice.

2 A Point Process Based Graphical Attribution Model

Jun Tao[1], Qian Chen[2], Lingzhou Xue[1], Jim Snyder[3], Amirhossein Meisami[3], [1]Pennsylvania State University, State College, PA, [2]Pennsylvania State University, State College, PA, [3]Adobe Inc., San Francisco, CA

Marketers employ various online advertising channels to reach customers, and they are particularly interested in the attribution problem -- measuring the degree to which each channel contributes to the conversion. To tackle this problem, this study develops a novel graph-based attribution modeling approach in the multi-channel setting. The proposed model utilizes customer-level path-to-purchase data to learn the conversion effects of different types of touch points, accounting for the full relational structure among touches. Based on the learned graph, we further proposes graphical attribution methods that assign more accurate conversion credits to each touch point and the corresponding channel. Our model results shed lights on resource allocation across channels and effective marketing.

3 CFPrice: Robust Pricing of Airline Ancillaries Under Distribution Shift Using Causal Information

Abhinav Garg[1], Sriram Somanchi[2], Lavanya Marla[3], [1]University of Illinois, Urbana Champaign, IL, [2]University of Notre Dame, Notre Dame, IN, [3]U of Illinois at Urbana-Champaign, Urbana, IL, Contact: garg19@illinois.edu

Many machine learning algorithms rely on the assumption that the test data are drawn from the same distribution as the training data to guarantee performance. COVID-19 has significantly affected the travel demand and purchase of ancillaries. We present a causal forest-based method for building robust pricing models under distribution shift using causal information. Extensive experiments on real-world airline customer data show that our proposed method can significantly improve the model performance and stability of prediction under distribution shift through simulations in an offline setting.

Monday, 8AM–9:15AM

MA81

JWM - Room 203

OR/Analytics Applications in Life Sciences

General Session

Session Chair

Pranava Goundan, [1</sup]

1 Clinical Supply Chain Waste Reduction Using AI/ML

Ankush Chandna, ZS Associates, Princeton, NJ, Contact: ankush.chandna@zs.com

Clinical Supplies, especially comparators and co-medications, represent a significant portion of the total cost of clinical trials. Across our industry, average waste is estimated at 55% of total production volume. The use of AI/ML techniques for clinical demand forecasting and supply planning, for both new and ongoing studies, presents an opportunity to reduce wastage and realize significant savings

2 What is the Length of Medication Therapy? a Special Class of Duration Models for Claims Data

Ka Lok Lee, Srihari Jaganathan, UCB Pharma, Atlanta, GA

Claims database is rich source for life science academics and practitioners to track and study patients' behavior longitudinally. An important and frequently studied metric is the length of medication therapy. A frequently seen phenomenon from the data is a sizeable drop-off that happens within the first month after initial fill. Various reasons can cause this phenomenon, and is quite unique for medication duration data. We show that standard models are ill-equipped to deal with the drop-off. In this work, the authors propose a special class of probability models that can specifically handle the initial drop and model the data accurately. We adopt the idea from a zero-inflated count model and apply it here. We illustrate the impressive performance with a numerical example and discuss further applications.

Monday, 8AM–9:15AM

MA82

JWM - Room 204

Creating Environments to Foster Diversity

Contributed Session

Session Chair

zeynep Yavic, The Ohio State University, Columbus, OH

1 **Championing of Digital Payments Platforms by Subsistence Entrepreneurs in Developing Country, Expanding Technology Adoption Models**

Alka Agarwal[1], Ashish K. Jha[2], Jyoti Jagasia[3], [1]S.P. Jain Institute of Management and Research, Mumbai, India; [2]Trinity Business School, Trinity College Dublin, University of Dublin, Dublin, Ireland; [3]S.P. Jain Institute of Management and Research, Mumbai, India. Contact: fpm18.alka@spjimr.org

We study how Digital payments platforms adoption was accelerated in the pandemic for subsistence entrepreneurs who suffer double jeopardy of resource scarcity and institutional voids hindering their technology adoption. We study this hitherto uncharted area in IS research using constructivist grounded theory. From 20 interviews we highlight a process that entails adoption and persistent use and also a new construct of championing.

2 **Into a Vicious Cycle: A Negative Spillover Effect of An Entrepreneurial Failure on An Assessment of Minority Entrepreneurs' Managerial Competence**

Seonghoon Kim[1], Matthew Potoski[1], Jessica Santana[2], [1]University of California, Santa Barbara, Santa Barbara, CA, [2]University of California, Santa Barbara, Santa Barbara, CA, Contact: seonghoon_kim@bren.ucsb.edu

In this research, we argue that when people see a business failure of a certain female or minority entrepreneur, they negatively assess managerial competence of all other female or racial-minority entrepreneurs of the same field. At the core of our argument is the role of group stereotypes. In the entrepreneurial domain, a stereotype has existed about female vs. male (or Black vs. white) entrepreneurs, such that people assess those underrepresented entrepreneurs as less competent than their counterparts. Under this circumstance, a female or racial-minority entrepreneur's business failure can trigger and reinforce people's already-negative stereotype, leading to more negative evaluations of all other female or minority entrepreneurs' managerial competence. In this paper, we derive relevant hypotheses and test them through an experimental vignette study approach.

3 **Regulations for Substitutable Medical Treatments**

Fan Zhou[1], Shima Nassiri[2], Ravi Anupindi[1], [1]University of Michigan, Ann Arbor, MI, [2]Amazon, San Bruno, CA, Contact: fanzhou@umich.edu

It is common practice for healthcare providers to offer several treatment choices to patients and make recommendations based on patients' characteristics. In this study, we consider the stent, a medical device used in percutaneous coronary intervention (PCI). There are two kinds of stents available in the market, and the high-price option shows higher quality only for high-risk patients. Without regulations, profit-maximizing providers can misuse these devices and limit patients' access to care by setting high prices. We are interested in regulation policies that help avoid such adverse effects.

4 **Pushing up Against The Glass Ceiling: Evaluation Apprehension, Gender, Creativity and Information Sharing**

zeynep yavic, The Ohio State University, columbus, OH, Contact: yavic.1@osu.edu

We outline an experiment to investigate the effect of expected evaluation on employees' creativity and information sharing patterns. We additionally examine the effect of gender on evaluation apprehension, as the psychological discomfort of evaluation has been theorized as a reason for gender discrimination in promotion policies. Subjects wrote short proposals and chose whether to submit their proposal for evaluation. We induced three organizational conditions: base, risk and competition. We predict that female subjects will try harder and write more creative proposals when subjected to evaluation apprehension, but will be less likely to share their proposals under expected evaluation than men. After carefully controlling for skill, we find support for the moderating role of gender and organizational conditions on evaluation apprehension effect.

Monday, 8AM–9:15AM

MA83

JWM - Room 205

spORts III

General Session

Session Chair

Liz Wanless, Ohio University, Athens, OH

1 **Analyzing Team Success in The NBa with Data Envelopment Analysis**

David W. Jacobson, Matthew Warner, Metropolitan State University, Saint Paul, MN, Contact: david.jacobson@metrostate.edu

Data Envelopment Analysis (DEA) is applied to analyze team success in the National Basketball Association (NBA). A two input and one output model is developed. The inputs considered are adjusted team offensive efficiency (points per 100 possessions) and adjusted team defensive efficiency (points allowed per 100 possessions). The output is regular season wins. The analysis looks at the efficiency scores for all 30 teams and compares the scores for the 16 playoff teams with the teams not making the playoffs.

2 Dynamic Scheduling of E-tournaments

Celso C. Ribeiro[1], Zhilong Dong[2], Yujie Ma[3], Ailec Zamora[1], Fengmin Xu[2], Kui Jing[2], [1]Universidade Federal Fluminense, Rio de Janeiro, Brazil; [2]Xi'an Jiaotong University, Xi'an, China; [3]Fudan University, Shanghai, China. Contact: celso.ribeiro@gmail.com

The Asian Olympic Council announced that electronic sports will be one of the 37 sports at the 2022 Asian Games. Optimization methods have been scarcely applied to e-sports scheduling: most of the viewership follow the games online and pay for viewing each game, teams do not move from one facility to another to play their games, and the number of teams may be very large. We propose a dynamic integer programming approach for scheduling e-tournaments, based on a modification of the Swiss system. The schedule of each round considers the rankings of the teams at the end of the previous round. The goal consists in maximizing the attractiveness to the viewership of the games played in each round. Repetitions of the same game should be avoided. The order of the games in each round enforces a fairness criterion. The approach was validated using data from tournaments of Arena of Valor and Dota 2.

3 The Multi-League Sports Scheduling Problem

Dries Goossens[1], Morteza Davari[2], Miao Li[1], [1]Ghent University, Gent, Belgium; [2]SKEMA Business School, Lille, France. Contact: dries.goossens@ugent.be

We introduce a general multi-league sports scheduling problem where timetables for multiple leagues must be determined simultaneously, a practical and challenging problem in amateur and youth sports. We consider round robin leagues with different numbers of teams. As the number of simultaneous home games that clubs can organize for their teams is limited by their venue capacity, the objective is to minimize capacity violations. Along with a MIP model which is formulated to optimize the starting round of each league as well as to settle when teams have their home games, we develop various methods to construct an initial solution, and a heuristic with several local search and perturbation components to improve on this. Extensive computational experiments reveal that our heuristic can efficiently provide high-quality solutions for artificial and realistic instances.

4 Instance Space Analysis. The Traveling Tournament Problem Explained

David Van Bulck[1], Fan Yang[2], Dries Goossens[1], [1]Ghent University, Gent, Belgium; [2]Shanghai Normal University: Shanghai, CN, Shanghai, China.

The traveling tournament problem (TTP) is to generate a sports timetable which minimizes the overall distance traveled by all teams. Since its introduction in 2003, dozens of algorithms have been proposed in the literature, of which the performance is typically compared on a set of well-known benchmark instances. Although these problem instances have undoubtedly revolutionized the field of sports timetabling, the diversity of these instances is rather limited. This talk proposes a new set of more diverse problem instances, explains what properties make that an instance is hard to solve, and explains which approach from the literature typically works well for what type of problem instances.

Monday, 8AM–9:15AM

MA84

JWM - Room 206

Simulation Flash Session

Flash Session

Session Chair

Thomas Brady, Purdue University Northwest, Valparaiso, IN

1 Bayesian Optimization with RKHS Kernels for Set-valued Input Functions

Poompol Buathong[1], David Ginsbourger[2], Tipaluck Krityakierne[3], [1]Cornell University, Ithaca, NY, [2]University of Bern, Bern, Switzerland; [3]Mahidol University, Bangkok, Thailand. Contact: pb482@cornell.edu

In this talk, we present a Bayesian optimization framework for expensive black-box set-valued input functions. The algorithm implements a Gaussian process surrogate model with a newly introduced class of set kernels using RKHS embeddings and the expected improvement criterion. Optimization capabilities of the proposed framework are numerically demonstrated on several synthetic datasets and two real-world applications, namely monitoring well selection in hydrogeology and material design in mechanical engineering. Performances compared to a previously studied class of set kernels are also discussed.

2 Real-time Digital Twin-based Optimization with Predictive Simulation Learning

Travis Goodwin[1], Jie Xu[1], Nurcin Celik[2], Chun-Hung Chen[1], [1]George Mason University, Fairfax, VA, [2]University of Miami, Coral Gables, FL, Contact: jxu13@gmu.edu

Digital twinning presents an exciting opportunity enabling real-time control of cyber-physical systems (CPS) with data-driven simulation, while facing prohibitive computational burdens. We introduce Sequential Allocation using Machine-learning Predictions as Light-weight Estimates (SAMPLE) to address this computational challenge by leveraging machine learning models trained off-line in a predictive simulation learning setting. SAMPLE integrates machine learning predictions with real-time simulation data to improve computational efficiency. Numerical results show the viability of SAMPLE to select in real-time optimal CPS control decisions.

3 Nested Heteroscedastic Gaussian Process for Simulation Metamodeling

Jin Zhao, Xi Chen, Virginia Tech, Blacksburg, VA, Contact: zjin20@vt.edu

In this work, we propose nested heteroscedastic Gaussian process (NHGP) modeling for the mean response surface prediction and inference based on large-scale heteroscedastic data sets. Consisting of sub-heteroscedastic GP models, NHGP has similar theoretical properties as standard heteroscedastic GP models but enjoys much lower computational complexity. Numerical evaluations are performed to demonstrate the performance of NHGP in comparison with competing methods.

4 A Discovery on Process Improvement Opportunities on a Covid Pcr Test Laboratory

Felipe Haro, Noorjax Consulting, Tallinn, Estonia.

PCR testing has become a mainstream activity since the COVID-19 pandemic. For this reason, laboratories need to improve throughput and speed, while maintaining an adequate service level. On this presentation we are not looking on how to improve the processes, but instead, we will look on the roadmap that lead to several discoveries on what really happens in these labs, how intelligent attempts to improve the processes lead to unexpected results, how process data information can be misinterpreted resulting in misleading turn around times, and the psychology of the laboratory scientists with respect to the intelligent rules that should govern the priority of samples processing.

5 Fixed Budget Ranking and Selection with Streaming Input Data

Yuhao Wang, Enlu Zhou, Georgia Institute of Technology, Atlanta, GA, Contact: yuhaowang@gatech.edu

We consider a fixed budget ranking and selection problem with input uncertainty, where unknown input distributions can be estimated using input data arriving in batches of varying sizes over time. Each time a batch arrives, the input distribution is updated and additional simulations are run with a given simulation budget. Within each time stage, we apply the large deviations theory to formulate an optimal budget allocation problem. We derive the optimality condition and design a dynamic optimal budget allocation procedure under streaming input data. We prove the consistency and asymptotic optimality of the procedure and numerically show its high efficiency.

6 Empowering Object Detection Models in Dynamic Environments with Novel Data Sampling and Augmentation Techniques

Mohammad Noroozi, Ankit Shah, University of South Florida, Tampa, FL

Object detection is focused on identifying pre-defined object classes and their precise locations. However, these AI-based models perform poorly in dynamic environments with unbounded sets of objects. Unlike human perception that can recognize new types of objects, which are previously unseen, based on numerous experiences, the AI models need to be trained effectively to identify new classes of objects. In this talk, we will present novel data sampling and data augmentation techniques to counter this shortcoming by synthesizing new images from historical data and demonstrate the effectiveness of our approach on a real-world data set using the YOLO family of deep learning models.

7 A Proactive Approach for Operational Decision Support in Primary Care

Yuan Zhou[1], Amith Viswanatha[1], Ammar Abdul Motaleb[1], Prabin Lamichhane[1], Kay-Yut Chen[1], Richard Young[2], Ayse Gurses[3], Yan Xiao[1], [1]The University of Texas at Arlington, Arlington, TX, [2]John Peter Smith Family Medicine Residency Program, Fort Worth, TX, [3]Johns Hopkins University, Baltimore, MD, Contact: yuan.zhou@uta.edu

Due to the large complexities in the primary care delivery system, one major challenge presented in its operations management is to make effective decisions proactively. In this research, we developed an integrated approach that combined predictive analytics, simulation modeling, and decision analytics to enable proactive decision-making in primary care settings. A case study was conducted in a local family medicine clinic to demonstrate the use of the proposed approach in managing patient no-shows. Three double-booking policies were developed and evaluated in terms of their impacts on the clinic productivity and efficiency, as well as the trade-offs between these two performances.

8 Automatic Differentiation for Gradient Estimators in Simulation

Matthew T. Ford[1], David J. Eckman[2], Shane Henderson[3], [1]Cornell University, Ithaca, NY, [2]Texas A&M University, College Station, TX, [3]Cornell University, Ithaca, NY, Contact: mtf62@cornell.edu

Automatic differentiation (AD) can provide infinitesimal perturbation analysis (IPA) derivative estimates directly from simulation code. These gradient estimators are simple to obtain analytically, at least in principle, but may be tedious to derive and implement in code. AD software tools aim to ease this workload by requiring little more than writing the simulation code. We review considerations when choosing an AD tool for simulation, demonstrate how to apply some specific AD tools to simulation, and provide insightful experiments highlighting the effects of different choices to be made when applying AD in simulation.

9 Rapid Machine Learning Using Simulation Technology

Thomas Brady[1], Edward J. Yellig[2], [1]Purdue University Northwest, Westville, IN, [2]Intel Corporation, Chandler, AZ, Contact: tbradyjr@pnw.edu

The marrying of computer simulation technology and machine learning algorithms can significantly shorten the *time* for Machine Learning to function. Simulation models generate large amounts of 'system data' in condensed time periods for Machine Learning algorithms to process, enabling knowledge extraction and generation to be completed efficiently. This presentation discusses an approach to architecture and knowledge representation of the combined technologies.

Monday, 8AM–9:15AM

MA85

JWM - Room 207

JFIG Paper competition II

Award Session

Session Chair

Daniel Kuhn, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, Switzerland.

Session Chair

Frank E. Curtis, Lehigh University, Bethlehem, PA

1 Conditional Uniformity and Hawkes Processes

Andrew Daw, University of Southern California, Marshall School of Business, Los Angeles, CA

The distribution of a Hawkes process's cluster size is classically known through a connection to branching processes, but this is irrespective of time. Insight into the chronology of the cluster has been much more elusive. Here, we employ a novel adaptation of the random time change theorem to establish an analog of the conditional uniformity property enjoyed by Poisson processes, yielding a parking-function-based decomposition that is valuable both methodologically and practically.

2 Online Capacity Scaling Augmented with Untrusted Machine Learning Predictions

Daan Rutten, Debankur Mukherjee, Georgia Institute of Technology, Atlanta, GA

In this paper, we analyze a continuous-time model for capacity scaling that generalizes much of the earlier related approaches. We propose a novel low-complexity algorithm, called the Adaptive Balanced Capacity Scaling (ABCS) algorithm, that has access to black-box ML predictions. Although ABCS is completely oblivious to the accuracy of these predictions, its performance depends on the error of the predictions. In particular, we prove that ABCS is (1 + epsilon)-competitive if the predictions are accurate, and yet, it has a uniformly bounded competitive ratio even if the predictions are completely inaccurate. Finally, we investigate the performance of this algorithm on a real-world dataset and carry out extensive numerical experiments, which positively support the theoretical results.

3 Convex Fairness Measures: Theory and Optimization

Man Yiu Tsang, Karmel S. Shehadeh, Lehigh University, Bethlehem, PA

We propose a new parameterized class of fairness measures, convex fairness measures, suitable for optimization contexts. This class includes our new proposed order-based fairness measure and several popular measures. We provide theoretical analyses and derive a dual representation of these measures. Importantly, this dual representation renders a unified mathematical expression and a geometric characterization for convex fairness measures through their dual sets. Moreover, we propose a generic framework for optimization problems with a convex fairness measure objective, including reformulations and solution methods. Finally, we provide a stability analysis on the choice of convex fairness measures in the objective of optimization models.

Monday, 8AM–9:15AM

MA86

JWM - Room 208

Modeling Advanced Air Mobility

General Session

Session Chair

Bo Zou, University of Illinois, Chicago, IL

1 Automated Pre-departure Flight Planning for High-density Advanced Air Mobility

Yu Zhang, University of South Florida, Tampa, FL, Contact: yuzhang@usf.edu

Advanced air mobility (AAM) is envisioned to move to highly automated and high-density operations in low altitude urban airspace in the future. Third-party service providers are anticipated to provide traffic management for hundreds of thousands of flights. This AAM research at USF attempts to provide pre-departure flight plans for medium to high-density AAM operations that can be employed by service providers. Besides developing mixed-integer programming models and efficient solution algorithms to obtain the conflict-free 4D trajectories at flight planning stage, experiments are performed to investigate the sensitivity of operating cost to three key cost parameters (electricity price, crew hourly rate, and maintenance hourly rate).

2 Presenter

Hsun Chao, Seejay Patel, Daniel DeLaurentis, Purdue University, West Lafayette, IN, Contact: chaoh@purdue.edu

The Federal Aviation Administration reported that the number of registered commercial drones is more than 300 thousand in 2022. Since the autonomous last-mile delivery is one of the popular drone applications, how delivery companies use drones is crucial to assess if the current airspace infrastructure can support the drone operations. This research assumes a drone can only leave from delivery centers and deliver one package. Then, the drone-van routing problem can identify the preferred delivery option for each census tract in the study region. Even though the estimated drone operation cost is lower than the van operation cost, the approach estimated more than 600 daily drone flights in the Chicago metropolitan area for only delivering 0.6% of the total package demand. The low payload capacity of drones seems to be the bottleneck in preventing pervasive drone usage.

3 Urban Air Taxi Fleet Operation Problem with Demand Consolidation

Haleh Sadat Ale Ahmad, Hani S. Mahmassani, Northwestern University, Evanston, IL

To address *Urban Air Taxi (UAT)* fleet operation problem, a concept of operations, including air pooling and short repositioning elimination, is proposed. Subsequently, a dynamic solution framework is developed, where a static and deterministic problem, modeled as a *Capacitated Location-Allocation-Routing Problem with Time Windows and Short Repositioning Elimination (CLARPTW-SRE)*, is solved at each decision epoch on a rolling horizon basis. The corresponding MIP could be solved quickly using commercial software for narrow time windows, enabling its real-time application. Consequently, the impacts of various exogenous and design parameters on demand consolidation are examined using comprehensive sensitivity analyses in a synthetic network. Furthermore, the framework is applied to the Chicago network using Chicago *Transportation Network Providers'* demand.

4 Data-driven Approach for Comprehensive Airspace Assessment of Small Unmanned Aircraft System Operations in Urban Environments

Soohwan Oh[1], Yoonjin Yoon[2], [1]Korean Advanced Institute of Science and Technology (KAIST), Daejeon, Korea, Republic of; [2]Korean Advanced Institute of Science and Technology (KAIST), Daejon, Korea, Republic of. Contact: suhwan@kaist.ac.kr

This study proposes a data-driven framework for comprehensive airspace assessment of small unmanned aircraft system operations in urban environments. We first define and estimate population risk of UAS operations, considering spatiotemporal variations of population movement. We then define and estimate airspace accessibility of UAS operations, considering the complexity of building distributions. Based on population risk and airspace accessibility, we perform a comprehensive airspace assessment for small unmanned aircraft system operations. Using our approach, we reflect the impact of the urban environment, including buildings and people, on the operable airspace, and we can identify areas with operable airspace even in urban areas with many buildings and people.

Monday, 8AM–9:15AM

MA87

JWM - Room 209

Flight Delays in Airline Networks

General Session

Session Chair

Vishwakant Malladi, Indian School of Business, Mohali, Punjab, India.

1 It's Not Simply Luck: The Impact of Network Strategy, Schedule Padding, and Operational Improvements on Domestic On-Time Performance in the US Airline Industry

Milind Sohoni[1], Chandrasekhar Manchiraju[2], Vinayak Deshpande[3], [1]Lubbock, [2]University of Texas - Dallas, Dallas, TX, [3]UNC Kenan-Flagler, Chapel Hill, NC

Airlines showcasetheir on-time performance (OTP), a globally accepted operational performancemetric, to demonstrate punctuality and service reliability and attract airtravelers. Airlines can adopt passive strategies, such as "schedulepadding", and active strategies, such as making "operationalchanges/improvements", to improve their OTP. We develop a framework inthis paper to study the impact of these active and passive actions on the OTPof airlines. Additionally, we study the effect of these strategies on OTPrankings, routinely used to compare airlines. We demonstrate through ouranalysis that operational improvements have the highest association with boththe change in OTP and OTP rankings of airlines, followed by schedule padding;the impact of network changes on OTP and OTP rankings is the lowest.

2 Resilient Airline Scheduling to Minimize Delay Risks

Deniz Simsek[1], M. Selim Akturk[2], [1]Northwestern University, Evanston, IL, [2]Bilkent University, Ankara, Turkey. Contact: deniz.simsek@kellogg.northwestern.edu

We show that by allowing a small deviation from the minimum cost schedule at the schedule generation phase, the potential recovery costs in the future can be reduced significantly due to the trade-off between the total operational costs and the deviation of the aircraft path variabilities. We aim to create resilient schedules, which could recover from the disruptions with a smaller number of flight cancellations. In order to incorporate the variability into our formulation as a surrogate measure to the resilience, we propose a data-driven methodology to estimate departure and arrival delay probabilities of flights and turnaround times of the aircraft. We formulate the problem as a bi-criteria nonlinear mixed-integer mathematical model with chance constraints, and utilize second order cone programming. This study is partially supported by TUBITAK Grant 2219.

3 Analysis of Centralized and Distributed Air Traffic Management

Rex K. Kincaid, William & Mary, Williamsburg, VA, Contact: rrkinc@wm.edu

To fully understand the key differences between centralized and distributed control of air traffic, the control problem is modeled abstractly, as an optimization problem, without the use of heuristics. By using this approach, specific conflict detection and resolution algorithms are not needed. Results indicate the strengths and weaknesses of each concept as a whole rather than an individual algorithm

4 A Statistical Analysis of Airline On-time Performance Data Using Benford'S Law

Shikhar P. Acharya[1], Biniv Maskay[2], [1]University of North Texas at Dallas, Dallas, TX, [2]Loras College, Dubuque, IA

Airline on-time data are reported to Bureau of Transportation Statistics (BTS) by air carriers that have at least 0.5 percent of total domestic scheduled-service passenger revenues. Since these data are *reported* rather than automatically collected by BTS, it may be subjected to human errors. We apply Benford's law to assess the reliability of departure delays reported by Delta Airlines and American Airlines departing from their major hubs for the years 2017-2021. The analysis shows that departure delay reported between 10 to 99 minutes does not conform to Benford's law. There seems to be rounding errors when the reported time delays are multiples of 10.

5 Data-driven Modeling of Delay Propagation in Air Transportation Networks

Vishwakant Malladi[1], Milind Sohoni[2], [1]Indian School of Business, Mohali, Punjab, India; [2]Indian School of Business, Hyderabad, India.

The propagation of delays in modern air transportation networks has significant financial implications. Modeling the propagation of delays in a stochastic environment is difficult due to the complexity of schedules, the size of the network, and the inter-temporal nature of dependencies. To model delay propagation in such networks we propose a framework called time-lagged subordinated Markov chains. The advantage of ou rproposed framework is that it is parsimonious and easy to simulate. We develop techniques to calibrate our framework, and estimate the lag and the intensity of delay propagation across the network. Using our model, we estimate the total impact of propagation on delay times, the contribution of each airport in the airline's network to delays, and identify the edges in the network with the highest impact on delay

Monday, 9:45AM–10:45AM

MP

CC - Sagamore 5
Plenary: Maxine Bédat
Plenary Session

Session Chair

Enver Yucesan, INSEAD, Singapore, NA, Singapore.

1 The Life and Death of Your Jeans

Maxine Bedat, New Standard Institute, Medicine Lake, MN

Maxine Bédat, founder and Director of think and do tank, New Standard Institute and author of Unraveled: The Life and Death of a Garment, an FT Business Book of the Year, will share the hidden world behind our clothing, highlighting key problems within our long supply chains, research that needs to be undertaken, and systems solutions that management science can champion.

Monday, 11AM–12:15 PM

MB01

CC - Room 101
Statistical Machine Learning in Healthcare
General Session

Session Chair

Yisha Xiang, Texas Tech University, Lubbock, TX

Session Chair

Ying Liao, Lubbock, TX

1 Feature Extraction of Echocardiograms Using Neural Network Image Segmentation

Gabriel Cacao, Dongping Du, Texas Tech University, Lubbock, TX

Echocardiograms contains many diagnostically useful features which have not been used in clinical decision-making. This study develops a Deep Learning model trained end-to-end on echocardiograms to predict segmentation for all structures of the heart, which facilitates rapid quantitative and qualitative analysis of the videos. A CNN associated with an unsupervised methodology is used to segment the structures of the heart, to reduce noise and ensure accuracy in edge detection. The network is built to work with multiple frames in the three-dimensional (3D) ultrasound. The unsupervised approach will enable automatic extraction of features from the segmented images without manual interventions.

2 Biologically Informed Machine Learning to Quantify Regional Heterogeneity of Tumor Recurrence in Glioblastoma

Hairong Wang[1], Michael Argenziano[2], Hyunsoo Yoon[3], Leland S. Hu[4], Andrea Hawkins-Daarud[4], Jack Grinband[2], Peter Canoll[2], Kristin Swanson[4], Jing Li[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]Columbia University, New York, NY, [3]Yonsei University, Seoul, Korea, Republic of; [4]Mayo Clinic, Phoenix, AZ, Contact: hairongwhr@gatech.com

Glioblastoma is the most common primary malignant brain tumor. Glioma heterogeneity has become increasingly appreciated with the advent of single cell transcriptomic analyses. We designed a non-invasive deep learning (DL) algorithm that leveraged unlabeled samples and biological domain knowledge from neuropathologists to augment the capability of data-driven DL training to predict three tissue-specific gene modules associated with cell proliferation, neuronal signaling, and cytokine/immune response using magnetic resonance imaging. Our model, composed of Uncertainty Transfer Network and Knowledge-Regularized Adversarial Autoencoder, substantially mitigates the biopsy sample shortage in training a robust model. Our study provides insights into data augmentation and model design, and has the potential to be applied to other biomedical applications.

3 An Unsupervised Ensemble Learning Approach to Fusing Multisource Prediction Scores

Shiva Afshar[1], Ying Lin[1], Shizhong Han[2], Yinghan Chen[3], [1]University of Houston, Houston, TX, [2]Johns Hopkins School of Medicine, Baltimore, MD, [3]University of Nevada, Reno, NV

Combining the predictors obtained from distributed data sources or machine learning algorithms is promising to achieve enhanced and robust performance in lots of classification problems. Ensemble learning is commonly used for combining predictors. However, it usually requires a large set of labeled data to estimate the accuracy of each predictor. Estimating the accuracy of each predictor without labeled data is still a challenging problem. This study developed a spectral-based unsupervised ensemble learning model to combine various correlated prediction scores and applied the proposed method to integrate the multisource disease-gene association scores for risk gene discovery.

4 DeepMiceTL: A Deep Transfer Learning Based Prediction of Mice Cardiac Arrhythmias Using Early Electrocardiograms

Ying Liao[1], Yisha Xiang[2], [1]Texas Tech University, LUBBOCK, TX, [2]Texas Tech University, Lubbock, TX

Genetic defects are among common causes of cardiac arrhythmias. Early detection of patients with such genetic defects prior to severe cardiac events is a healthcare imperative. However, developing effective and inexpensive screening tools for early identification of these patients is challenging because it is difficult to test the efficacy of any such tools on humans. Due to a high genetic homology, we use mouse models to develop a method to predict genetic abnormality associated arrhythmias. We hypothesize that mice with genetic defects present subtle abnormalities in their early ECGs before severe arrhythmias occur and that these subtle patterns can be detected by deep learning methods. To address the issue of data scarcity, we propose a deep transfer learning (TL) model, DeepMiceTL, which leverages knowledge from human ECGs to predict cardiac arrhythmias in mice .

Monday, 11AM–12:15 PM

MB02

CC - Room 102

Deep Learning Methods in Energy Systems Research

General Session

Session Chair

Jie Han, University of Texas, Arlington, TX

Session Chair

Shouyi Wang, University of Texas at Arlington, Arlington, TX

1 Electricity Price Forecasting with Transformer

Jie Han, Rhitu Thapa, Sanyogita Piya, University of Texas at Arlington, Arlington, TX, Contact: jie.han@mavs.uta.edu

Electricity price forecasting is increasingly critical for participants to make competitive bids in deregulated markets due to the higher uncertainty brought by escalated percentage of electricity generated by renewable energies. we developed a transformer based electricity price forecasting model for Texas electricity company, ERCOT. Extreme spikes, as high as 9000 dollars per MWh, were considered and coped with classification techniques. Besides, our model can be used for different horizons, whether intraday or day-ahead, of electricity forecasting. By comparing with different state-of-the-art models, our model shows better performances in different forecasting scenarios.

2 Visual Interpretation of Convolutional Neural Networks for Tree-risk Prediction and Conflict Detection

Nasko Apostolov[1], Ryan Suttle[2], Sanjay Arwade[1], Brian Kane[3], Jimi Oke[1], [1]University of Massachusetts Amherst, Amherst, MA, [2]HortScience | Bartlett Consulting, Berkeley, CA, [3]University of Massachusetts Amherst, Amherst, MA, Contact: aapostolov@umass.edu

Power outages are often caused by tree-powerline conflicts. Pruning efforts increase clearing costs and impact tree health, leaving communities susceptible to hazardous conditions. Automated approaches for risk assessment are thus a cost-effective solution for mitigation. First, we train a convolutional neural network (CNN) to predict high-risk tree-powerline conflicts using expert-labeled images. Second, we train another CNN to identify conflict regions within the labeled images. Integrating the conflict identifier with the conflict risk predictor, we develop the Visual Interpretability Score (VIS) metric, which quantifies the extent of a CNN's attention on the areas of interest in an image for enhanced model selection. This novel method thus promotes sustainable resilience via interpretable artificial intelligence.

3 A Deep Learning-based Battery Sizing Optimization Tool for Hybridizing Generation Plants

Yingqian Lin[1], Binghui Li[2], Thomas Mosier[1], [1]Idaho National Laboratory, Idaho Falls, ID, [2]Idaho National Laboratory, Idaho Falls, ID, Contact: yingqian.lin@inl.gov

Hybrid generation and energy storage systems offer the ability to increase flexibility of the combined asset. Yet, existing tools to optimize energy storage sizing are either too rudimentary or too complex to implement. This work presents a novel deep learning-based battery sizing optimization tool that is designed to help generation asset owners easily assess preliminary sizing considerations for potential battery investments to hybridize their generation facility. The tool uses deep learning to predict revenue and battery degradation over a broad search space of potential battery sizes, estimates capital and operating costs, and computes financial performance of each potential battery system investment, recommending a system with maximum financial performance. The tool is tested and validated for hydropower generation.

4 Econometric Modeling of Intraday Electricity Market Price with Inadequate Historical Data

Saeed Mohammadi, Mohammad Reza Hesamzadeh, KTH Royal Institute of Technology, Stockholm, Sweden. Contact: saeedmoh@kth.se

The intraday (ID) electricity markets have received an increasing attention in the recent EU electricity market discussions. This is partly due to the growing uncertainty in the underlying power system. The ID market is an adjustment platform which provides the liquidity to deal with such trading risks. To have the most favorable trade, market participants need a proper model for ID market price to optimally adjust their positions by trading in ID market. Inadequate historical data for ID market makes it further challenging to model. This research proposes econometric models, i.e. long short-term memory, deep convolutional generative adversarial networks, and No-U-Turn sampler algorithms, to model the ID hourly prices. Our proposed econometric models show a promising performance in the Nordic ID database.

5 A Neural Network Approach to High-dimensional Optimal Switching Problems with Jumps in Energy Markets

April Nellis[1], Erhan Bayraktar[2], Asaf Cohen[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: nellisa@umich.edu

We consider optimal switching problems represented by a coupled system of forward-backward stochastic differential equations, in which finite-variational jumps in the forward process drive jumps in a backward process representing the value function of a switching problem. We develop a backward-in-time machine learning algorithm that uses a sequence of neural networks and the dynamic programming principle to solve for optimal switching strategies, where the neural networks accurately learn the added jump components. We then apply this algorithm to a variety of problems arising from energy production and scheduling problems, ranging in dimension from two to ten. Our results show that the algorithm performs with accuracy and the computation time grown linearly with dimension, demonstrating the value of the algorithm for solving high-dimensional problems.

Monday, 11AM–12:15 PM

MB03

CC - Room 103

Advances in Deep Learning Methods and Applications I

General Session

Session Chair

Shouyi Wang, University of Texas at Arlington, Arlington, TX

Session Chair

Linh Ho Manh, University of Texas at Arlington, Arlington, TX

1 Overparametrized Multi-layer Neural Networks: Uniform Concentration of Neural Tangent Kernel and Convergence of Stochastic Gradient Descent

Jiaming Xu[1], Hanjing Zhu[2], [1]Duke University, Durham, NC, [2]Fuqua School of Business, Duke University, Durham, NC, Contact: hz176@duke.edu

There has been a recent surge of interest in understanding the convergence of gradient descent (GD) and stochastic gradient descent (SGD) in overparametrized neural networks. Most previous works assume that the training data is provided a priori in a batch, while less attention has been paid to the important setting where the training data arrives in a stream. In this paper, we show the neural tangent kernel (NTK) function of every hidden layer converges uniformly to some deterministic kernel function. This significantly improves over existing results which only prove pointwise concentration of the NTK function of the last hidden layer. Furthermore, we apply the uniform concentration result to the streaming data setup and show that with overparametrization and random initialization, the prediction error of multi-layer neural networks under SGD converges in expectation.

2 Deep Learning Based Sleep Detection Model

Jaynish Vaghela, Dell Inc., Austin, TX

Driving while drowsy is a serious problem in the United States. A report from the NHTSA estimates that drowsy driving leads to 100,000 reported crashes each year, 71,000 injuries & 800 fatalities, & a $12.5B cost. One solution is to identify & alert when a driver is falling asleep. In this work I propose two image-based frameworks for the detection & recognition of drowsiness based on a video feed of the driver's face. Both frameworks are broadly divided into two parts, namely, feature extraction followed by time series-based prediction. The two frameworks differ in the way

features are extracted & fed into an LSTM Network to make predictions. The model aims to monitor a driver's condition in real-time. From the video, an image-based noninvasive technique is used to detect the facial features of the driver with time & classify drowsiness & sound an alarm if drowsy.

3 Molecules Classification from Ultra-violet Spectra by Different Featurization Methods

Linh Ho Manh[1], Victoria C. P. Chen[2], Kevin Schug[1], Shouyi Wang[3], [1]University of Texas at Arlington, Aarlington, TX, [2]The University of Texas at Arlington, Arlington, TX, [3]University of Texas at Arlington, Arlington, TX, Contact: linh.homanh@mavs.uta.edu

Machine Learning has been applied to several domains in material science and chemistry, to predict molecular properties such as partition coefficient (logP), and rate of absorption, Vacuum ultraviolet spectroscopy (VUV), similar to mass spectra, is an interesting chemical property and provides quantitative information, especially for fuels. In addition, evidence also suggests that machine learning models require sufficient and organized data. In this research, 122 molecules of four different types: monoaromatic, diaromatic, alkene, and diene are studied. The truth labels of datasets are retrieved by clustering the corresponding VUV spectra in four different clusters. Another interesting aspect of this research is the characterization of molecules from structural information to the graph representation of molecules.

Monday, 11AM–12:15 PM

MB04

CC - Room 104

Multimodal Fusion with Application to Medicine, Military, and Beyond (Part 1)

General Session

Session Chair

Nathan B. Gaw, Air Force Institute of Technology, Beavercreek, OH

1 Predicting Flight Error for Pilot Training Using Explainable Multimodal Physiological Signals

Gregory Barry, Air Force Institute of Technology

Throughout the USAF's pilot training, student pilots are evaluated at the end of a mission and given a grade from their instructor. The delay in starting and finishing pilot training is a continual crux the USAF has attempted to fix, while working to better train each and every pilot. We hypothesize that recorded multimodal physiological data from training flights can have key features extracted, which then enable proper prediction of cumulative flight error. Such predictions can expedite grading, and allow the proper personalization of training curriculums to minimize training duration while maximizing effectiveness of training missions experienced. Extracting explainable features will allow precise selection of key physiological sensors to begin integrating within every pilot training mission.

2 Federated Generalized Scalar-on-Tensor Regression

Elif Konyar, Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL, Contact: elif.konyar@ufl.edu

Increase in the need to generate, store, and analyze data at the edge of networks, and the rise of concerns about data privacy have led to federated learning frameworks. These frameworks allow local clients to learn local models and collaborate with other clients in developing a global model while handling communication and storage limitations, and data privacy issues. Moreover, complex systems are generating high dimensional data for which tensor regression approaches provide accurate results by capturing complex correlation structures of data. In this paper, we propose federated scalar-on-tensor regression model where local tensor regression models are learned at the edge, and their parameters are shared with and updated by a global client. This new approach is promising in many areas such as agriculture and healthcare where data is high dimensional and localized.

3 AVATAR: Adversarial Self-supervised Domain Adaptation Network for Target Domain

Jun Kataoka[1], Hyunsoo Yoon[2], [1]Binghamton University, Binghamton, NY, [2]Yonsei University, Seoul, Korea, Republic of. Contact: jkataok1@binghamton.edu

We propose an unsupervised domain adaption (UDA) method to predict unlabeled data on the target domain, given labeled data from the source domain. Mainstream UDA models aim to learn domain-invariant features from the two domains. However, such methods risk misclassifying the target domain when domain discrepancy is large. To tackle this problem, we propose Adversarial self-superVised domain Adaptation network for TArget domain (AVATAR) algorithm, which outperforms state-of-the-art UDA models by reducing the domain discrepancy while enhancing the discrimination using a domain adversarial learning, a discriminative deep clustering, and a confidence-based pseudo-labeling strategy. Our proposed model outperforms the state-of-the-art methods in two UDA benchmarks.

4 **Presenter**

Chun-An Chou, Northeastern University, Boston, MA

Monday, 11AM–12:15 PM

MB05

CC - Room 105

Machine Learning and Artificial Intelligence for Medical Image Analysis

General Session

Session Chair

Fangyun Bai, Arlington, TX

Session Chair

Sara Masoud, Wayne State University, Detroit, MI

1 Ultra-high Dimensional Quantile Regression for Longitudinal Data: An Application to Blood Pressure Analysis

Tianhai Zu[1], Heng Lian[2], Brittany Green[3], Yan Yu[4], [1]University of Cincinnati, Cincinnati, OH, [2]City University of Hong Kong, Hong Kong, China; [3]University of Louisville, Louisville, KY, [4]University of Cincinnati, Cincinnati, OH, Contact: zuti@mail.uc.edu

Despite advances in research, identifying important genotype risk factors for high blood pressure remains challenging. Traditional genome-wide association studies (GWAS) focus on one SNP at a time. We aim to select over half a million SNPs and phenotype variables via simultaneous modeling and variable selection, focusing on the blood pressure levels at high quantiles. We develop and apply a novel penalized quantile generalized estimating equations approach to tackle this high dimensional, longitudinal, quantile problem with time-varying covariates. Importantly, we identify interesting new SNPs and some plausible pathways for high blood pressure. Besides, blood pressure levels are likely heterogeneous, where the risk factors identified differ among quantiles. We provide an efficient computational algorithm and establish challenging theoretical properties.

2 Feature Selection for Brain Imaging Predictors of Potential Super-ager and Cognitive Decline Trajectories - a Uk Biobank Classification Study

Parvin Mohammadiarvejeh, Guiping Hu, Auriel A. Willette, Iowa State University, Ames, IA, Contact: pmohamm@iastate.edu

Aging is characterized by cognitive decline in cognitive processes. Adults, aged 80 years or older, are "Super-Agers" that exhibit cognitive performance like younger adults. Due to the unknown association between the anatomical and neuropathological structure of the brain in mid-life with improvement or decline in executive function, we aim to use machine learning techniques to select the most relevant structural magnetic resonance imaging (sMRI) features to classify the observations into the Positive-Ager or Cognitive Decline groups.

a Predictive Framework for Otolaryngology Outpatient's Endoscope Need Analysis

David Lanier, Wayne State University

The ENT clinic at a medium-sized health career facility in the Midwest serving the veteran population recently transitioned reprocessing of scopes from a high-level disinfectant method to a safer process performed by the sterile processing department (SPD). The demand for scopes for future patient visits is not clearly known but may be understood based on patient, provider, and other visit-related factors. These factors are available to the clinic before the visit and using binary classification, may be used to help inform SPD of ENT scope needs earlier out. Using several classification packages available in Python, we were able to define a model to determine clinic day scope needs with high accuracy.

Monday, 11AM–12:15 PM

MB06

CC - Room 106

Data Mining and Machine Learning Innovations to Advance Operations Efficiency

General Session

Session Chair

Jia Liu, Auburn University

Session Chair

Wenmeng Tian, Mississippi State University, Mississippi State, MS

1 Feature-Level Geometric Accuracy Prediction for Additive Production

Yuhang Yang, Davis McGregor, Sameh Tawfick, William King, Chenhui Shao, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: chshao@illinois.edu

This talk will present a new hybrid hierarchical modeling (HHM) approach to characterize the feature-level geometric accuracy of parts produced across multiple identical additive manufacturing (AM) machines. HHM organizes part measurement data into a hierarchy that represents data from individual parts, the positions of parts within the builds, and the machines that produced those parts. Part geometric variability is decomposed into a large-scale part-to-part trend and a small-scale feature-level variability. The effectiveness of the HHM method is demonstrated using experimental data collected from 70 hexagonal lattice parts over seven builds produced by three identical AM machines.

2 A Bayesian Neural Network-based Cox Model for Time-to-event Analysis

Ye Kwon Huh[1], Minhee Kim[1], Kaibo Liu[2], [1]University of Wisconsin-Madison, Madison, WI, [2]UW-Madison, Madison, WI, Contact: yhuh8@wisc.edu

We present a new framework for analyzing time-to-event data by extending the Cox proportional hazards model with Bayesian Neural Networks. Existing deep learning-based survival models only offer point estimates of the time-to-event, which can be insufficient to fully capture the stochastic nature of degradation processes. In contrast, our proposed model provides accurate interval estimates of the time-to-event and quantifies the uncertainty of the predictions. Furthermore, the proposed method can support both time-independent and time-dependent covariates. Numerical studies on both simulation data and real-life degradation datasets demonstrate the effectiveness of our model compared to established survival analysis models.

3 Enhancing Reduced-order Finite Element Analysis with Statistical Learning and Its Application to Additive Manufacturing

Xinchao Liu, Xiao Liu, University of Arkansas, Fayetteville, AR, Contact: xl037@uark.edu

The development of reduced-order Finite Element Analysis (FEA) is an active research field, which aims to relieve the computational burden in numerically solving various complex engineering problems. We use statistical learning to enhance the reduced-order FEA and provide two solutions. The first solution is to treat the FEA as a black box. We propose a DMD-VARX model to make probabilistic predictions for future time steps. The second solution is to intrusively build a physical Ordinary Differential Equation (ODE) based reduced-order model with parametric local POD bases. We predict local POD bases using regression trees on Grassmann Manifold. Both solutions are illustrated by the heat transfer numerical example of Electron Beam Melting (EBM) additive manufacturing and the results are compared with the full-order FEA.

4 Predictive Machine Learning for Prescriptive Applications: A Coupled Training-validating Approach

Ebrahim Mortaz[1], Alexander Vinel[2], [1]Pace University, New York, NY, [2]Auburn University, Auburn, AL

We propose a new method for training predictive machine learning models for prescriptive applications. Coupled validation approach is based on tweaking the validation step in the standard training-validating-testing scheme, specifically considering the prescription loss as the objective for hyper-parameter calibration. It allows for intelligent introduction of bias in the prediction stage to improve decision making at the prescriptive stage, and is generally applicable to most machine learning methods, including recently proposed hybrid prediction-stochastic-optimization techniques, and can be easily implemented without model-specific mathematical modeling. Several experiments with synthetic and real data demonstrate promising results in reducing the prescription costs in both deterministic and stochastic models.

Monday, 11AM–12:15 PM

MB07

CC - Room 107

Explainable AI in Practice: Challenges and Methodologies

General Session

Session Chair

Swarup Chandra, HPE, San Jose, CA

1 Explainable AI The Last Mile

Venkatesh Ravichandran, Amazon, Sunnyvale, CA

Explainable AI in practice is a challenging art. Deep learning techniques have helped in development of powerful pattern recognition software that maps sequences to other sequences or a set of observed features to a classification decision. Given the luxury of vast amounts of data and computing resources, it’s easier to make a prediction but harder to explain it. This reduces overall trust in prediction, yielding a solution that is not adopted in practice. In this talk, we explore popular techniques that has helped explainability in the areas of computer vision and natural language processing. Explainability leads to trust which in turn helps users to adopt AI solutions. It's the last mile, that helps deliver the value AI promises at scale.

2 **Robust Vulnerability Detection Systems Using Explainable AI Methods**
Mahmoud Zamani[1], Kevin Hamlen[2], Latifur Khan[3], [1]UTDallas, Richardson, TX, [2]The University of Texas at Dallas, RIchardson, TX, [3]The University of Texas at Dallas, Richardson, TX, Contact: mxz173130@utdallas.edu
Software vulnerability is one of the main reasons why programs are prone to attacks. These attacks can often have irrecoverable consequences such as leaked information and compromised systems. Explainable AI techniques are one way to identify the features that make a program vulnerable with learning default rules directly from data or using statistical methods. This allows one to claim a program as vulnerable if they share the same set of features and scores. In this work, we plan on testing different state-of-the-art Explainable AI techniques to determine which features make a program the most vulnerable and generate description about those vulnerabilities for the end users to take action against.

3 **On AI Visualization**
Ran Jin[1], Parshin Shojaee[2], Xiaoyu Chen[3], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Blackburg, VA, [3]University of Louisville, Louisville, KY, Contact: jran5@vt.edu
This paper summarizes a latest visualization of AI methods.

Monday, 11AM–12:15 PM

MB08

CC - Room 108
Data Analytics for Crowdfunding Research and Development
General Session

Session Chair
Hongwei Wang, Tongji University, Shanghai, China.

Session Chair
Jialing Zhao, Shanghai,China, China.

1 **The Digital-enabled Sharing Economy: The Role of Matching Technology**
HUIYI LITAN, Institute of Economics, School of Social Sciences, Tsinghua University, Beijing, China. Contact: lthy19@mails.tsinghua.edu.cn
Much of the success in the sharing economy surrounds digital platforms and large-scale matching technologies. We construct game-theoretic models to examine the impacts of B2C and C2C sharing and analyze how technology provides benefits to various parties. In the B2C sharing, platform profit has an inverse U-shape relationship with its technology level. Notably, platform-optimal technology is less than social-optimal technology. The improvement of technology benefits high-preference consumers more. Our findings have practical implications for sharing business operations and the governments. In the C2C sharing, the improvement of technology brings more sharing consumers. However, the platform faces the dilemma of consumer quantity and profit margin. Our finding explains the phenomenon that C2C platforms like Uber have been bleeding money.

2 **Strategic Approaches in Enhancing The Crowdsourcing Platforms' Performance**
Sina Zare, Loyola Marymount University, Los Angeles, CA
There are many strategic factors contributing to the performance of different crowdsourcing platforms. Investigating such factors may help the platforms' designers, managers, and players maximize mutual outcomes.

3 **Can Crowd-funding Inhibit the Initiators' Overconfidence Under the Background of Digital Economy?**
Wei Wang[1], Ying Li[2], [12]Huaqiao University, Quanzhou City, China.
Short-sighted behavior resulting from overconfidence is a topic of key concerns in academia and management practice. Based on behavioral finance, we investigated the relationship between initiators' confidence and crowd-funding fundraising outcomes by text mining, taking into account the realities of China's digital economy. The results show that overconfidence is common among crowd-funding projects initiators. Moreover, digital economy can effectively inhibit the degree of overconfidence of crowd-funding initiators. The path analysis shows that digital economy is increasing the rationality of crowd-funding projects implementation by reducing the degree of information asymmetry. In addition, digital economy clearly boosts the success rate of crowd-funding.

Monday, 11AM–12:15 PM

MB09

CC - Room 109
Artificial Intelligence Flash Session I

Flash Session

Session Chair
Samuel Pfrommer, UC Berkeley, Berkeley, CA

1 Will Negative Emotions in Reviews Always Moderate The Impact of Tailored Managerial Responses on Customer Satisfaction?

Yimei Zhou[1], Hewei Yang[1], Yifan Yu[2], Jinghua Huang[3], [1]Tsinghua University, Beijing, China; [2]University of Washington, Seattle, WA, [3]Tsinghua University, Beijing, China. Contact: zhouym.18@sem.tsinghua.edu.cn

Many firms are struggling with how to respond to online reviews, especially negative reviews. However, there is limited work on managerial response (MR) considering the differences among the various negative emotions. Utilizing a dataset from a restaurant review platform, this study aims to investigate whether the impact of tailored MR on customer satisfaction is moderated by four basic negative emotions (anger, disgust, anxiety, and sadness), and how the moderating effects of these negative emotions are influenced by psychological distance. We found that the positive moderating effect of different negative emotions varies and the negative moderating effect of psychological distance varies.

2 Towards Venture Capital Investment Strategy: A Reinforcement Learning Perspective

Howard Zhong, ESCP Business School, Paris, France.

Venture capital investments play an essential role in the growth and evolution of early-stage startups. However, only a significant small portion of VC-backed startups can successfully exit. In this paper, we propose a novel reinforcement learning-based model to facilitate venture capitalists' decision-making. Our multi-agent RL model can dynamically choose the best candidates and optimize sequential investment decisions for a portfolio of startups. We conduct extensive experimental studies to demonstrate our method's superiority and present interesting managerial insights.

3 Detecting Intentions of Image Posts by Leveraging The Crowd Wisdom

Shuang Gao, Arizona State University, Tempe, AZ

Marketers nowadays can learn from UGC to better understand the consumer needs and improve service quality. In recent years, the trend of UGC has moved from text format to visual format. For visual analytics, most machine vision models are set up to recognize objects, but usually not able to understand the intentions of image posts. However, human readers can understand the intention and react with their likes and comments, which may contain their understanding. Therefore, we proposed to leverage the crowd wisdom from selected comments to help the machine in intention classification. Our work benefits brand management in social media.

4 Online Stock Portfolio Selection with Hints: An Empirical Study

Kevin Xiao[1], Cong Zhou[2], Jialiang Chen[2], Yu Xia[3], Zhengyuan Zhou[2], [12]Stern School of Business, New York University, NYC, NY, [3]New York University, NYC, NY

There are (at least) two common paradigms when it comes to portfolio selection: one is based on making accurate predictions about equity prices using sophisticated machine learning models, and the other is universal portfolio allocation that does not attempt to predict -- and hence does not make any statistical assumptions of --the movements of prices. We perform an empirical study to see whether algorithms that combine statistical predictions with the universal portfolio allocation algorithms would be able to retain the best of both worlds of robustness and high returns.

5 Algorithmic Bias and Corporate Responsibility: How Companies Hide Behind The False Veil of The Technological Imperative

Kirsten Martin, University of Notre Dame

In this presentation, I argue that claiming algorithms are neutral or that the design decisions of computer scientists are neutral obscures the morally important decisions of computer and data scientists. I argue specifically that judging AI on efficiency or accurate and pretending algorithms are inscrutable produces a veil of the technological imperative which shields corporations from being held accountable for the value-laden decisions made in the design, development and deployment of algorithms. While there is always more to be researched and understood, we know quite a lot about testing algorithms. I then outline how the development of algorithms should be critically examined to elucidate the value-laden biases encoded in design and development. The moral examination of AI pierces the (false) veil of the technological imperative.

6 Evidential Reasoning Rule for Bayes Inference with Big Data and Belief Rule Based System for Interpretable Machine Learning

Dong-Ling Xu, Jian-Bo Yang, Manchester University, Manchester, United Kingdom. Contact: l.xu@manchester.ac.uk

Bayes inference is a powerful tool for inference under uncertainty. However it needs perfect probability information which is achievable in small scale but not in big data. In this presentation, we present the evidential reasoning (ER) rule which extends Bayes rule in situations where there may be missing data and therefore unknown probability information, and when probability information may not be reliable. Using examples from fraud detection application, we demonstrate how Bayes inference can be conducted through the ER rule when there is missing and unreliable probability information. Based on the ER rule, a belief rule base (BRB) system technique for interpretable machine learning is also presented. Its learning capability, interpretability and potential applications in machine learning are illustrated by examples.

7 Flash Paper

Zhiwei Qin[1], Hongtu Zhu[2], Jieping Ye[3], [1]Lyft, San Francisco, CA, [2]UNC Chapel Hill, Chapel Hill, NC, [3]University of Michigan, Ann Arbor, MI

In this paper, we systemically review the literature on reinforcement learning approaches to decision optimization problems in a typical ridesharing system. Papers on the topics of rideshare matching, vehicle repositioning, ride-pooling, routing, and dynamic pricing are covered. We also introduce popular data sets and open simulation environments to facilitate further research and development. Subsequently, we discuss a number of challenges and opportunities for reinforcement learning research on this important domain.

8 Flash Paper

Honghao Wei, Ann Arbor, MI

Existing start-of-the-art approaches for solving repositioning in large-scale ride-hailing platforms are optimization based methods, which has high computational complexity and are restricted by the size of the vehicle network. Each time a new optimization problem needs to be solved when the traffic pattern varies, which bring more limitations when deploying to real-time system. We propose a neural-network based optimizer for solving particular forms optimization problems, including the ride-hailing problem, using insights from the Actor-Critic method in reinforcement learning. Our approach can be trained with different traffic patterns offline and output the near-optimal solution when implemented online without further training, which is more efficient and desirable. Numerical results verifies the robustness of our approach.

9 Flash Paper

Seoung Bum Kim, Korea University, Korea, Republic of.

Robust artificial intelligence (AI) is AI capable of maintaining good performance under various analytic constraints. I will be presenting the methods and applications of robust AI.

10 Projected Randomized Smoothing for Certified Adversarial Robustness

Samuel Pfrommer[1], Brendon Anderson[2], Somayeh Sojoudi[2], [1]University of California, Berkeley, Berkeley, CA, [2]University of California, Berkeley, Berkeley, CA, Contact: sam.pfrommer@berkeley.edu

This work considers a classifier architecture that first projects onto a low-dimensional approximation of the data manifold and then applies a standard classifier. By performing randomized smoothing in the low-dimensional projected space, we characterize the certified region of our smoothed composite classifier in the high-dimensional input space and prove a lower bound on its volume. We show experimentally that unprotected classifiers are vulnerable to perturbations that are normal to the data manifold yet are certified under our method. We compare the volume of our certified regions against baselines and show that our method improves on the state-of-the-art by many orders of magnitude.

Monday, 11AM–12:15 PM

MB10

CC - Room 110

AI, Non-Fungible Tokens (NFTs), and Blockchain

General Session

Session Chair

Xiang Wan, University of Florida, Gainesville, FL

1 Complementing The "Get Big Fast" Platform Growth Strategy with Opt-in Signal: Evidence from The Lazy Minting Policy in An Nft Marketplace

Hong Zhang[1], Hongchang Wang[2], Amit Mehra[3], Zhiqiang Zheng[3], [1]University of Texas at Dallas, Richardson, TX, [2]University of Texas at Dallas, Allen, TX, [3]University of Texas at Dallas, Richardson, TX, Contact: hong.zhang@utdallas.edu

To avoid stagnation, a company must learn how to expand its business sustainably. In this study, we propose a new platform-growth strategy, wherein the "get-big-fast" strategy is complemented with a compelling opt-in quality-signaling design. We use an example of this new strategy, namely *lazy minting* in the context of NFT, to examine its impacts on market performance. We propose two underlying countervailing mechanisms: the *market thickness effect* and the *quality signaling effect.* We find that although the introduction of lazy minting reduces the overall matching likelihood (for intensified market thickness), it improves market performance in the gas-minting segment (indicating a prevailing quality signaling effect). Our study pinpoints the effectiveness of a new seeding strategy in managing thicker markets, by the virtue of efficient tiered market segmentation.

2 Integrating Imperfect Machines and Unmindful Users: Assessing Human-bot Hybrid Designs for Managing Discussions in Online Communities

Xinyu Fu[1], Narayan Ramasubbu[2], Dennis F. Galletta[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, Contact: xinyu.fu@pitt.edu

Machines, even with high prediction accuracy, are still imperfect. Thus, they are often deployed in assemblage configurations that require active human intervention in the workflow. Nonetheless, users are unresponsive to machines' errors. This paper explored the factors that trigger users to detect such errors in the context of online communities. In particular, we simulated an online news discussion forum where the content moderation task is crowdsourced to users assisted by a bot. The bot flags potential inappropriate comments and receives feedback from users who can confirm or override its assessments. We found that self-explanation could help users to become more vigilant to the actions of imperfect bots. There is also a tradeoff between human-bot hybrid designs that encourage engagement and those that emphasize moderation decision quality.

3 Nft Digital Artwork Pricing Using Image Analytics and Auction Models

Chi Zhang[1], Venkatesh Shankar[1], Xiaohui Zhang[2], [1]Texas A&M University, College Station, TX, [2]Arizona State University, Tempe, AZ

Non-fungible tokens (NFTs) can be used as public proof of ownership for various types of digital files. Online platforms, such as Foundation and SuperRare, have leveraged this property to track the copyright ownership of digital artworks and created corresponding online marketplaces. Digital artworks are traded as NFTs through auctions on these platforms. However, research on the valuation and pricing of NFT objects is sparse. In this research, we address two key questions. What is the relationship between the content of digital artworks and their prices? What are the optimal reserve prices for different types of digital artworks? We address these questions by using computer vision methods and economic models of auctions on a dataset collected from a major NFT digital artwork platform. The results from this study provide a deeper understanding of the pricing of NFT objects.

Monday, 11AM–12:15 PM

MB11

CC - Room 111

[Incorporating AI into Healthcare Delivery]

General Session

Session Chair

Sidian Lin, Harvard University

1 Can Predictive Technology Help Improve Acute Care Operations? Investigating The Impact of Virtual Triage Adoption

Jiatao Ding, Michael Freeman, Sameer Hasija, INSEAD, Singapore, Singapore. Contact: jiatao.ding@insead.edu

This paper develops a queueing game model to investigate the impact of virtual triage on patient self-triage and choice of care in the acute care setting. We find that, due to its decentralized nature, when virtual triage excessively recommends emergency (primary) care, it could bring about a decrease in ED (GP) visits. Another important finding is that for any arbitrary self-triage accuracy, the adoption of informative virtual triage can worsen system performance, even when the virtual triage recommendation is reasonably accurate. To unlock the potential operational benefits of virtual triage, we characterize the optimal virtual triage accuracy subjective to the receiver operating characteristic (ROC) curve, and how the optimal accuracy changes as the triage capability improves over time.

2 Offline Policy Learning of Mobile Health Interventions for Bipolar Disorder Patients

SIDIAN LIN, Soroush Saghafian, Jessica Lipschitz, Harvard University, Cambridge, MA

The development of mobile health technologies gives rise to the possibility of long-term monitoring for chronic diseases such as mental disorders. In this study, we focus on applying an offline contextual bandit model to the observational dataset of bipolar disorder patients, and find that deciding whether or not to send interventions using a bandit algorithm can help those patients. We share some insights on how to translate contextual bandits to the complex real-world data. Without actual actions from the data, we design a reward mechanism based on the comparison between post-intervention affect and pre-intervention affect, and simulate actions from potential outcomes. Given that mood transitions widely exist in most mental disorders, such design can be easily applied to other mental illnesses where new policies can be learned and evaluated in a safer way.

3 Using Machine Learning to Identify and Increase Utilization of Marginal Kidneys in The Deceased Donor Waiting List

Nikhil Agarwal[1], Itai Ashlagi[2], Grace Guan[2], Jamie Kang[2], Paulo Somaini[3], Jiacheng Zou[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Stanford University, Stanford, CA, [3]Stanford Graduate School of Business, Stanford, CA, Contact: jiachengzou@stanford.edu

In the US, over 20% of deceased donor kidneys are discarded after being recovered for transplantation. While cadaver kidneys are allocated based on priority points, many organ offers are being declined and such organs accumulate cold-ischemic times that further reduce their quality. The kidney allocation system allows out-of-sequence offers of kidneys that are in risk of being discarded. Exploiting this lever and working towards improving efficiency and reducing organ discard, we develop a mechanism that (i) predicts whether a kidney is hard-to-place, (ii) recommends how to make out-of-sequence offers for such organs. We estimate the causal effects of this mechanism in a field experiment with organ procurement organizations.

4 Machine Learning-driven Patient Operational Characteristics Prediction System Deployed at a Large Hospital Network

Liangyuan Na[1], Dimitris Bertsimas[1], Ali Haddad-Sisakht[2], Kimberly Villalobos Carballo[1], Kyle Maulden[1], Yi Wang[1], Yiwen Zhang[1], [1]Massachusetts Institute of Technolgy, Cambridge, MA, [2]Dynamic Ideas LLC, Waltham, MA, Contact: lyna@mit.edu

In collaboration with Hartford HealthCare, we have developed and implemented machine learning models for all inpatients in 4 hospitals to predict 8 outcomes daily, including mortality risk, discharge disposition, discharge probabilities and ICU risks next 1-2 days. Every morning, our pipeline extracts and processes EMR data, constructs auxiliary and time-series features, and makes predictions using XGBoost models (0.8+ AUCs). Our end-to-end software in production integrates online predictions with model explanation visualization and a color-coded alert system, which assists physicians with identifying exacerbations and timely discharges. Pilot deployment in Hartford Hospital reduced the length-of-stay of the units by 5% despite the interference of COVID. The adoption recently expanded to 3 other hospitals, and will soon cover all 7 hospitals in the network.

Monday, 11AM–12:15 PM

MB12

CC - Room 113

Interpretable Machine Learning for High-Stakes Decisions

General Session

Session Chair

Harsh Parikh, Durham, NC

1 Interpretable Deep Learning Models for Better Clinician-AI Communication in Clinical Mammography

Alina Barnett, Duke University, Durham, NC

The success of deep learning models has led to great hopes for medical AI, especially in medical imaging. Deep learning models are powerful algorithms that have superior performance for image classification, however, they are criticized as “black box” models, meaning that their decisions cannot be readily explained. This lack of interpretability has been identified as a major barrier of the translation of AI systems to the clinic. Here, I present an interpretable model designed to assist clinicians. It imitates the reasoning process of a radiologist and provides an explanation of each decision using appropriate medical terminology. Each medical feature is classified using an interpretable computer vision model that produces explanations of the form: “this part of the image looks like that prototypical image part learned during training.

2 A Holistic Approach to Interpretability in Financial Lending

Chaofan Chen, University of Maine, Orono, ME, Contact: chaofan.chen@maine.edu

We propose a framework for lending decisions based on explainable and interpretable AI, including a globally interpretable machine learning model, an interactive visualization of the model, and several types of explanations for any given decision. The machine learning model is a two-layer additive risk model, which is decomposable and globally transparent. Our online visualization tool allows exploration of this model, showing precisely how it came to its conclusion. We provide three types of explanations that are consistent with the global model: a set of features that were the most important for the model’s prediction, rule-based summary-explanations, and case-based reasoning explanations. Our framework earned the FICO recognition award for the Explainable Machine Learning Challenge, which was the first public challenge in explainable machine learning.

Monday, 11AM–12:15 PM

MB13

CC - Room 114

Telecommunications and Network Analytics Section Best Paper Award

Award Session

Session Chair

Abdullah Konak, Penn State Berks, Reading, PA

1 Influence Maximization with Latency Requirements on Social Networks

Subramanian Raghavan[1], Rui Zhang[2], [1]University of Maryland-College Park, College Park, MD, [2]Leeds School of Business University of Colorado Boulder, Boulder, CO, Contact: raghavan@umd.edu

The Positive Influence Dominating Set with Partial Payments (PIDS-PP) occurs in social networks where the effects of direct influence predominate. We develop a strong compact extended formulation that provides integral solutions for the node selection variables when the underlying graph is a tree. We project the compact extended formulation onto the payment space, providing an equivalently strong formulation that has exponentially many constraints. Our computational experience on a test-bed of 100 real-world graph instances (with up to approximately 465,000 nodes and 835,000 edges) demonstrates the efficacy of our strongest payment space formulation. It finds solutions that are on average 0.4% from optimality, and solves 80 out of the 100 instances to optimality.

2 Robust Power Management Via Learning and Game Design

Zhengyuan Zhou, Stern School of Business, New York University, New York, NY

We consider the target-rate power management problem for wireless networks; and we propose two simple, distributed power management schemes that regulate power in a provably robust manner by efficiently leveraging past information. Both schemes are obtained via a combined approach of learning and “game design” where we (1) design a game with suitable payoff functions such that the optimal joint power profile in the original power management problem is the unique Nash equilibrium of the designed game; (2) derive distributed power management algorithms by directing the networks’ users to employ a no-regret learning algorithm to maximize their individual utility over time. o establish convergence, we focus on the well-known online eager gradient descent learning algorithm in the class of weighted strongly monotone games. In this class of games, we show that when players only have access to imperfect stochastic feedback, multiagent online eager gradient descent converges to the unique Nash equilibrium in mean square at a <span class=”MathJax” id=”MathJax-Element-1-Frame” tabindex=”0” data-mathml=”O(1T)” role=”presentation” style=”box-sizing: border-box; display: inline; line-height: normal; font-size: 16px; word-spacing: normal; word-wrap: normal; white-space: nowrap; float: none; direction: ltr; max-width: none; max-height: none; min-width: 0px; min-height: 0px; border: 0px; padding: 0px; margin: 0px; position: relative;”> ;(1 ;) rate.

3 Age of Information for Single Buffer Systems with Vacation Server

Jin Xu[1], I-Hong Hou[2], Natarajan Gautam[3], [1]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [2]Texas A&M Univserity, College Station, TX, [3]Syracuse University, Manlius, NY

We study the information freshness in M/G/1 queueing system with the server taking multiple vacations. We aim to evaluate the information freshness in this system with both i.i.d. and non-i.i.d. vacations under three different scheduling policies, namely Conventional Buffer System, Buffer Relaxation System, and Conventional Buffer System with Preemption in Service. For the systems with i.i.d. vacations, we derive the closed-form expressions of the expected Age of Information (AoI), the expected Peak Age of Information (PAoI), and the variance of peak age under each policy. For systems with non-i.i.d. vacations, we use the polling system as an example and provide the closed-form expression of its PAoI under each policy. We explore the conditions under which one of these policies has advantages over the others for each information freshness metric.

4 Optimal Steiner Trees Under Node and Edge Privacy Conflicts

Alessandro Hill[1], Roberto Baldacci[2,3], Stefan Voß[4], [1]California Polytechnic State University, San Luis Obispo, CA, [2]University of Bologna, Cesena, Italy; [3]Hamad Bin Khalifa University, Doha, Qatar; [4]University of Hamburg, Hamburg, Germany.

We suggest concepts and solution methodologies for a series of strategic network design problems that find application in highly data-sensitive industries, such as, for instance, the high-tech, governmental, or military sector. Our focus is on the installation of widely used cost-efficient tree-structured communication infrastructure. As base model we use the well-known Steiner tree problem, in which we are given terminal nodes, optional Steiner nodes, and potential network links between nodes. Its objective is to connect all terminals to a distributor node using a tree of minimum total edge costs. The novel, practically relevant side constraints are related to privacy concerns of customers, represented by terminals. In order to account for these, we study four privacy models that restrict the eligible infrastructure for the customer-distributor data exchange: (I) Selected pairs of terminals mutually exclude themselves as intermediate data-transmission nodes; (II) some pairs of terminals require disjoint paths to the distributor; (III) individual terminals forbid routing their data through allegedly untrustworthy links; and (IV) certain terminals do not allow the usage of doubtful links on their entire network branch. These topological data-privacy requirements significantly complicate the notoriously hard optimization problem. We clarify the model relationships by establishing dominance results, point out potential extensions and derive reduction tests. We present corresponding, strong non-compact integer programming (IP) formulations and embed these in efficient cutting plane methods. In addition, we develop constraint programming formulations that are used complementally to derive primal solutions. In a computational study, we analyze the performance of our methods on a diverse set of literature-based test instances.

Monday, 11AM–12:15 PM

MB14

CC - Room 115

Modeling and Control of Traffic in a Smart-Cities Environment

General Session

Session Chair

Raphael Stern, University of Minnesota, MN

1 Modeling Traffic Flow in The Era of Vehicle Automation and Electrification

Xingan (David) Kan, 1</sup

Vehicle automation has been highly anticipated as it promises to potentially reduce congestion by improving capacity. In fact, most new vehicles sold today are partially automated via Adaptive Cruise Control (ACC). Contrary to previous expectations, microscopic models and simulations developed based on trajectory data obtained from over 20,000 miles of field experiments suggest that ACC could exacerbate congestion when compared with human drivers. Fortunately, when ACC is paired with electric powertrain, the instantaneous torque and constant power of the electric motor could mitigate the negative impact of ACC and even deliver improved capacity. This has been demonstrated by recent field experiments that generated more than 1000 miles of trajectory data, using mainstream electric vehicles equipped with ACC.

2 Probabilistic Traffic State Prediction Based on Vehicle Trajectory Data

Mohammadreza Khajeh Hosseini, Alireza Talebpour, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: ataleb@illinois.edu

Accurate prediction of traffic flow dynamics is a crucial step in any effective congestion mitigation strategy. While most traffic state prediction algorithms focus on aggregated measures (i.e., flow, density/occupancy, and speed), this presentation offers a methodology to utilize probabilistic prediction of traffic flow dynamics at the trajectory level to accurately predict the traffic state. The findings suggest significant improvements in the accuracy of traffic state prediction compared to the existing algorithms.

3 Optimal Feedback Control Law for Automated Vehicles in The Presence of Cyberattacks: A Min-max Approach

Shi'an Wang, Michael Levin, Raphael Stern, University of Minnesota, Minneapolis, MN, Contact: wang8975@umn.edu

The advent of automated vehicles (AVs) is expected to bring a broad spectrum of benefits to future transportation systems, ranging from smoothed traffic flow to increased urban mobility. Despite the benefits promised by AVs, emerging AV technologies open a door for cyberattack, where a select number of AVs are compromised to drive in an adversarial manner, degrading the performance of transportation systems. In this study, we derive optimal feedback control laws for AVs to minimize the worst-case potential disturbance to traffic flow due to AVs attacked. This is formulated as a general min-max control problem assuming bounded magnitude of the attack. A Hamiltonian function is constructed to determine the AV control policy so that the most severe disturbance to traffic flow is minimized. The effectiveness of the approach is illustrated via numerical simulation.

4 The I-24 Mobility Technology Interstate Observation Network

Derek Gloudemans, Vanderbilt University, Nashville, TN

Proposed technologies such as autonomous vehicles and truck platooning promise to increase safety and mobility without built infrastructure. However, the effects of these technologies on surrounding vehicles are unclear. To assess these effects requires trajectory data for each vehicle on the roadway, and no existing sources for such data exist.

This work presents the I-24 Mobility Technology Interstate Observation Network (I24-MOTION), a first-in-kind testbed that provides fine-grained vehicle trajectories. The testbed covers four miles of roadway with over 300 traffic cameras and utilizes vehicle tracking and positioning algorithms to continuously produce complete trajectory data. Within one week of operation, I-24 MOTION will be the largest source of such data and will enable testing and analysis of next-generation transportation technologies.

Monday, 11AM–12:15 PM

MB15

CC - Room 120

Topics in Global Health Care Operations

General Session

Session Chair

Lesley Meng, Yale School of Management, Yale University, New Haven, CT

Session Chair

Hummy Song, University of Pennsylvania, Philadelphia, PA

1 Blood Inventory Management Based on Flexible Donor Allocation Design

Yu Shi[1], Saed Alizamir[2], Babak Abbasi[3], Zahra Hosseinifard[4], [1]Yale University, New Haven, CT, [2]Yale University, New Haven, CT, [3]RMIT University, Melbourne, Vic, Australia; [4]The University of Melbourne, Parkville, Australia. Contact: yu.shi@yale.edu

Blood is a perishable and scarce resource in supporting vital activities. The volatility in blood inventory could result in unnecessary shortage and waste. Recent studies also suggest the correlation between the transfused blood age and the risk of adverse outcomes. Ensuring a sustainable blood supply with minimal shortage and waste, while keeping fresh blood, requires smart design of donor allocations. To study the problem, we conduct analysis using national-level blood inventory data in Australia from 2015 to 2019. We design an incentivization algorithm to avoid shortage while maintaining blood freshness. By targeting the repeated donors as the incentivized group, we experiment two different re-allocation strategies. We achieve both an improvement in blood freshness and a decrease in inventory volatility through re-allocating flexible blood donors.

2 Leapfrogging for Last-mile Delivery in Health Care

Harriet Jeon, Hummy Song, Claudio Lucarelli, University of Pennsylvania, Philadelphia, PA, Contact: hyjeon@wharton.upenn.edu

The access to and quality of health care, especially in hard-to-reach areas, are challenges for many countries. Traditional solutions improve geographic connectivity through incremental and costly infrastructure investments. Radical technological innovations may allow leapfrogging to directly improve access to quality medical care. Using data from Rwandan public hospitals, we examine whether adopting drone delivery technology improves operational and health outcomes. We find that adopting drone delivery leads to a 62% reduction in blood inventory and an 87% decrease in inpatient mortality for patients with postpartum hemorrhage (PPH). Hospitals that experienced road infrastructure improvements prior to adopting drone delivery see a quarter of the decline in PPH mortality as facilities that only adopted drone delivery, suggesting a leapfrogging effect.

3 The Role of Peer Familiarity in Shared Service Delivery: An Investigation into Shared Medical Appointments

Nazli Sonmez[1], Kamalini Ramdas[2], Ryan Buell[3], [1]Bilkent University, Ankara, Turkey; [2]London Business School, London, United Kingdom; [3]Harvard Business School, Boston, MA, Contact: nazlisonmez@bilkent.edu.tr

In shared service delivery, a group of customers is served at once. We examine how peer familiarity impacts service outcomes in shared service delivery in the context of shared medical appointments (SMA) - in which patients with similar chronic conditions meet with a doctor at once, and each receives one-on-one care in turn. Using data from the treatment arm of a prior multistage randomized controlled trial at a large hospital in India and an instrumental variable approach, we find that having familiar peers in the group significantly increases patient satisfaction, taking advantage of plausibly exogenous variation in peer familiarity. Our results shed light on an important aspect of how shared medical appointment groups should be formed. The insights obtained could also be valuable when considering delivery innovation in other traditionally one-on-one service settings.

4 Capacity Investment in Global Vaccine Supply Chains Under Regulatory Risks

Vincent (Junhao) Yu[1], Karen L. Donohue[2], Karthik Natarajan[3], [1]Poole College of Management, North Carolina State University, Raleigh, NC, [2]University of Minnesota, Minneapolis, MN, [3]Carlson School of Management, University of Minnesota, Minneapolis, MN, Contact: knataraj@umn.edu

The COVID-19 pandemic created unprecedented pressure on global healthcare supply chains. Due to the limited supply of critical products such as vaccines, several national governments implemented policies in recent times to limit their exports, a phenomenon dubbed by the media as "vaccine nationalism." We investigate potential implications of such government mandates on vaccine manufacturers' capacity investment decisions and the associated public health outcomes. We consider two types of government mandates: a complete ban on exports of the vaccine or a prioritization mandate that allows exporting only after domestic demand has been fulfilled. Our results indicate that the mandates do not necessarily result in the intended consequence of increasing the local availability of vaccines. In addition, the public health outcomes might also suffer under such mandates.

Monday, 11AM–12:15 PM

MB16

CC - Room 121

OR Applications for Medical Decision-making

General Session

Session Chair

Daniel Felipe Otero-Leon, University of Michigan, Ann Arbor, MI

1 Average Treatment Effect Estimation of On-treatment 24-hour Urine on Preventative Pharmacological Therapy Adherence in Stone Formers

Kevin B. Smith[1], Siqian Shen[2], Phyllis L. Yan[2], Joseph J. Crivelli[3], Ryan S. Hsi[4], Vahakn Shahinian[2], John M. Hollingsworth[5], Brian T. Denton[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, [3]University of Alabama at Birmingham School of Medicine, Birmingham, AL, [4]Vanderbilt University Medical Center, Nashville, TN, [5]University of Michigan, Ann Arbor, MI, Contact: kvbsmith@umich.edu

Kidney stones are prevalent in approximately 8.8% of people in the United States (US), and estimates suggest that 50% of those will experience at least one recurrent stone event. Several medications can help patients avoid kidney stone recurrence, but adherence is often poor. In the absence of randomized trials, we used observational data, including demographics, pharmacy claims, and medical records, to estimate the causal effect of medical interventions on treatment adherence. We discuss three unique matching and propensity score methods that seek to account for unmeasured confounders to estimate the causal effect of interventions on adherence to treatment. Finally, we discuss opportunities for optimizing decisions about whether and when to use interventions for patients. We conclude with a discussion of future research opportunities.

2 Data-driven Optimal Intervention Decisions Based on Risk Scores

Osman Ozaltin, Jessica Mele, Julie L. Swann, North Carolina State University, Raleigh, NC, Contact: oyozalti@ncsu.edu

We propose a newsvendor approach to optimize deployment of two preventative public health interventions based on costs, effectiveness, and the distribution of risk in the population. The optimal decision is defined by identifying two decision thresholds that partition the population into three groups: individuals who receive no intervention, who receive the less effective intervention, and who receive the more effective intervention. We apply our results to unpredicted pneumonia hospitalization using claims data. Based on the intervention costs and effectiveness, the recommended strategy has the ability to reduce overall costs significantly compared to doing nothing.

3 Trauma Care Center Network Planning for Covid-19: A Two-stage Stochastic Programming Framework

Alakshendra Joshi[1], Eduardo Perez[1], Francis A. Mendez Mediavilla[2], [1]Texas State University, San Marcos, TX, [2]Texas State University, San Marcos, TX, Contact: eduardopr@txstate.edu

Trauma care services are a vital part of all healthcare-based network as timely accessibility is important for citizens. Trauma care access is even more relevant when unexpected events such as the COVID-19 pandemic overload the capacity of the hospitals. The optimal geographic configuration of trauma care centers is key to maximizing accessibility while promoting the efficient use of resources. This research reports on the development of a two-stage stochastic optimization model for geospatial expansion of a trauma network in the state of Texas. The stochastic optimization model recommends the siting of new trauma care centers according to the geographic distribution of the injured population. The model has the potential to benefit both patients and institutions, by facilitating prompt access and promoting the efficient use of resources.

4 Queueing-location-allocation Model for Hiv Viral Load Testing in Kenya

Yinsheng Wang[1], Anjuli Wagner[2], Rena Petal[3], Shan Liu[4],

[1]University of Washington, Seattle, WA, [2]University of Washington, Seattle, WA, [3]University of Washington, Seattle, WA, [4]University of Washington, Seattle, WA, Contact: yinshw@uw.edu

Point-of-care (POC) technologies have revolutionized diagnostic testing and management for HIV care. However, healthcare providers in Kenya are facing limited resources in conducting routine HIV viral load (VL) testing. In this work, we modeled the reduction in total turnaround time associated with the placement of POC machines in selecting "hub" facilities (sites with a POC machine) and "spoke" (sites that send samples to a hub) facilities in western Kenya. By incorporating a queueing model into integer programming, we determine the optimal placement of limited POC VL machines within a hub-and-spoke network to balance budget impact and minimize turnaround time. The solution algorithm is based on approximation schemes.

Monday, 11AM–12:15 PM

MB17

CC - Room 122

Drones for Healthcare Delivery

General Session

Session Chair

Shakiba Enayati, University of Missouri - Saint Louis, St Louis, MO

1 Current state, future potential and scaling challenges for healthcare drone delivery

Robin Riedel, McKinsey & Company, San Francisco, CA

This presentation will lay out the current state of healthcare drone deliveries in the U.S. and explore the key use cases and technologies leveraged; the economics in comparison to alternative modes and their key drivers; and challenges for scale up, including regulation, technology, customer acceptance and safety/security of shipments.

2 A Simulation-based Performance Evaluation Model for Drone Location and Scheduling Problem

Zabih Ghelichi[1], Monica Gentili[2], Pitu B. Mirchandani[3], [1]BNSF Railway, Fort Worth, TX, [2]University of Louisville, Louisville, KY, [3]Arizona State University, Tempe, AZ

We propose a simulation-based performance evaluation model for the drone-based delivery of aid items to disaster-affected areas in humanitarian logistics. Our goal is to develop a simulation-based system to perform analytical studies, evaluate the performance of a drone delivery system in humanitarian logistics, and support the decision-making process in such a context. In particular, we develop a simulation model capable of capturing the dynamics and variabilities of the drone-based delivery system in emergency scenarios, including demand rates, demand locations, time-dependent parameters, and possible failures of drones in the system. An optimization model is integrated into the simulation system to update the drones' schedules and delivery assignments.

3 Vaccine Distribution with Drones in Less Developed Countries

Shakiba Enayati[1], Haitao Li[2], James Campbell[2], [1]University of Missouri Saint Louis, St Louis, MO, [2]University of Missouri - St. Louis, Saint Louis, MO, Contact: senayati@umsl.edu

Vaccine distribution in less-developed countries is challenging due to the remote populations, the lack of reliable and fast transportation, and the need to maintain the cold chain. This research develops two MILP formulations to optimize the multi-modal national vaccine supply network, where drones can also distribute vaccines to regional health distribution centers (DCs) to exploit drones' advantages in fast speed and low cost. The models optimize vaccine flows, DC, relay station and drone base locations with multi-stop drone paths that allow drone recharging, and satisfy cold chain requirements. Our experiments study the value of multiple types of drones and multi-stop drone paths for the island nation of Vanuatu. Solutions with drones are shown to generate large savings, with differentiated roles for large and small drones.

4 Sustainable Logistics Using Lockers and Drone - E-bike Tandems

Stephanie Santiago-Montano, Daniel F. Silva, Alice E. Smith, Auburn University, Auburn, AL

The healthcare industry is looking for innovative ideas to improve their delivery systems and overcome barriers (like limited access) by developing sustainable/efficient operational methods. This study addresses the two-echelon multi-trip capacitated vehicle routing problem with home-delivery and optional self-pickup services using drones and electric-assisted bikes. A mathematical formulation that determines the vehicle routes that minimize the total traveling cost is introduced. Instances are generated to compare traditional truck-based networks and the proposed tandem networks and investigate total traveling cost and emissions tradeoffs. Results suggest that with a minor increase in total traveling cost, significant reductions in emissions could be achieved.

Monday, 11AM–12:15 PM

MB18

CC - Room 123

Industry-based Practice, Success Stories or Applications

Flash Session

Session Chair

Cecilia Zenteno Langle, 1</sup

Session Chair

Christopher Sun, Massachusetts Institute of Technology, Cambridge, MA

1 Data Driven Algorithms for Joint Inter-day and Intra-day Scheduling in Hospitals

Linger Sun[1], Xinyun Chen[2], Pengyi Shi[3], [1]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [2]Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [3]Purdue University, West Lafayette, IN, Contact: lingersun@link.cuhk.edu.cn

We consider a joint inter-day and intra-day scheduling problem to improve patient flows through the imaging diagnosis services of a hospital. We model this problem as high-dimensional MDP, and develop a data-driven framework to solve it. To reduce the dimensionality, we leverage Linear-Quadratic (LQ) control formulas so that the MDP can be solved efficiently. Moreover, assuming costs are unknown and need to be estimated via collecting data in an online fashion, we develop reinforcement learning (RL) based algorithms. We provide theoretical analysis on the solution of our proposed algorithms, especially under special cost structure, and provide sufficient managerial insights.

2 MULTIDISCIPLINARY CARE INTERVENTIONs for PATIENTs with COMPLEX MEDICAl and SOCIAL NEEDS

Hari Balasubramanian, Univ of Massachusetts- Amherst, Amherst, MA

Patients with multiple chronic conditions as well as unmet social needs have a significant impact of healthcare costs and utlization. Holistic, person-centered care interventions, often led by a multidisciplinary team consisting of nurses, community health workers and social workers, have emerged as a strategy to engage with and help improve the health and wellbeing of such patients. While such interventions have been adopted by a range of organizations including payers, primary care providers, and hospitals, operational questions that are vital to successful interventions have not yet been investigated. In this talk, we describe a complex care intervention developed by the Camden Coalition of Healthcare Providers, an organization with significant experience in interventions for patients with complex medical and social needs.

3 AI-Enhanced Healthcare Task Management

Dessislava A. Pachamanova, Wiljeana J. Glover, Zhi Li, Babson College, Wellesley, MA, Contact: dpachamanova@babson.edu

Healthcare providers and staff spend an ever-increasing amount of time on administrative tasks, with limited understanding of task patterns to inform resource allocation. Based on a collaboration with a healthcare task management platform and a mental health practice, this project successfully performed task identification and mapping using natural language processing and user-generated data. More broadly, the talk will outline a framework for increasing understanding of healthcare administrative tasks and task completion networks and ultimately reducing administrative task burden by utilizing artificial intelligence algorithms to learn and optimize system behavior.

4 Observation Unit Routing Decisions with Consideration of Capacity

Keely Dwyer-Matzky[1], Dessislava Pachamanova[2], Vera Tilson[1], [1]University of Rochester, Rochester, NY, [2]Babson College, Boston, MA, Contact: vera.tilson@simon.rochester.edu

We discuss a practical real-time optimization algorithm for placing patients into the observation unit vs. an inpatient ward in the hospital. The algorithm balances the need to place a patient in the OU with considerations of available capacity.

5 Treatment Planning of Victims with Heterogeneous Time-sensitivities in Mass Casualty Incidents

Yunting Shi[1], Nan Liu[2], Guohua Wan[1], [1]Shanghai Jiao Tong University, Shanghai, China; [2]Boston College, Chestnut Hill, MA, Contact: nan.liu@bc.edu

Mass casualty incidents (MCI) lead to a sudden jump in patient demand, making it inevitable to ration medical resources. Informed by a unique timestamps dataset collected during a large-scale earthquake, we develop data-driven approaches to plan treatment of victims with heterogeneous time-sensitivities to do the greatest good to the greatest number. By demonstrating the value of adopting data-driven approaches in MCI response, our research holds strong potentials to improve emergency response and to inform its policy making.

6 Caring for Those Who Care: Analytics for Community Health

Jonathan Eugene Helm[1], Iman Attari[1], Buyun Li[2], [1]Indiana University, Bloomington, IN, [2]Kelley School of Business; Indiana University, Bloomington, IN, Contact: helmj@indiana.edu

This talk will highlight ongoing work integrating predictive and prescriptive analytics for decision support for caregivers in the healthcare system. Topics will cover personalized prevention and treatment strategies for substance use disorder, infection-aware nurse staffing to protect one of the hospital's most valuable resources, and supply chain responsibility for the opioid crisis.

7 Optimizing Intra-hospital Patient Transport Services

Martin S. Copenhaver[1], Retsef Levi[2], Christopher Sun[3], A. Cecilia Zenteno[4], [1]Massachusetts General Hospital, Cambridge, MA, [2]MIT, Cambridge, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, [4]Massachusetts General Hospital, Boston, MA, Contact: clfsun@mit.edu

Intra-hospital patient transportation services are an integral part of daily logistic activities in a hospital, facilitating patient flow between inpatient units on stretchers, wheelchairs, and beds. Delays stemming from suboptimal transport practices can significantly impact operations of procedural areas and test sites, potentially compromising quality of care. In this project, we identified the primary drivers of patient transport delays at Massachusetts General Hospital, and propose analytical frameworks to address these issues.

8 Reshaping National Organ Allocation Policy

Theodore P. Papalexopoulos[1], Dimitris Bertsimas[2], Nikolaos Trichakis[3], James Alcorn[4], Darren Stewart[4], Rebecca Goff[4], [1]Massachusetts Institute of Technology, Boston, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT, Cambridge, MA, [4]UNOS, Richmond, VA, Contact: ntrichakis@mit.edu

The Organ Procurement and Transplantation Network (OPTN) is overhauling its organ allocation policies in a generational change, aiming for more efficient and equitable outcomes. We introduce a novel analytical framework to enable dynamic exploration of the efficient frontier of policy options. Jointly with OPTN, we applied our framework to the design of a new allocation policy for lungs, which was eventually approved for implementation. From 2023, all lungs in the U.S. will be allocated according to the said policy, projected to reduce waitlist mortality by 20% compared to current policy.

9 Advance Notice of Diagnostic Service for Hospital Inpatients

Miao Bai[1], Nan Liu[2], Zheng Zhang[3], [1]University of Connecticut, Storrs, CT, [2]Boston College, Chestnut Hill, MA, [3]Zhejiang University, Hangzhou, China.

Inpatients are often viewed as ``on-demand" for diagnostic service and they are notified only when service capacity is available. This way of arrangement causes chaos and inefficiencies in diagnostic services. Informed by a unique dataset collected at Mayo Clinic, we develop an MDP-based advance notice policy for inpatient diagnostic service. We show several structural properties of the model and demonstrate the value of advance notice in a case study based on real-world data.

Monday, 11AM–12:15 PM

MB19

CC - Room 124

Modeling and Optimization in Healthcare

Contributed Session

Session Chair

Bingnan Lu, National University of Singapore, Singapore, Singapore.

1 Patient Referral Strategies Using Potential Patient Arrival Information in a Hierarchical Medical System

RUILU HUANG, Central South University, Changsha, China. Contact: rlhuang1994@gmail.com

This paper investigates patient referral strategies in a hierarchical medical system in terms of the imbalance in healthcare demand between general hospitals and community healthcare centers, so as to make better use of resources and minimize patient waiting times. In this work, a class of proactive referral strategies is proposed using potential future patient arrival information and queueing theory models. Unlike standard online referral strategies, the proposed strategy is able to identify potential congestion and advance patient referrals with the help of predictive information. In addition, we also discuss and analyses the referral strategy in case of deviations in the results of the prediction model. The simulation results demonstrate that the proposed strategy is an effective solution.

2 Optimal Location of a Remote Dental Service Unit

Jong Youl Lee[1], Balaraman Rajan[2], Abraham Seidmann[3], [1]University of Rochester, Rochester, NY, [2]California State University East Bay, Pleasanton, CA, [3]Boston University, Newton, MA, Contact: jongyoul.lee@simon.rochester.edu

We explore the economics of a major hospital operating a remote dental unit in a distant rural area. Specifically, we characterize the optimal location of the remote unit and examine the impact of operating a remote dental unit on the profit of a dental hospital. The ideal scenario, from a patient coverage perspective, is to put the remote unit location far enough away that patients accessing the remote unit are distinct from patients accessing the main hospital center to avoid redundancy (market cannibalization). However, we show that such a placement may not always be optimal for the hospital's profit and derive conditions under which the optimal patient coverage for the hospital and the remote unit overlaps. Our findings lead to policy implications for dental care reimbursement and service expansion.

3 Preference-based Allocation of Patients to Nursing Homes

Rebekka Arntzen, Centrum Wiskunde & Informatica, Amsterdam, Netherlands. Contact: rebekka.arntzen@cwi.nl

In many countries, the rapid aging of the population leads to excessive waiting times for long-term care centers. We propose a new and easy-to-implement method for the optimal allocation of patients-in-need to nursing homes, balancing the trade-off between the waiting time performance and the individual patients' preferences and levels of flexibility. We validate the model for a real life use case of allocating somatic patients to nursing in the Amsterdam area. The results show that if more patients replacements are approved, the allocation model can reduce the abandonment fraction under the current policy from 30.2% to 7.9% and waiting times at the same time. Moreover, with the allocation model individual preferences can be served better, which thus provides a powerful means to face the increasing need for patient-centered and sustainable long-term care solutions.

4 Pooled Testing in The Presence of Congestion

Bingnan Lu[1], Saif Benjaafar[2], Benjamin Legros[3], Oualid Jouini[4], [1]National University of Singapore, Singapore, Singapore; [2]University of Minnesota, Minneapolis, MN, [3]EM Normandie, Paris, France; [4]CentraleSupelec, Gif-sur-Yvette, France. Contact: luke_lu@nus.edu.sg

We study the operation of a testing facility that diagnoses infected individuals. In particular, we focus on how the facility should select the sample pooling size that minimizes the total waiting time for testing results. We model the testing process as a two-stage tandem queueing system with batch service and re-entry. We provide conditions on the disease prevalence rate and the arrival intensity that guarantee system stability (i.e. a finite expected waiting time). We provide analytical expressions for estimating expected time spent in the system by each sample. We also develop an algorithm to obtain the batch size that minimizes the delay in delivering test results. We show that, in general, the optimal batch size decreases in the prevalence rate and increases in the testing times.

Monday, 11AM–12:15 PM

MB20

CC - Room 125

Decision Analysis and Behavioral Research

General Session

Session Chair

Detlof von Winterfeldt, USC, Los Angeles, CA

1 Creating the Essential Front-End for a Quality Decision Analysis

Ralph L. Keeney, Duke University, San Francisco, CA

The front-end of any decision analysis involves defining the decision, stating its objectives, and specifying alternatives. It is necessary to do each of these well to structure your decision so you can subsequentially provide a quality decision analysis that produces information and insight for a quality decision. This presentation describes shortcomings and errors commonly made when conducting the front-end structuring and presents procedures to do this effectively.

2 BEHAVIORAL MEASUREs of RISK TAKING

Richard S. John, University of Southern California, Los Angeles, CA

Several behavioral measures of risk-taking have been developed that do not explicitly represent the choice alternatives as lotteries. These measures involve games involving an award for each trial successfully passed and a likelihood of a significant loss for a failed trial. The typical measure of risk-taking is the number of trials attempted by the respondent; stopping before a failed trial results in a sure gain depending on the number of successful trials completed. Such measures have shown to be predictive of a number of relevant outcomes, including various psychopathologies. However, studies have demonstrated that these measures demonstrate low convergent validity. This presentation uses lottery representations of different game measures to better understand the nature of respondent decisions at each trial to continue or not continue.

3 Improving Graphs for Climate Change Communications: Insights from Interviews with Policy Makers

Wändi Bruine de Bruin, University of Southern California, Los Angeles, CA

Graphs are central to science communication, including climate change. However, climate experts may design graphs that are too complex for their audiences. We interviewed international policy makers from 12 countries who are the key audience of the Intergovernmental Panel on Climate Change (IPCC). Policy makers commented on graphs drafted by climate experts for a recently released IPCC report. Policy makers' main suggestion was to focus each graph on a clear key message. They also suggested that it would help to have labels, titles and captions that clearly state what the graphs mean. Based on policy makers' suggestions and the graph design literature, we present a checklist to inform better graph design for science communication.

4 THE VALUe of HOMELAND SECURITY RESEARCH

Detlof von Winterfeldt, USC, Los Angeles, CA, Contact: detlof@aol.com

The Science and Technology Directorate (S&T) of the Department of Homeland Security (DHS) spends about $800 million per year on Research and Development (R&D) projects. Congress frequently asks about the return on this investment. Using a combination of decision analysis, risk analysis, and benefit-cost analysis we evaluated 25 R&D projects funded by S&T that were used or considered to be useful by DHS component agencies. For most project we found sufficiently high net benefits to justify their costs.

5 Policy Choice and The Wisdom of Crowds

Nicholas Otis, UC Berkeley, Berkeley, CA, Contact: nicholas_otis@berkeley.edu

Using data from seven large-scale randomized experiments, I test whether crowds of academic experts can forecast the relative effectiveness of policy interventions. The experiments span a diverse set of outcomes (e.g., consumption, COVID-19 vaccination), locations (Kenya, Sweden, the United States), and interventions (e.g., information provision, soft-skills training). While 65% of individual experts identify which of two competing policies will have a larger causal effect, the average forecast from bootstrapped crowds of 30 experts identifies the better policy 85% of the time. Only 10 experts are needed to produce a 18-percentage point (27%) improvement in policy choice.

Monday, 11AM–12:15 PM

MB21

CC - Room 126

Decisions Under Risk and Uncertainty

General Session

Session Chair

Sreyaa Guha, Nova School of Business and Economics, Carcavelos, Portugal.

1 Algorithmic Explanations and Human Decision-making: A Randomized Field Experiment

Charles Wan[1], Rodrigo Belo[2], Leid Zejnilovic[2], [1]Erasmus University, Rotterdam, Netherlands; [2]Nova School of Business and Economics, Lisbon, Portugal.

We model how humans react to changes in explanation sets provided by algorithms in the context of a prediction task. We use data from a randomized field experiment in a public employment agency in which counselors were presented with a new algorithm that predicts the likelihood of long-term unemployment. We find that counselors' predictions can be explained with a sparser model than those of the machine learning algorithms. We also show that when presented with explanations that are part of their mental model, counselors become more confident on their decisions, but are wrong more often, compromising their overall performance. We discuss managerial implications.

2 Algorithms and Adaptive Risk Attitudes in Resource Allocation Problems

Pranadharthiharan Narayanan[1], Jeeva Somasundaram[2], Matthias Seifert[3], [1]IE Business School, Madrid, Spain; [2]INSTITUTO DE EMPRESA (IE), Madrid, Spain; [3]Operations & Technology Area, IE Business School - IE University, Madrid, Spain. Contact: prana@student.ie.edu

We examine the influence of algorithms on risk taking behavior in resource allocation problems (e.g. multi-item newsvendor). Using a simple model, we predict that decision-makers systematically anchor and adapt their risk preferences based on the type of algorithmic advice they observe. Across two studies (N = 381), consistent with our model predictions, we find that subjects who receive highly risk-averse algorithmic recommendations (HRA condition) act more risk-averse compared to those who receive slightly risk-averse, risk-neutral or no algorithmic recommendations (control condition). Strikingly, even after the algorithm is removed, subjects in the HRA condition continue to display higher levels of risk-aversion compared to those in the control condition. Our findings demonstrate the mutability of human risk preferences when exposed to algorithmic aids.

3 When Do You Want to be Precise?: In The Context of Judgmental Forecasting

Moon Su Koo, Yun Shin Lee, Chan Jean Lee, Korea Advanced Institute of Science and Technology, Seoul, Korea, Republic of. Contact: mskoo@kaist.ac.kr

We investigate how the precision level of numbers used in judgmental forecasting affects forecast accuracy. We design a behavioral experiment where subjects are asked to make judgmental forecasts for consecutive periods for a stationary time series. In one treatment, subjects are asked to use precise numbers to make their forecasts, and in another treatment, no such an instruction is given. We find that the instruction to use precise numbers improves performance in a less volatile time series environment whereas it deteriorates performance in a highly volatile environment. When the instruction to use precise numbers is not given, subjects who feel more confident tend to use more precise numbers, which leads to worse forecasting performance in a highly volatile environment.

4 How Does The Newsvendor React to near Misses?

Florian Mathis Federspiel[1], Robin Dillon-Merrill[2], Matthias Seifert[3], [1]INCAE Business School, Escazu, Costa Rica; [2]McDonough School of Business, Georgetown University, Washington, DC, [3]Operations & Technology Area, IE Business School - IE University, Madrid, Spain. Contact: florian.federspiel@incae.edu

We study *when* and *why* repeated near misses (i.e., near inventory stockouts) lead to inappropriate order adjustments and risk-taking. Besides anecdotal evidence, little is known about the behavioral consequences and risks from repeated near misses in inventory decisions. We offer a theoretical foundation and empirical support from two experimental studies to shed light upon a novel bias applicable to newsvendor decision-making, showing that if prior events do not cause the decision-maker to reflect on how close a near-miss situation could have been to a disastrous consequence, these repeated events can lead to irrational order adjustments. Lastly, we show that messages directly alerting newsvendors to the risk of stockouts were insufficient to debias her behavior following near misses, highlighting the bias's resilience and importance for follow up studies.

5 Asset Pricing Under Knightian Uncertainty with Skewness Preference and Ambiguity Aversion

Soroush Ghazi, Mark Schneider, University of Alabama, Tuscaloosa, AL

We study a representative agent model that separates beliefs, Knightian uncertainty, and uncertainty attitude. We show that this framework helps explain four types of empirical puzzles for the aggregate stock market: (i) puzzles related to matching basic market moments (the risk-free rate, equity premium, variance risk premium, and risk-neutral entropy); (ii) return predictability puzzles (pertaining to the return predictability of the price-dividend ratio, variance risk premium, market crash risk, and market correlation); (iii) the pricing kernel puzzle and the dynamics of the pricing kernel; and (iv) the puzzle pertaining to identifying the risk-return tradeoff for the aggregate market.

Monday, 11AM–12:15 PM

MB22

CC - Room 127

Humanitarian Operations and SDGs: Progress Today

General Session

Session Chair

Maria Besiou, Kuehne Logistics University Gmbh, Hamburg, Germany.

Session Chair

Luk N. Van Wassenhove, INSEAD, Fontainebleau Cedex, France.

Session Chair

Alfonso Pedraza-Martinez, Indiana University, Bloomington, IN

1 Operations Research Applications for Fighting Labor Exploitation in Agricultural Supply Chains

Nathan Kunz[1], Ioannis Kougkoulos[2], M. Selim Cakir[3], Doreen Boyd[4], Alexander Trautrims[5], Stefan Gold[6], [1]University of North Florida, Jacksonville, FL, [2]The American College of Greece, Athens, Greece; [3]University of Bristol, Bristol, United Kingdom; [4]University of Nottingham, Notthingham, United Kingdom; [5]University of Nottingham, Notthingham, United Kingdom;

[6]University of Kassel, Kassel, Germany. Contact: nathan.kunz@unf.edu
Modern slavery and labor exploitation is a global problem affecting more than 40 million people worldwide, and the agricultural sector is particularly at risk. Labor exploitation often results from forced migration, and humanitarian operations have an important role to play in addressing this problem. This paper develops a multi-method approach to fight labor exploitation in strawberry production in Greece. It further discusses the applicability of different operations research tools to fight the exploitation of refugees and migrant workers in agricultural supply chains.

2 A Systems Framework for International Development: The Data-layered Causal Loop Diagram

Erica L. Gralla[1], Courtney Blair[2], Finley Wetmore[1], Jarrod D. Goentzel[3], Megan Peters[1], [1]George Washington University, Washington, DC, [2]Oxford University, Oxford, United Kingdom; [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: egralla@gwu.edu

Meeting the United Nations Sustainable Development Goals (SDGs) will require adapting or redirecting a variety of very complex global and local human systems. We suggest an approach that tailors system dynamics tools to the data-poor and fragmented environment of development work. Our "data-layered causal loop diagram" was developed through a 4-year engagement with USAID/Uganda. We illustrate it with an application to agricultural financing in Uganda, which highlighted a lack of demand for agricultural loans as a major barrier to broadening agricultural financing.

3 Operationalizing Climate Resilience Under Data Deficiency_Logical Vs. Latent Resilience Constructs

Lamis Amer, Murat Erkoc, University of Miami, Miami, FL, Contact: lxa659@miami.edu

Climate resilience is fundamental in sustainable development to mitigate risks due to climate change. Using resilience in decision models necessitates the development of metrics that can be mapped to the decision variables, and reflected in the objective, and constraints. In order to measure resilience, research relies on historical performance degradation data to predict future responses. In most cases, such data, however, is not available. To tackle this, we propose a methodology to measure resilience based on relevant systems' characteristics. We employ statistical latent variable models to map the observed system-related variables into the unobserved variable representing resilience. We also develop a reliability-based (logical) model for resilience assessment and compare the sensitivity of both models to the constructed theory using a real-life setting.

Monday, 11AM–12:15 PM

MB23

CC - Room 128

Resilient Infrastructure and Communities

General Session

Session Chair

Andres David Gonzalez, University of Oklahoma

1 Quantifying and Visualizing Mobility Changes During The Covid-19 Pandemic to Build Resilient Communities

Gabriela Gongora-Svartzman, Carnegie Mellon University, Pittsburgh, PA, Contact: ggongora@cmu.edu

Over the last couple of years, transportation services have experienced major impacts due to changes in demand, scarcity of drivers, differences in people's mobility patterns, and riders' hesitance to different mandates and policies related to the Covid-19 pandemic. Aside from system resilience, the social resilience of different communities that rely on transportation services (e.g., urban versus rural) has been tested. This work explores the impacts of Covid-19 on mobility and transportation in major cities. Using social media along with mobility data to identify communities, this work establishes a framework for gentrification and displacement, incorporating riders' perceptions of transportation services. Future work suggests how to re-think resilience as we re-build mobility in this "new normal".

2 THE ISOLATED COMMUNITY EVACUATION PROBLEm for RESPONSE PURPOSES

Klaas Fiete Krutein[1,2], Linda Boyle[3], Anne Goodchild[4], [1]University of Washington, Seattle, WA, [2]Convoy, Inc., Seattle, WA, [3]University of Washington, Seattle, WA, [4]University of Washington, Seattle, WA, Contact: fietekrutein@gmail.com

During responses to evacuation notices, decisions on resource allocation need to be made quickly. Frequently, information about the location and exact numbers of evacuees is incomplete. This is especially relevant for evacuations that require the coordination of evacuation resources. While the recently introduced ICEP has provided an evacuation planning tool for isolated areas, it relies on accurate data to provide a good solution. This research solves this problem through a robust optimization (R-ICEP) and a rolling-horizon optimization (RH-ICEP) variant of the ICEP. Computational results demonstrate the value of using evolving information which can help emergency coordinators to respond more efficiently to isolated community evacuations.

3 Resilient Matchings in The Capacitated House Allocation Problem with Ties and Conflicts

Matthew Williams[1], Ozlem Ergun[2], [1]United States Coast Guard Academy, New London, CT, [2]Northeastern University, Boston, MA, Contact: matthew.b.williams@uscga.edu

In the context of matching military members to duty stations, we consider a two-stage, stochastic variant of the assignment problem. A match is constructed between military members and duty stations in the first stage. In the second stage, a subset of duty stations becomes unavailable, and the members matched to those stations must be reassigned. Our objective is to find an initial match such that its cost, plus the average cost of reassignments required in the second stage, is minimized. We develop a novel variant of the SAA technique for this problem, utilizing instance parameters to identify “important” second-stage scenarios which are likely to occur and significantly impact any high-quality, first-stage solution. Our algorithm quickly constructed solutions within 5% of optimal for 67% of our problem instances and within 10% of optimal for 92% of our problem instances.

4 A Building and Utility Intervention Decision Support Model with Socio-economic Constraints: Application to Lumberton, Nc

Hesam Talebiyan[1], Himadri Sen Gupta[2], Andres David Gonzalez[2], Leonardo Duenas-Osorio[1], [1]Rice University, Houston, TX, [2]University of Oklahoma, Norman, OK, Contact: hesam.talebiyan@rice.edu

We propose a comprehensive framework to find consistent retrofit and restoration decisions for coupled building and utility systems. To this end, we use an iterative process integrating currently-independent mixed-integer optimization models of each system. Also, we consider the socio-economic context of decisions by incorporating population dislocation trajectories and community-level policy levers. The novelty of the study rests on the integration of various irreducible and non-linear models and the explicit modeling of feedback loops and decision interconnections in search of strategies to support community resilience.

Monday, 11AM–12:15 PM

MB24

CC - Wabash 1

University of Arkansas / Optimization Direct

Technology Tutorial

1 Analytics in the Classroom: A Hands-on Approach

Ronald Freeze, University of Arkansas, Fayetteville, AR, Contact: rfreeze@walton.uark.edu

The University of Arkansas would like to invite you to this workshop that will provide faculty participants with hands-on training in the SAS Viya analytics applications. These exercises focus on the use of data analytics and big data. The workshop will focus on connecting directly from SAS Viya to the Dillards data set that resides on the Teradata Intelliflex platform at the University of Arkansas. The data set used is updated weekly by Dillards and allows predictive analytics along with machine learning (and other analytic techniques) to be tested and validated in real time during the semester. All materials and resources demonstrated at the workshop are available free of charge to the participants and the students in their courses.

2 ODH Python Primer

Robert Ashford, Optimization Direct, Inc., Harrington Park, NJ, Contact: rwa@optimizationdirect.com

This short tutorial shows participants how to build a basic model using the ODH|CPLEX in Python. This session includes setting the Python environment, reading data from a csv or spreadsheet, creating variables, objective functions, and constraints, solving the model, and returning the results. Additionally, this session points the participants to further reading so that they may expand their capabilities. Furthermore, we will present the brand new ODH|Gurobi generic API and demonstrate it in Python.

Monday, 11AM–12:15 PM

MB25

CC - Wabash 2

Product Recall Research: Dimensions, Methods, and Regulator Implications

Tutorial Session

Session Chair

Douglas R. Shier, Clemson University, Pittsboro, NC

1 Product Recall Research: Dimensions, Methods, and Stakeholders

George Ball[1], Kaitlin Wowak[2], Ujjal Kumar Mukherjee[3], [1]Indiana University, Bloomington, IN, [2]University of Notre Dame, Notre Dame, IN, [3]University of Illinois, Urbana-Champaign, Champaign, IL

Product recalls create complications for manufacturers, opportunities for competitors, inconveniences for regulators, and indicate potentially serious health hazards to consumers. However, from a scholarly perspective, recalls are unique phenomenon that can enable novel research contributions. In this tutorial, we discuss past perspectives, present evolution, and future opportunities in product recall research by evaluating the domain across three elements: dimensions, methods, and stakeholders. First, we discuss the three dimensions of recall research: causes, decision-making, and consequences. We provide a particular focus on recall decision-making, as this voluntary decision on the part of the manufacturer is fraught with intriguing behavioral biases. Second, we examine the literature from an emerging methodological perspective and offer guidance on future research design, using a combination of existing and hitherto under-utilized methods. Third, we propose research opportunities and insights from the viewpoint of four key stakeholders: manufacturers, competitors, regulators, and consumers. We conclude by pulling back the curtain on our research partnership with one of the primary recall regulators, the Food and Drug Administration, and show how regulator research collaboration can simultaneously enhance and embroil independent scholarly inquiry.

Monday, 11AM–12:30 PM

MB26

CC - Wabash 3

Advances in Location Models

General Session

Session Chair

Karthik Kannan, Southern Methodist University, Dallas, TX

1 A Binary-linear Programming-based Matheuristic for The Obnoxious P-median Problem

Tamara Bigler, University of Bern, Bern, Switzerland. Contact: tamara.bigler@unibe.ch

Facilities such as waste plants or wind turbines are often referred to as obnoxious facilities because they have negative side effects on their close environment. In the obnoxious p-median problem, a set of clients and a set of potential locations for obnoxious facilities are given, from which p facilities must be opened. The objective is to maximize the sum of the minimum distance between each client and the set of opened facilities. For the first time, we propose a matheuristic for this planning problem. The matheuristic covers different areas of the search space in parallel and is flexible to incorporate additional fairness constraints. Our computational results show that the matheuristic is competitive with the leading metaheuristic on small instances and outperforms the leading metaheuristic on medium and large instances in terms of solution quality and running times.

2 Two-stage Facility Location with Site Preparation Costs

Ronald McGarvey[1], Andreas Holger Thorsen[2], [1]IESEG, Paris, France; [2]Montana State University, Bozeman, MT, Contact: r.mcgarvey@ieseg.fr

Consider a situation in which an initial decision is made to prepare a set *J* of locations for potential future use supporting a set of customers under uncertain demand. Once the demand is revealed, the decision maker then makes a recourse decision selecting the set *K* of actual facility locations to be opened, where *K* is a subset of *J*. Let *alpha_j* denote the cost to prepare site *j* during the first stage. During the second stage, let *gamma_j* denote the cost to open site *j* if site *j* had been prepared during the first stage. We present robust MILP formulations of this problem, develop a computationally-efficient solution algorithm, and examine numerical test instances to identify the relationship between problem conditions (e.g., relative magnitude of transportation versus facility opening costs) and the optimal solution's ratio of cardinalities of *K* and *J*.

3 State of The Arts: Understanding Infrastructure Bias Using Location Analytics

Karthik Kannan[1], Sridhar Narasimhan[2], [1]Southern Methodist University, Dallas, TX, [2]Georgia Institute of Technology, Atlanta, GA

There is empirical evidence that the existing arts infrastructure in the USA is not accessible to all segments of the population in an equitable manner, thereby reducing the demand for arts attendance. Infrastructure bias emerges when the location of existing nonprofit arts and cultural organizations favors some communities while disadvantaging others from having equitable access to artistic and socio-cultural engagement. We first identify and describe this bias and examine how facility location models can be used to alleviate some of these biases.

4 Shipment Consolidation in Hub Location Modeling with Time-definite Transportation

Khaled Shah[1], Sibel Alumur Alev[1], James H. Bookbinder[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Toronto, ON, Canada. Contact: jbookbinder@uwaterloo.ca

Hub location is a strategic decision that may be influenced by operational decisions such as inventory and shipment consolidation. Considering these decisions simultaneously may further optimize the strategic and operational decisions of a supply chain. We consider a hub location problem, where demands between origin-destination pairs are spread over a multi-period time horizon and incorporate shipment consolidation decisions. We optimize locations of hubs, type and number of vehicles operating between hubs, and time and quantity of dispatch between hubs. We formulate the problem as a mixed-integer optimization model and propose a variable neighborhood search algorithm to solve large-scale instances. We evaluate the performance of the model and algorithm on different instances from the USAF dataset.

Monday, 11AM–12:15 PM

MB27

CC - Room 138

Supply Networks

General Session

Session Chair

Han Zhang, Michigan State University, East Lansing, MI

1 Inventory Productivity and Stock Returns in Manufacturing Networks

Deepak Agrawal[1], Nikolay Osadchiy[2], [1]Emory's Goizueta Business School, Atlanta, GA, [2]Emory University, Atlanta, GA, Contact: deepak.agrawal@emory.edu

We provide a novel, supply network-based perspective on inventory productivity -- one of the central topics in operations management. Using data from 2003 to 2019, we find that inventory productivity reduces materially and statistically significantly for firms located upstream in the supply network, and increases for highly connected and central firms. Firms with high inventory productivity show high equity valuations and abnormal returns, with both valuations and abnormal returns amplified for upstream, less connected and less central firms. Our results show that financial markets offer outsized rewards for improving inventory productivity to upstream firms and highlight the role of supply network position data for predicting firms' inventory productivity and financial performance.

2 Contracting Mechanisms for Stable Sourcing Networks

Jennifer K. Ryan[1], Lusheng Shao[2], Daewon Sun[3], [1]University of Nebraska–Lincoln, Lincoln, NE, [2]The University of Melbourne, Melbourne, Australia; [3]University of Notre Dame, Notre Dame, IN, Contact: lusheng.shao@unimelb.edu.au

We study profit allocation for a sourcing network, in which a buyer sources from a set of differentiated suppliers with limited capacity under uncertain demand for the final product. Whereas the buyer takes the lead in forming the sourcing network and designing the contract mechanism, due to their substantial bargaining power, the suppliers take the lead in determining the terms of the contract. We propose a fixed-fee contracting mechanism that ensures a stable network in the myopic sense. We also demonstrate that the grand coalition is stable in a farsighted sense under the Shapley value allocation.

3 Attracting International Migrant Labor: Investment Optimization to Alleviate Supply Chain Labor Shortages

Anna B. Nagurney, University of Massachusetts-Amherst, Amherst, MA

We construct a new supply chain network optimization model that includes both domestic labor and international migrant labor from multiple countries, with the latter made possible through investments in attracting labor subject to a budget constraint. We allow for different wage settings for domestic versus migrant labor and also have the flexibility of providing true information as to the wages of migrants or not. Algorithmically solved numerical examples, motivated by a high value agricultural product — that of truffles, demonstrate the insights in terms of profits, prices, product path flows, and investments.

Monday, 11AM–12:15 PM

MB28

CC - Room 139

Emerging Topics in Sustainable Operations

General Session

Session Chair

Greys Sosic, University of Southern California, Los

Angeles, CA

Session Chair

Hailong Cui, University of Minnesota, Minneapolis, MN

1 Effect of Sustainable Firm Entry on Customer Channel Choices and Existing Retailer Market Shares

Hans Heese[1], Eda Kemahlioglu Ziya[2], Olga Perdikaki[3], [1]North Carolina State University, Singapore, NC, [2]North Carolina State, Raleigh, NC, [3]University of South Carolina, Columbia, SC, Contact: ekemahl@ncsu.edu

We study how the entry of a new firm that sells an assortment of sustainable consumer goods affects consumers' channel choices and the existing retailers' market shares. We characterize consumers' shopping preferences in a market with a premium-price retailer and a low-price retailer that each sells two different types of product offerings—packaged goods and fresh goods. We find that the low-price retailer becomes more vulnerable with the entry of the sustainable firm, as such entry decreases this retailer's sales at least weakly in both product categories. In contrast, a retailer that charges premium prices and offers more sustainable fresh products can benefit from the entry of a sustainable competitor.

2 Electricity Pricing for Residential Solar Plus Storage Customers: Environmental and Economic Impacts

Sinan Yorukoglu[1], Nur Sunar[2], Jayashankar M. Swaminathan[2], [1]University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC

Residential electricity customers are increasingly pairing battery storage systems with solar panels under net metering. The caveat is that these solar plus storage customers can be subject to different retail electricity pricing rules depending on their locations. We study the impact of common retail electricity pricing rules on customer benefit, utility profits as well as the environment. To do so, we first establish the customer's optimal policy under different pricing rules. We find that solar plus storage customers and the utility can be better off under the same or different pricing rules depending on the battery adoption level and some market conditions. Using rich real-life data, we calibrate our model and verify our findings.

3 Hyperlocal Food Sharing: Household VS Commercial Food Donation Channel

Haonan Zhang[1], Ekaterina Astashkina[2], Masha Shunko[3], [1]Foster School of Business, University of Washington, Seattle, WA, [2]Ross School of Business, University of Michigan, Ann Arbor, MI, [3]University of Washington, Seattle, WA, Contact: hzhang96@uw.edu

We utilize the proprietary dataset from the world's largest food sharing platform, which facilitates donation of soon-to-expire excess food generated by (i) households and (ii) food businesses (supermarkets, grocery stores, bakeries, etc.) to the households in need. The platform aims to reduce household- & commercial- food waste and alleviate hunger. We adopt the novel, difference-in-differences approach with multiple treatment periods to causally identify and quantify the impact of the introduction of the second (commercial) channel as opposed to just the household channel onto the donation activities performed by households. Our preliminary investigation suggest that allowing the donations from the commercial channel lead to an 8% of improvement in the treated neighborhoods as opposed to non-treated.

4 Labor Malpractice: The Role of Operations and Supply Chains

Niyazi Taneri[1], Wei Kiat Lim[2], Hsiao-Hui Lee[3], Sameer Hasija[4], [1]Cambridge Judge Business School, Cambridge, United Kingdom; [2]NUS, Singapore, Singapore; [3]National Chengchi University, Taipei, Taiwan; [4]Insead, Singapore, Singapore.

Well-intentioned efforts by governments, NGOs, and companies to eliminate labor exploitation have failed to curb unjust labor practice. The premise of this paper is that labor malpractice is not solely a corporate social responsibility and human resources issue; rather, its incidence can be driven by day-to-day operations. We thus develop and test hypotheses that identify key operational drivers of labor malpractice. Our analysis of a panel of controversy records from 2008 to 2019 reveals that sales volatility and supply chain spillovers have an impact on labor malpractice. This shows that the operations and supply chain function of the firm needs to be at the center of efforts to reduce labor malpractice.

Monday, 11AM–12:15 PM

MB29

CC - Room 140

Session in Healthcare

General Session

Session Chair

Mili Mehrotra, University Of Illinois Urbana Champaign, Champaign, IL

Session Chair

Xueze Song, Universityof Illinois-Urbana-Champaign, Champaign, IL

1 A Near-optimal Algorithm for Real-time Order Acceptance: An Application in Postacute Healthcare Services

Zihao Qu, The University of Texas at Dallas, Richardson, TX

We study a joint capacity investment and real-time accept/reject optimization problem in an infinite horizon with an application in post-acute care. To maximize the average profit per period, the firm accepts/rejects stochastic referral arrivals in real time. Accepted referrals require different resources over an episode. A referral differs in the revenue, the resource requirement, the frequency of resource usage, and the stochastic duration of the episode. Using a simple policy, we derive a worst-case guarantee on its optimality gap, and show that our policy is asymptotically optimal. We also illustrate the impressive numerical performance of our policy using public healthcare data.

2 Does Supply Chain Diversion Fuel The Opioid Epidemic? Evidence from a Quasi-experiment

Jingwen Yang, University of Minnesota Twin Cities, Minneapolis, MN

The opioid epidemic is commonly referred to as the worst drug crisis in American history. Myriad factors have been examined regarding their influence on the crisis. However, whether diversion of prescription opioids from legal supply chain channels to illegal marketplaces, namely, supply chain diversion, contributes to the ongoing crisis remains an important yet understudied question. Utilizing a quasi-experimental research design, this study estimates the extent to which the Drug Supply Chain Security Act (DSCSA) curbs the epidemic, thereby revealing the impacts of supply chain diversion on exacerbating the crisis. The study also explores a potential supply chain diversion mechanism and explores demographic populations susceptible to the diverted opioids.

3 Vaccine Prioritization in a Social Network Against a Pandemic Outbreak

Yang Zhang[1], Dong Liang[2], Ming Hu[3], [1]Brunel University London, London, United Kingdom; [2]Tsinghua University, Beijing, China; [3]University of Toronto, Minneapolis, MN, Contact: yang.zhang@brunel.ac.uk

We investigate the vaccination over a social network to curb a pandemic (e.g. COVID-19). Because the supply of the vaccine is limited, the planner has to prioritize different social groups (represented by different nodes in a social network) in the order of receiving the vaccine. The conventional wisdom suggests a vulnerability-first allocation: the vaccination should begin with those who suffer most from the infection and then reach out to those suffering less. However, given the contagious nature of the disease, the planner may also consider the role of different social groups in transmitting the virus (characterized by their centrality in the social network). We show that the optimal vaccination policy combines *vulnerability* and *transmissivity*, and follows the *Bonacich priority* which linearly depends on a variant of Bonacich centrality of the social network.

4 An Analysis of Compensation Contracts in Clinical Studies

Xueze Song[1], Mili Mehrotra[2], Tharanga Kumudini Rajapakshe[3], [1]Universityof Illinois-Urbana-Champaign, Champaign, IL, [2]University Of Illinois Urbana Champaign, Champaign, IL, [3]University of Florida, Gainesville, FL, Contact: xuezes2@illinois.edu

Participant retention is a significant challenge faced by clinical studies. In this work, we consider how the sponsor of a clinical study can motivate investigators and coordinators to improve participant retention for the study. We identify three different clinical study settings observed in practice and derive the optimal compensation contracts.

Monday, 11AM–12:15 PM

MB30

CC - Room 141

Managing Customer Experience in Service Encounter

General Session

Session Chair

Nan Liu, Boston College, Chestnut Hill, MA

1 Structural Estimation and Machine Learning for Airport Security Checkpoint Arrivals Forecast

Ke Cai[1], Fernando Bernstein[2], N. Bora Keskin[2], Adam J. Mersereau[3], Serhan Ziya[4], [1]Duke University, Durham, NC, [2]Duke University, Durham, NC, [3]University of North Carolina at Chapel Hill, Chapel Hill, NC, [4]University of North Carolina, Chapel Hill, NC, Contact: christina.cai@duke.edu

Airport passenger arrival processes highly depend on the distribution of how early passengers arrive prior to their flights' departure times (earliness distribution). Using passenger arrival data collected as a part of our collaboration with a large airport, we leverage a structural method to estimate the earliness distribution and obtain a forecast of the passenger arrival process. We compare this structural method to a machine learning forecasting approach and discuss their relative performance using the dataset.

2 What Causes Delays in Admission to Rehabilitation Care? a Structural Estimation Approach

Berk Gorgulu[1], Vahid Sarhangian[1], Jing Dong[2], [1]University of Toronto, Toronto, ON, Canada; [2]Columbia University, New York, NY, Contact: bgorgulu@mie.utoronto.ca

The increase in demand for rehabilitation care has led to long admission delays. These delays not only affect patient outcomes but also lead to bed blocking in acute care. Admission delays can be caused by capacity constraints or extra processing requirements. It is important to identify different sources to delay to identify effective delay mitigation strategies accordingly. However, standard data only includes a single (combined) measure of delay, and the bed allocation decisions in practice can be quite complicated with multiple determinant factors. In this work, we develop a hidden Markov chain to identify and quantify different sources of delays. The estimation results are then combined with queueing model to evaluate the effectiveness of different interventions to reduce admission delays.

3 Causal Inference in Queueing Systems

Zhenghang Xu[1], Opher Baron[1], Dmitry Krass[1], Arik Senderovich[2], [1]University of Toronto, Toronto, ON, Canada; [2]York University, Toronto, ON, Canada. Contact: zhenghang.xu@mail.utoronto.ca

Simulation is a powerful tool for the prescriptive analysis of queues. With ample data and expert knowledge, a good model can be constructed and used to predict impact of interventions. However, such manual construction is both time- and skill-demanding. Moreover it could be subjective - if the expert failed to note an important feature of the system, the model will not be accurate. As an alternative, we propose a data-driven representation of queueing models, justified by G-computation formula. We describe the queueing data generation process with structural equations and apply machine learning to fit the equations to data. Through numerical experiment, we show that this approach can replace the explicit dynamics of simulator. Our model is shown to capture interventions in M/G/c queues with independent hyper-exponential service time and first-in-first-out discipline.

4 Design of Patient Visit Itineraries in Tandem Systems

Nan Liu[1], Guohua Wan[2], Shan Wang[3], [1]Boston College, Chestnut Hill, MA, [2]Shanghai Jiao Tong University, Shanghai, China; [3]Sun Yat-sen Univerisity, Guangzhou, China. Contact: wangsh337@mail.sysu.edu.cn

In many healthcare settings, patients receive a series of services during a single visit. Examples include infusion, orthopedic visit, and mammography testing. A key commonality is the tandem structure, where each stage involves a non-trivial random service time. We study how to manage such tandem service systems via appointment scheduling.

Monday, 11AM–12:15 PM

MB31

CC - Room 142

Sustainable and Socially Responsible Operations

General Session

Session Chair

Dennis Zhang, Washington University in St Louis, ST LOUIS, MO

Session Chair

Xiaoyang Long, University of Wisconsin-Madison, Madison, WI

1 Incentivizing Recycling to Improve Sustainability: Evidence from Field Experiments

Dayton Steele[1], Atalay Atasu[2], Saravanan Kesavan[3], [1]University of Minnesota, Minnneapolis, MN, [2]INSEAD, Fontainebleau, France; [3]University of North Carolina-Chapel Hill, Chapel Hill, NC

The growing focus on sustainability initiatives for businesses has increased the need to understand how to encourage customers to participate. Through a partnership with a consumer electronics company, we conduct a set of field experiments to understand how its customers respond to incentives to return products to be recycled.

2 Green E-commerce: Environmental Impact of Fast Delivery

Chenshan Hu[1], Xiaoyang Long[2], Jiankun Sun[3], Dennis Zhang[4], [1]Washington University in St. Louis, Saint Louis, MO, [2]University of Wisconsin-Madison, Madison, WI,

[3]Imperial College London, London, United Kingdom; [4]Washington University in St Louis, ST LOUIS, MO, Contact: chenshan.hu@wustl.edu

In this paper, we empirically investigate how an increase in delivery speed influences customer purchasing behaviour and evaluate how this leads to environmental issues. Then, we develop an analytical model to explain our empirical results and accordingly, propose delivery pricing policies to achieve both environmental benefits and decent company revenue.

3 Reforming The Circular Supply Chain of Lead Acid Battery to Reduce Lead Pollution in Bangladesh

Qiong Wang[1], Amrita Kundu[2], Erica Plambeck[3], [1]University of Illinois, Urbana, IL, [2]McDonough School of Business, Georgetown University, District of Columbia, DC, [3]Stanford University, Stanford, CA, Contact: qwang04@illinois.edu

Informal recycling of lead acid batteries (LABs) is causing tremendous lead pollution in Bangladesh. We show that informal recyclers gain competitive advantage over environmentally-sound formal recycling when the salvage price of used LABs is excessively high, which is the case in practice. The high salvage price also induces buyers to replace LABs more frequently, further increasing the flow of informally-recycled lead. We identify buyers' inability to differentiate quality of new batteries and their liquidity constraint as two contributing factors to the high salvage price. Therefore, introducing business innovation to address the latter two issues can significantly reduce lead pollution by curtailing both the flow of ULABs and the fraction that goes to informal recycling.

4 Capping Mobile Data Access Creates Value for Base-of-the-pyramid Users - Evidence from a Mumbai Settlement

Kamalini Ramdas, Alp Sungu, London Business School, London, United Kingdom. Contact: kramdas@london.edu

Through an app that we developed to track second-by-second mobile data usage, we find that addictive smartphone usage increases the information isolation of the poor. In an experiment that we conducted in the poorest neighborhood in Mumbai, we find that participants binge on entertainment early in a data plan and face subsequent data shortages. We randomly assigned participants to either a daily capped data plan or a standard plan. Daily data caps reduce social media checking and increase late-plan access to digitally-delivered information, translating into a life-improving outcome: higher attendance at in-person health camps that participants were invited to via WhatsApp.

Monday, 11AM–12:15 PM

MB32

CC - Room 143
OM-Marketing Interface
General Session

Session Chair
Fang Fang, CAL STATE LOS ANGELES, San Gabriel, CA

1 A Stochastic, Dynamic Model for Optimizing Home Video Release

Franco Berbeglia[1], Timothy Derdenger[2], Sridhar R. Tayur[2], [1]Purdue University, Lafayette, IN, [2]Carnegie Mellon University, Pittsburgh, PA

Using the movie industry shock of the COVID-19 pandemic on box office, disc sales and rentals, VOD and pVOD, and sVOD availability, we estimate a dynamic structural model that permits the analysis of counterfactuals related to format release timing strategies. Specifically, we analyze the impact of day-and-date strategies on box office ticket sales, the availability of streaming on home video and box office ticket sales, and the consequences of theater removal.

2 Artificial Intelligence: Information Collection and Behavior-based Pricing Under Privacy Concerns

Krista J Li, Indiana University, IN

Consumers are concerned about giving away private information while using AI products. We show that consumers' privacy concerns decrease a monopolist's profit but increase competing firms' profits. Moreover, consumers' privacy concerns decrease consumer surplus and social welfare. By leveraging consumers' purchase history data, AI firms can undertake behavior-based pricing (BBP) to price discriminate between repeat and new consumers. We find that a monopolistic firm increases information collection while competing firms decrease it after adopting BBP. Although the literature has commonly found BBP unprofitable, we find that AI firms' adoption of BBP is profitable when competition is sufficiently intense. Therefore, AI firms can benefit from consumers' privacy concerns and the practice of BBP.

3 Bm Retailer's Exclusive Brand Introduction Decision and Consumer Showrooming: A Dual Channel Perspective

Prasenjit Mandal[1], Abhishek Roy[2], Preetam Basu[3], [1]NEOMA Business School, Reims, France; [2]Temple University, Fox School of Business, Philadelphia, PA, [3]Kent

Business School, Canterbury, United Kingdom.
Consumers often exhibit showrooming behaviour in which they visit a brick-and-mortar (BM) store to gather product information but complete the product purchase in the online channel. To combat consumer showrooming, many BM retailers carry exclusive store brands that are not available online. We investigate how consumer showrooming interacts with a BM retailer's exclusive store brand strategy. We study a supply chain comprising of an upstream manufacturer that sells its products to end consumers through a BM retailer and its online channel. The common wisdom is that a BM retailer suffers from consumer showrooming. Contrary to that notion, our findings reveal that the BM retailer can benefit from consumer showrooming when it carries an exclusive store brand. Further, the exclusive store brand strategy may lead to a 'win-win' outcome for the BM retailer and the manufacturer.

4 Nudging Patients Towards Cost-effective Providers: Analysis of An Insurer's Effort-based and Cash Reward-based Mechanisms

Fang Fang[1], Mili Mehrotra[2], Harihara Prasad Natarajan[3], [1]CAL STATE LOS ANGELES, San Gabriel, CA, [2]University Of Illinois Urbana Champaign, Champaign, IL, [3]University of Miami, Coral Gables, FL, Contact: ffang2@calstatela.edu

This paper examines how an insurer uses effort and cash rewards to nudge patients towards cost-effective providers. We build a stylized analytical model that captures the salient aspects of the insurer's decision problem while considering the key drivers of its enrollee's provider choices. With this versatile framework, we analyze the HIC's optimal effort and reward, individually and jointly, under different cost-share structures (e.g., copayment and coinsurance). We find that neither a reward-only nor an effort-only approach uniformly outperforms the other. Additionally, we find conditions when a joint approach that combines effort and a cash reward could perform better than the individual approaches, indicating that the two mechanisms serve as tactical complements.

Monday, 11AM–12:15 PM

MB33

CC - Room 144

Sustainable Operations

General Session

Session Chair

Shirin Shahsavand, Washington State University, Pullman, WA

1 Do Recycling Standards Create of Destroy Value? Evidence from The National Sword Policy

Christian Blanco[1], Mateus Ferreira-Lima[1], Suvrat Dhanorkar[2], [1]The Ohio State University, Columbus, OH, [2]Pennsylvania State University, University Park, PA, Contact: ssd14@psu.edu

In 2018 China has implemented the National Sword Policy (Sword). Sword imposes a 0.5% allowable contamination rate in bales of waste products while completely banning the imports of over eight types of plastic materials. Because of Sword, 78% of all plastic waste generated in the United States no longer had a destination, causing a supply and demand imbalance. We built a fixed-effects panel regression model using five years of daily prices (2016-2020) for 28 product categories to investigate 1) the effects of Sword on the price of waste products in the United States, and 2) what interventions were effective in mitigating the effects of the Sword. Our preliminary results show that Sword caused a drop in the overall price of recyclable materials and that only some policies were effective in mitigating the negative impact of Sword on the price of recyclable materials.

2 Supplier Development and Greenwashing in a Multi-tier Supply Chain

Can Baris Cetin[1,2], Ozgen Karaer[3], Georges Zaccour[2], [1]HEC Montreal, Montreal, QC, Canada; [2]GERAD, Montreal, QC, Canada; [3]Middle East Technical University, Ankara, Turkey.

We investigate the strategic interaction between a buyer and two suppliers in a supply chain with a game-theoretical model. The buyer and tier-1 supplier are environmentally sustainable and want to improve the environmental image of products with the improvement in the tier-2 supplier's environmental quality to enhance demand by benefiting from the environmental consciousness of the consumers. To achieve that, either one of the downstream players offers to share the investment cost of the tier-2 supplier and the buyer advertises the product's environmental quality. When the advertised quality exceeds the true quality, this excess is called greenwashing. If greenwashing is exposed, consumers punish the supply chain by not buying the product.

3 A Game Theory Model of Public-private Partnerships in Prescribed Fires

Esther Jose, Jun Zhuang, University at Buffalo, Buffalo, NY, Contact: estherjo@buffalo.edu

Prescribed fires are fires ignited and managed in a specific region for various reasons including reducing the fuel load of a region to make it less susceptible to wildfire losses. Their effectiveness is well established. However, private entities are discouraged from conducting prescribed fire due to reasons like (i) lack of resources and funding and (ii) legal barriers such as liability for prescribed fire accidents. We construct a sequential game theory model to identify the optimal decisions of the government with respect to liability laws and providing resources, and the optimal amount of prescribed fires that private entities should then conduct. We also conduct a case study on privately owned lands in Oregon. The results indicate that it is beneficial for public policy-makers to invest in private prescribed fire when the monetary risk to the government is high.

4 Can Fast Fashion be Sustainable? An Analysis of Sustainability Initiatives in Fast Fashion Industry

Shirin Shahsavand[1], Kevin Mayo[2], [1]Washington State University, Pullman, WA, [2]Indiana University, Bloomington, IN, Contact: shirin.shahsavand@wsu.edu

The fashion industry generates increasing amounts of waste and produces more greenhouse gas emissions than international shipping and flights combined. Fast fashion firms are considered key polluters in the sector due to their over-production and poor product quality. Several fast fashion manufacturers have implemented sustainability initiatives to alleviate their environmental footprint and connect with environmentally conscious customers. We investigate the effectiveness of such initiatives in reducing the companies' environmental impacts and gaining market share. We then propose a model for finding the optimal sustainable strategy. We believe the insights from this research may apply both to fast fashion and other high waste industries.

Monday, 11AM–12:15 PM

MB34

CC - Room 145

Sustainability Paradigms for Renewable Energy Systems

General Session

Session Chair

Victoria Chen, University of Texas at Arlington, TX

1 Estimation of State-based Appliance Signatures Using Nonlinear Programming for Non-intrusive Load Monitoring Algorithms

Marina Materikina[1], Jackelyn Macias-Brijil[2], Jay Michael Rosenberger[3], Victoria C. P. Chen[1], Wei-Jen Lee[1], [1]The University of Texas at Arlington, Arlington, TX, [2]The University of Texas at Arlington, Arlington, TX, [3]University of Texas-Arlington, Arlington, TX, Contact: marina.materikina@mavs.uta.edu

Rapidly developing renewable energy sources adds more challenges to production and demand response (DR) planning for utility companies. The detailed study of customers' electricity consumption behavior can stimulate the effective drive of DR programs. The connection between customers and energy providers could be achieved through non-intrusive load monitoring (NILM) to analyze the electricity patterns of individual appliances. The estimation of power consumption for each mode of an appliance is an important step that can affect the accuracy of load detection in the disaggregation phase. To improve the disaggregation accuracy for optimization NILM algorithms, the detailed signatures for state-based appliances such as washing machines were studied through Nonlinear programming with piecewise function, where the function depended on the shape of the modes.

2 A Study of Washing Machine Energy Usage in Household Non-intrusive Load Monitoring

Eshan Singhal[1], Marina Materikina[2], Aiden J. J. Guild[1], Victoria C. P. Chen[3], Jay Michael Rosenberger[4], Wei-Jen Lee[1], [1]University of Texas Arlington, Arlington, TX, [2]University of Texas Arlington, Mansfield, TX, [3]The University of Texas at Arlington, Arlington, TX, [4]University of Texas-Arlington, Arlington, TX, Contact: Eshansinghal05@gmail.com

In non-intrusive load monitoring (NILM) the goal is to identify what major appliances are operating at a given time point, using only the total energy usage of the house. To represent the energy usage of a particular appliance, an average value is typically assumed. However, given real time energy usage data, average values do not adequately capture real patterns. In this talk, we examine the energy usage patterns from a clothes washing machine. Data were collected both from real world usage and via a controlled experimental design.

3 An Optimization Model for Prioritizing Organic Waste to Energy-Renewable (POWER)

Bahareh Nasirian, Victoria C. P. Chen, Jay M. Rosenberger, Melanie L. Sattler, The University of Texas at Arlington, Arlington, TX

The POWER project studies the generation of biogas from anaerobic digestion of food and yard waste as a potential renewable energy source. In this talk, a mixed integer program with a quadratic cost term (MIQP) is presented to optimize the location of anaerobic digestion facilities, the construction of new digesters, and the transportation of organic waste to these facilities. Compared to existing processes at landfills or composting facilities, the POWER process imposes different costs, including expenses for transporting food and yard waste, facility costs, and the costs for digesters, fuel conversion, and refueling stations. This project addresses sustainability objectives by reducing landfill waste, creating renewable energy for transportation, and minimizing life cycle costs.

4 Green Building Sustainability Assessment Decision Optimization

Victoria C. P. Chen[1], Erick Jones[2], Shirish Rao[3], Jay Michael Rosenberger[3], [1]The University of Texas at Arlington, Arlington, TX, [2]University of Texas, Arlington, TX, [3]University of Texas-Arlington, Arlington, TX, Contact: vchen@uta.edu

Buildings play a vital role in society, and the construction industry is one of the largest consumers of natural resources. Sustainability assessment of building design must analyze a variety of decision variables, both qualitative and quantitative, and must address the three pillars of people, planet, and prosperity, corresponding to social, environmental, and economic performance objectives. In this talk, we discuss the challenges in optimizing green building design.

Monday, 11AM–12:15 PM

MB35

CC - Sagamore 1

Telecommunication Networks

General Session

Session Chair

Nayan Chakrabarty, University of Arkansas, Fayetteville, AR

1 Estimating Wireless Mesh Network Vulnerability: A Search for The "Best" Interference Model

Tanveer Hossain Bhuiyan[1], Hugh Medal[2], [1]University of Tennessee, Knoxville, Ammon, ID, [2]University of Tennessee, Knoxville, TN, Contact: tbhuiyan@vols.utk.edu

This paper studies the problem of placing a set of jammers in 3-D space to minimize the throughput of a wireless communication network. The main goal of this paper is to study the effects of jamming under the following models of interference: physical, capture, protocol, and interference range. This paper presents a mixed-integer programming model as well as a branch-and-cut and a heuristic procedure for the jammer location problem under several models of interference. We implement multiple valid inequalities including clique and odd-cycle inequalities to speed up the branch-and-cut algorithm. Numerical experiments demonstrate the effect of different interference models on runtime and solution tractability, as well as provide insights into designing a network to be jamming-resistant.

2 Multi-layer Error Detection in Large Scale File Transfers

Arash Sarabi, Arizona State University, Tempe, AZ, Contact: sarabi.arash@asu.edu

We introduced a Multi-Layer Error Detection (MLED) architecture that significantly reduces the Undetected Error Probability (UEP) in large scale file transfers. As you know, reliability in petabyte-scale file transfers is critical for data collected from scientific instruments. We introduced a new architecture and will present the conditions under which it reduces the UEP in transferring big data. MLED generalizes existing error detection approaches used in file transfer. MLED is parameterized by a number of layers n, and a policy Pi for each layer $1 \le i \le n$ that describes its operation. Analytical results show that a petabyte-size file transfer in MLED with $n = 2$ using CRC-32s improves UEP by 2.49E+28 compared to a single-layer CRC-64, when the BER is 10E−10.

3 A Global Climate Hazard Assessment of Mobile Infrastructure for 2G, 3G, 4g and 5G Sites

Edward Oughton, George Mason University, Fairfax, VA

There is currently an urgent need to quantify the potential impacts of climate-related hazards on infrastructure and users, especially for hitherto neglected infrastructure sectors, such as telecommunications. Thus, quantitative scenario analysis can produce geospatial hazard information that can be used in multiple different ways to inform future mitigation decisions. This global analysis will focus on establishing who has cellular connectivity and who does not, before evaluating the number of 2G, 3G, 4G and 5G towers at risk. Finally, those regions/communities most vulnerable to mobile infrastructure failure will be identified. The analysis is a novel contribution as the approach utilizes a global database of over 47 million cellular sites, enabling a consistent global assessment of vulnerable mobile infrastructure assets.

4 Time-based Redeployment of Multi-class Nodes for Reliable Wireless Sensor Network Coverage

Nayan Chakrabarty, Kelly Sullivan, University of Arkansas,

Fayetteville, AR, Contact: nchakrab@uark.edu
Wireless sensor networks are applied to monitor phenomena in a variety of applications; however, sensor nodes fail over time causing the network's coverage to degrade. With this motivation, we consider the problem of redeploying nodes into the network over time to maintain the network's coverage. Extending previous research that assumes nodes are identical with respect to time to failure, we use multiple classes of sensor nodes to represent a scenario where nodes' times to failure are dependent on positioning in the network. We contribute an efficient Monte Carlo method, based upon system survival signature and incremental network search, to evaluate the coverage reliability and cost rate of a network under a given time-based redeployment policy. We apply these results to identify time-based redeployment policies that are efficient with respect to cost and reliability.

Monday, 11AM–12:15 PM

MB36

CC - Sagamore 2
Quantum Optimization
General Session

Session Chair

Brandon Augustino, Lehigh University

1 Reinforcement Learning with Quantum Circuit Parameters

SungHo KANG, In Chan CHOI, Taesu CHEONG, GwangJong Ko, Haneul KIM, KOREA University, Seoul, Korea, Republic of. Contact: ght2game@korea.ac.kr
Recently, a methodology for solving optimization problems based on quantum circuits has been proposed. However, in the case of quantum circuits, the circuit configuration is important to solve the optimization problem, but it is also important to efficiently tune various parameters among the circuit components. We present a reinforcement learning research methodology that learns the parameters of an efficient quantum circuit according to the topological structure of the problem. In this study, we propose a methodology that applies reinforcement learning to the Max-cut problem.

2 Provable Quantum Advantages for Optimization and Machine Learning

Xiaodi Wu, University of Maryland, College Park, MD
Recent developments suggest that quantum algorithms might offer significant provable speed-ups for optimization and machine learning problems. In this talk, I will describe three recent developments in my group. (1) The first one optimizes a general (dimension n) convex function over a convex body using O(n) quantum queries to function value and membership oracles; it gives a quadratic improvement over the best-known classical algorithm. (2) The second one solves n-dimensional SDPs with m constraints in O(\sqrt{n} +\sqrt{m}), whereas the state-of-the-art classical algorithms run in time at least linear in n and m. (3) The third one is a sublinear quantum algorithm for training linear and kernel-based classifiers that run in O(\sqrt{n}+\sqrt{d}) given n data points in R^d, whereas the state-of-the-art (and optimal) classical algorithm runs in O(n +d).

3 State Evolution of Iterative Circuits

Muqing Zheng[1], Tamás Terlaky[2], Xiu Yang[2], [1]Lehigh University, Bethlehem, PA, [2]Lehigh University, Bethlehem, PA, Contact: muz219@lehigh.edu
Noise has dramatically restricted the complexity and capabilities of model quantum devices. To understand such disturbance, a common practice in noise simulation is to use benchmarking tests to infer the parameters of noise channels of all basic operations, which might complicate the noise description while viewing the system from a larger picture. In this research, we propose a data-driven approach to view a quantum circuit from a dynamical-system perspective, such that a classical tool, Kalman smoother, can be applied to this problem. By utilizing time-series measurement data, we can infer the state evolution process in an iterative algorithm in real quantum devices classically. Experiments conducted on IBM's Qiskit backend-noise simulators and real quantum backends show that our approach can well predict measurement outcomes and the density matrices of states.

4 Inexact Feasible Interior Point Methods (ipms) for Linear Optimization (lo) with Iterative Refinement (ir) for Classic and Quantum Computing

Tamas Terlaky[1], Mohammadhossein Mohammadisiahroudi[2], Ramin Fakhimi[2], Zeguan Wu[3], [1]Lehigh University, Bethlehem, PA, [2]Lehigh University, Bethlehem, PA, [3]Lehigh University, Bethlehem, PA, Contact: terlaky@lehigh.edu
We apply Quantum Linear System Algorithms (QLSAs) to Newton systems within IPMs to gain quantum speedup in solving LO problems. Due to their inexact nature, QLSAs can be applied only to inexact variants of IPMs, which are inexact infeasible methods due to the inexact nature f their computations. We propose Inexact-Feasible IPMs (IF-IPM) for LO problems, using novel Newton systems to generate

inexact but feasible steps. We show that this method enjoys the to-date best iteration complexity. Further, we explore how QLSAs can be used efficiently in iterative refinement schemes to find an exact optimal solution without excessive calls to QLSAs. Finally, we experiment with the proposed IF-IPM's efficiency using IBMs QISKIT environment.

Monday, 11AM–12:15 PM

MB37

CC - Sagamore 6

Optimization Society's Award Session II

Award Session

Session Chair

Alper Atamturk, IEOR, UC Berkeley, Berkeley, CA

Session Chair

Andy Sun, MIT, Cambridge, MA

1 Egon Balas Prize - Cut-generating functions

Amitabh Basu, Johns Hopkins University, Baltimore, MD

I will give an overview of research in cut-generating functions, a topic within mixed-integer optimization that was heavily influenced by Prof. Egon Balas' seminal ideas from the 1970s. My goal is to convey the basic principles behind this approach to cutting plane theory and present a subset of representative results in the area.

2 Young Researchers Prize - Coordinate Descent Without Coordinates: Tangent Subspace Descent on Riemannian Manifolds

David Gutman[1], Nam Ho-Nguyen[2], [1]Texas Tech University, Lubbock, TX, [2]University of Sydney, Sydney, Australia.

We consider an extension of the coordinate descent algorithm to manifold domains, and provide convergence analyses for geodesically convex and non- convex smooth objective functions. Our key insight is to draw an analogy between coordinate blocks in Euclidean space and tangent subspaces of a manifold. Hence, our method is called tangent subspace descent (TSD). The core principle behind ensuring convergence of TSD is the appropriate choice of subspace at each iteration. To this end, we propose two novel conditions: the gap ensuring and C-randomized norm conditions on deterministic and randomized modes of subspace selection respectively. These ensure convergence for smooth functions, and are satisfied in practical contexts. We propose randomized and deterministic subspace selection rules of particular practical interest for the Stiefel manifold.

3 Student Paper Prize - Semi-Discrete Optimal Transport: Hardness, Regularization, and Numerical Solution

Bahar Taskesen, EPFL, Lausanne, Switzerland.

Semi-discrete optimal transport (OT) problems evaluate the Wasserstein distance between a discrete and a continuous distribution. We first prove that semi-discrete OT is #P-hard. To find approximate solutions, we perturb the transportation cost with ambiguous noise and introduce a distributionally robust dual OT problem whose objective function is smoothed with the most adverse noise distributions. We also prove that smoothing the dual is equivalent to regularizing the primal objective, and we identify ambiguity sets that give rise to several known and new regularization schemes. To solve the regularized optimal transport problems efficiently, we develop a stochastic gradient descent algorithm with imprecise stochastic gradient oracles.

4 Student Paper Prize - Adaptive Bin Packing with Overflow

Sebastian Perez Salazar, Rice University, Houston, TX

We consider the problem of packing items with random sizes into bins. Upon an item's arrival, only a probability distribution of its size is available. We must pack the item into an available bin or place it in a new bin. After packing the item, we observe its actual size, and an overflow can occur; this incurs a penalty and renders the corresponding bin unusable. The objective is to minimize the expected cost given by the number of opened bins and the overflow penalties. We present a "risk-budgeted" algorithm, with expected cost bounded by a constant times the expected cost of the optimal packing policy for i.i.d. sizes. We also construct a soft-capacity PTAS for general random variables and show that computing the optimal cost is #P-hard.

5 Student Paper Prize - Convex Chance-Constrained Programs with Wasserstein Ambiguity

Haoming Shen, University of Michigan, Ann Arbor, MI

We identify sufficient conditions that lead to convex feasible regions of chance constraints with Wasserstein ambiguity. First, when uncertainty arises from the left-hand side of a pessimistic single chance constraint, we derive a convex and conic representation if the Wasserstein ball is centered around a Gaussian distribution. Second, when uncertainty arises from the right-hand side of a pessimistic joint chance constraint, we show that the ensuing feasible region is convex if the Wasserstein ball is centered around a log-concave distribution.

Monday, 11AM–12:15 PM

MB38

CC - Sagamore 7

Optimization under Uncertainty: Theory and Applications (i)

General Session

Session Chair

Roozbeh Qorbanian, University of Luxembourg, Luxembourg, Luxembourg.

1 Improving Upper Confidence Reinforcement Learning with Bootstrapping

Sanghwa Kim[1], Seungki Min[1], Kyoung-Kuk Kim[2], [1]Korea Advanced Institute of Science & Technology, Daejeon, Korea, Republic of; [2]Korea Advanced Institute of Science & Technology, Seoul, Korea, Republic of. Contact: tkdghk9667@kaist.ac.kr

In the task of online learning in Markov decision processes with finite state and action spaces, upper confidence reinforcement learning (UCRL) algorithms are proven to have near-optimal regret bounds, but often suffer from poor empirical performance.We propose a principled way of improving UCRL algorithms while preserving their theoretical guarantees: motivated by Hao, et al. (2019), we propose to utilize a nonparametric bootstrapping technique to measure the uncertainty in rewards and state transitions more accurately so as to promote a more efficient exploration.We observe that in our numerical experiments the suggested method can improve the existing UCRL algorithms by up to 80% in terms of reduction in regret, and prove that these algorithms also enjoy the near-optimal regret bounds under certain conditions.

2 A Dynamic Rebalancing Portfolio Model Based on Momentum and Reversal Strategies for Intraday Trading

Jing-Rung Yu, Chi-Ju Lai, National Chi-Nan University, Nantou, Taiwan.

We adopt the Omega portfolio model to perform intraday trading based on momentum and reversal strategies. In the model, the top 1% and the last 1% of the intraday returns of S&P 500 composite stocks are assigned to long and short sell, respectively. The proposed dynamic approach optimizes asset allocations based on intraday and historical returns, which can be an alternative for algorithmic trading.

3 Multi-class Advance Patient Scheduling with Overtime: A Dynamic Robust Approach

Hamid Arzani[1], Hossein Abouee Mehrizi[2], Saeed Ghadimi[1], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, waterloo, ON, Canada.

We present a simple, efficient algorithm for the dynamic multi-class advance patient scheduling (MAPS), which is a challenging problem due to the high variability in the daily patient arrivals and the high dimensionality of the problem. Specifically, we consider the MAPS problem in which patients of different classes have different service times and incur different waiting costs to the system. Exploiting patient-level offline data, we develop a distributionally robust model and present a dynamic algorithm to schedule patients upon arrival. To quantify uncertainty in arrivals, we apply a coherent risk measure that allows us to compute robust solutions against perturbations. We examine the performance of the algorithm by leveraging the MRI data from hospitals in Ontario and show that the dynamic robust model outperforms the dynamic stochastic approach significantly.

Monday, 11AM–12:15 PM

MB39

CC - Room 201

Bayesian Optimization

General Session

Session Chair

Raul Astudillo, Cornell University, Ithaca, NY

Session Chair

Peter Frazier, Cornell University, Ithaca, NY

1 Triangulation Candidates for Bayesian Optimization

Robert B. Gramacy[1], Annie Sauer[2], Nathan Wycoff[3], [1]Virginia Tech, Blacksburg VA, VA, [2]Virginia Tech, Blacksburg, VA, [3]Georgetown University, Washington, DC, Contact: nathan.wycoff@georgetown.edu

In Bayesian optimization, selection of the next point to evaluate consists of an "inner optimization" over a new-data acquisition criterion, which can be numerically cumbersome. In such cases it is not uncommon to replace the continuous search with a discrete one over random candidates. Here we

propose using candidates based on a Delaunay triangulation of the existing input design. In addition to detailing construction of these "tricands", based on a simple wrapper around a conventional convex hull library, we promote several advantages based on properties of the geometric criterion involved. We then demonstrate empirically how tricands can lead to better Bayesian optimization performance compared to both numerically optimized acquisitions and random candidate-based alternatives on benchmark problems.

2 Bayesian Nested Super-level Set Estimation for Model Risk Quantification

Eunhye Song, Georgia Institute of Technology, Atlanta, GA, Contact: eus358@psu.edu

In this talk, we discuss a sequential sampling procedure that efficiently estimates a nested super-level set with an application to model risk analysis for discrete simulation optimization. We consider a simulation model whose input distributions are estimated from data using a Bayesian framework. Given the posterior on the input models, we propose the "risk set" to measure suboptimality of implementing arbitrary solution x. The □-level risk set of x is the set of solutions whose expected performance is better than x by a practically meaningful margin (>□) with significant probability (>□). We model the simulator's response surface using a Gaussian process and devise one-step look-ahead sampling rule as well as a roll-out procedure to estimate the risk set efficiently. Application to an ambulance dispatching center location problem will be shown.

3 High-dimensional Bayesian Optimization with Sparse Axis-aligned Subspaces

David Eriksson, Meta, Boulder, CO

Bayesian optimization (BO) is a powerful paradigm for sample-efficient optimization of black-box objective functions and has been successfully used in many real-world scientific and industrial applications. However, even with recent methodological advances, the application of BO to problems with small evaluation budgets is generally limited to simple low-dimensional domains. In this talk, we introduce our new Sparse Axis-Aligned Subspace BO (SAASBO) method which is very sample-efficient and can handle search spaces with hundreds of tunable parameters. We show that SAASBO achieves excellent performance on several high-dimensional real-world problems, including optimizing a production-scale on-device natural language understanding model at Meta.

4 PRE-TRAINING HELPS BAYESIAN OPTIMIZATION TOO

Zi Wang[1], George E. Dahl[2], Kevin Swersky[3], Chansoo Lee[4], Zelda Mariet[1], Zachary Nado[1], Justin Gilmer[2], Jasper Snoek[1], Zoubin Ghahramani[5], [1]Google Research, Cambridge, MA, [2]Google Research, Mountain View, CA, [3]Google Research, Toronto, ON, Canada; [4]Google Research, Pittsburgh, PA, [5]Google Research, London, United Kingdom. Contact: wangzi@google.com

Optimization is one of the fundamental pillars for machine learning, and yet, machine learning can also contribute to better optimization methods. Bayesian optimization can be seen as the latter case. In this talk, we will dive into the regime where the benefit of machine learning is even more strengthened for optimization: we use pre-training to fix the critical drawback of poorly specified priors in Bayesian optimization. We present the theoretical understanding of Bayesian optimization with pre-trained models, as well as empirical successes.

Monday, 11AM–12:15 PM

MB40

CC - Room 202

Conic Programming

General Session

Session Chair

Negar Soheili, University of Illinois Chicago

1 Sparse Non-sos Putinar-type Positivstellensatze

Luis F. Zuluaga[1], Juan C. Vera[2], Lorenz Marinus Roebers[3], [1]Lehigh University, Bethlehem, PA, [2]Tilburg University, Tilburg, Netherlands; [3]University of Tilburg, Tilburgh, Netherlands. Contact: luis.zuluaga@lehigh.edu

Recently, non-SOS Positivstellensätze for polynomials on compact semialgebraic sets, following the general form of Schmüdgen's Positivstellensatz, have been derived by appropriately replacing the SOS polynomials with other classes of polynomials. An open question in the literature is how to obtain similar results following the general form of Putinar's Positivstellensatz. In this talk, we show the existence of Putinar-type Positivstellensätze that are constructed using non-SOS classes of non-negative polynomials, such as SONC, SDSOS and DSOS polynomials. Furthermore, we show that these certificates can be written with inherent sparsity characteristics.

2 Semidefinite Representable Reformulations of Two Variants of The Trust-region Subproblem

Sarah Kelly, Yuyuan Ouyang, Boshi Yang, Clemson University, Clemson, SC, Contact: boshiy@clemson.edu

In this talk we consider two variants of the trust-region subproblem which has been studied recently in the literature. The first variant minimizes a quadratic function over the intersection of two balls. The second variant minimizes a quadratic function over the intersection of a ball and a special second-order conic representable set. For each problem, we provide a semidefinite representable reformulation. The results are based on a simple observation that partitions the feasible region into extended trust-region subproblems with a linear constraint.

3 The Projection and Rescaling Algorithm for Solving Conic Feasibility Problems

Negar Soheili[1], Javier F. Pena[2], [1]University of Illinois-Chicago, Chicago, IL, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: nazad@uic.edu

The projection and rescaling algorithm is a recent method for solving conic feasibility problems. The gist of this algorithm is to enhance a low-cost first-order method (a basic procedure) with an adaptive reconditioning transformation (a rescaling step). We present multiple sets of numerical experiments on synthetic second-order cone instances with varied levels of conditioning. Our computational experiments provide promising evidence of the effectiveness of the projection and rescaling algorithm.

4 GENERALIZED SEMI-INFINITE PROGRAMMING

Xiaomeng Hu, Jiawang Nie, University of California San Diego, San Diego, CA, Contact: x8hu@ucsd.edu

We talk about Generalized Semi-Infinite Programming (GSIP) problems, which is given by polynomial functions. We propose Moment-SOS relaxations to solve GSIP. The classical Semi-Infinite Programming (SIP) problem can also be solved as a special case of GSIP.

Monday, 11AM–12:15 PM

MB41

CC - Room 203

Optimization for Machine Learning

General Session

Session Chair

Lam M. Nguyen, IBM Research, Thomas J. Watson Research Center, Ossining, NY

Session Chair

Trang Tran, Cornell University, Ithaca, NY

1 Beyond Lazy Training for Over-parameterized Tensor Decomposition

Chenwei Wu, Duke University, Durham, NC, Contact: chenwei.wu592@duke.edu

Over-parameterization is an important technique in training neural networks. In both theory and practice, training a larger network allows the optimization algorithm to avoid bad local optimal solutions. In this paper we study a closely related tensor decomposition problem: given an l-th order tensor in $(R^d)^l$ of rank r (where r d), can variants of gradient descent find a rank m decomposition where m>r? We show that in a lazy training regime (similar to the NTK regime for neural networks) one needs at least $m=\Omega(d^{l-1})$, while a variant of gradient descent can find an approximate tensor when $m=O(r^{2.5l}\log d)$. Our results show that gradient descent on over-parameterized objectives could go beyond the lazy training regime and utilize certain low-rank structures in the data.

2 High-order Variance-reduced Gradients for Finite-sum Optimization

Dongruo Zhou, 1</sup

How to utilize high-order information of the objective function, e.g., Hessian smoothness condition, in stochastic optimization, has attracted great interest in recent years. This talk will introduce a stochastic high-order variance-reduced gradient for both the convex/nonconvex finite-sum optimization. I will show that by equipping this new gradient estimator, existing algorithms can find global minima (convex optimization) or first-order stationary points (nonconvex optimization) faster under several complexity measures, including gradient and Hessian sample complexities.

3 Nesterov Accelerated Shuffling Gradient Method for Convex Optimization

Trang Tran[1], Lam M. Nguyen[2], Katya Scheinberg[1], [1]Cornell University, Ithaca, NY, [2]IBM Research, Thomas J. Watson Research Center, Ossining, NY

In this paper, we propose Nesterov Accelerated Shuffling Gradient (NASG), a new algorithm for the convex finite-sum minimization problems. Our method integrates the traditional Nesterov's acceleration momentum with different shuffling sampling schemes. We show that our algorithm has an improved rate of O(1/T) using unified shuffling schemes, where T is the number of epochs. This rate is better than that of any other shuffling gradient methods in convex regime. Our convergence analysis does not require an assumption on bounded domain or a bounded gradient condition. For randomized shuffling schemes, we improve the convergence bound further. When employing some initial condition, we show that our method converges faster near the small neighborhood of the solution. Numerical simulations demonstrate the efficiency of our algorithm.

4 Convergence and Stability of The Stochastic Proximal Point Algorithm with Momentum

J. Lyle Kim[1], Panos Toulis[2], Anastasios Kyrillidis[3], [1]Rice University, Houston, TX, [2]University of Chicago, Chicago, IL, [3]Rice University, Houston, TX

Stochastic gradient descent with momentum (SGDM) is the dominant algorithm in many optimization scenarios. Yet, in the stochastic setting, momentum interferes with gradient noise, leading to specific step size and momentum choices to converge. Proximal point methods, on the other hand, have gained much attention due to their numerical stability and elasticity against imperfect tuning. Their stochastic accelerated variants though have received limited attention: how momentum interacts with the stability of proximal point methods remains largely unstudied. To address this, we study the stochastic proximal point algorithm with momentum (SPPAM), and show that SPPAM allows a faster linear convergence to a neighborhood compared to stochastic proximal point algorithm (SPPA). Further, we show that SPPAM depends on problem constants more favorably than SGDM.

5 New Perspective on The Convergence to a Global Solution of Finite-sum Optimization

Lam M. Nguyen[1], Trang Tran[2], Marten van Dijk[3], [1]IBM Research, Thomas J. Watson Research Center, Ossining, NY, [2]Cornell University, Ithaca, NY, [3]University of Connecticut, Storrs, CT

Deep neural networks have shown great success in many machine learning tasks. Their training is challenging since the loss surface of the network architecture is generally non-convex, or even non-smooth. We propose a reformulation of the minimization problem allowing for a new recursive algorithmic framework. By using bounded style assumptions, we prove convergence to an \epsilon-(global) minimum using O(1/\epsilon^3) gradient computations. Our theoretical foundation motivates further study, implementation, and optimization of the new algorithmic framework and further investigation of its non-standard bounded style assumptions.

Monday, 11AM–12:15 PM

MB42

CC - Room 204

Latest Developments in Optimization Software Part 2

General Session

Session Chair

Hans Mittelmann, Arizona State University, Tempe, AZ

4 Advanced Techniques in The Xpress Integer Solvers

Imre Polik, FICO, Cary, NC

In this talk we are going to present a few newly introduced integer techniques in the FICO Xpress optimization solvers, and discuss the best way to take advantage of them. Topics in both linear and nonlinear optimization will appear.

1 New Developments in The Xpress Solver

Michael Perregaard, FICO, Birmingham, United Kingdom. Contact: michaelperregaard@fico.com

We will present some of the many recent mprovements to the Xpress Solver. We will show some of the new and enhanced features and the improvements that have gone into our mixed integer and nonlinear solvers.

2 Latest Developments in Optimization with Matlab

Steve Grikschat, MathWorks, Natick

MATLAB has solvers for continuous and discrete optimization problems. They can solve both analytical and black-box models, including those with multiple objectives and those black-box models with discrete variables where relaxations do not exist. Recent enhancements to these solvers and the capabilities for modeling optimization problems will be presented.

3 Latest Developments in The Artelys Knitro Optimization Solver

Richard Waltz, Artelys, Los Angeles, CA

Artelys Knitro is the premier solver for nonlinear optimization problems. Knitro offers both interior-point and active-set algorithms for continuous models, as well as tools for handling problems with integer variables and other discrete structure. This talk will highlight the latest developments in Knitro, focusing on some of the recent advances in solving mixed-integer nonlinear problems. We will also present some Knitro results on large-scale models from various applications.

Monday, 11AM–12:15 PM

MB43

CC - Room 205

Block Decomposable and Coordinate Descent Methods

General Session

Session Chair

David Gutman, Texas Tech University, Lubbock, TX

1 **Coordinate Descent Without Coordinates**

David Huckleberry Gutman[1], Nam Ho-Nguyen[2], [1]Texas Tech University, Lubbock, TX, [2]University of Sydney, Sydney, Australia. Contact: david.gutman@ttu.edu

We consider an extension of the coordinate descent algorithm to manifold domains, and provide convergence analyses for geodesically convex and non- convex smooth objective functions. Our key insight is to draw an analogy between coordinate blocks in Euclidean space and tangent subspaces of a manifold. Hence, our method is called tangent subspace descent (TSD). The core principle behind ensuring convergence of TSD is the appropriate choice of subspace at each iteration. To this end, we propose two novel conditions: the gap ensuring and C-randomized norm conditions on deterministic and randomized modes of subspace selection respectively. These ensure convergence for smooth functions, and are satisfied in practical contexts. We propose randomized and deterministic subspace selection rules of particular practical interest for the Stiefel manifold.

2 **The Inexact Cyclic Block Proximal Gradient Method and Inexact Proximal Maps**

Leandro Farias Maia[1], David Gutman[2], Ryan Christopher Hughes[3], [1]Texas Tech University, Lubbock, TX, [2]Texas Tech University, Lubbock, TX, [3]Addx Corporation, Alexandria, VA, Contact: leandro.maia@ttu.edu

In this talk, we expand the Cyclic Block Proximal Gradient method for block separable, composite minimization to allow for inexactly computed gradients and proximal maps. The resultant algorithm, the Inexact Cyclic Block Proximal Gradient (I-CBPG) method, shares the same convergence rate as its exactly computed analogue, provided how the allowable errors decrease. The foundation of our convergence analysis is our proposed ?-Second Prox Theorem, which contains a tight relationship between inexact proximal map evaluations and ?-subgradients. Further, we highlight numerical experiments that showcase the practical computational advantage of I-CBPG for certain fixed tolerances of approximation error and for a dynamically decreasing error tolerance regime in particular.

3 **On The Complexity of a Practical Primal-Dual Coordinate Method**

Ahmet Alacaoglu[1], Volkan Cevher[2], Stephen J. Wright[1], [1]University of Wisconsin-Madison, Madison, WI, [2]EPFL, Lausanne, Switzerland. Contact: alacaoglu@wisc.edu

We prove complexity bounds for the primal-dual algorithm with random extrapolation and coordinate descent (PURE-CD), which has been shown to obtain good practical performance for solving convex-concave min-max problems with bilinear coupling. Our results either match or improve the best-known complexities for dense and sparse (strongly)-convex-(strongly)-concave problems.

Monday, 11AM–12:15 PM

MB44

CC - Room 206

Supply Chain Networks

General Session

Session Chair

Navneet Vidyarthi, Concordia University, Verdun, QC, Canada.

1 **DISSIMILAR TREEs in GRAPHS: AN APPLICATIOn to ILLICIT SUPPLY CHAINS**

Rashid Anzoom, Rakesh Nagi, Chrysafis Vogiatzis, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: ranzoom2@illinois.edu

The clandestine nature of illicit supply chains makes them highly resilient to detection. Unlike their licit counterparts, designing an illicit supply network is not solely focused on cost minimization. Thus, their investigation should involve searching for a diverse set of possible networks rather than a single optimal one. This talk discusses the possible approaches for extracting network structures that are dissimilar to a customized degree (a generalization of k-best and k-disjoint structures). We focus specifically on deriving dissimilar trees within a graph, which is a relatively unexplored topic. We also discuss a possible computational acceleration through the incorporation of GPU computing.

2 **Material Supply Network Optimization in The Energy and Utility Industry**

Haitao Li, University of Missouri - St. Louis, Saint Louis, MO, Contact: lihait@umsl.edu

The energy and utility industry has a significant need for efficient and resilient material supply networks in today's competitive markets and volatile business environment. We identify three unique features and challenges in managing a utility company's material supply network: contracting and business rules, growing and varying demands, and supply disruption risks. Mathematical programming based optimization models are presented to address them. A case study at a Fortune 500 utility company is presented to showcase the application of an integrated location-inventory optimization model and its capability for data-driven decision-support.

3 Omnichannel Distribution Network Design

Aditya Malik[1], Navneet Vidyarthi[1], Ivan Contreras[2], [1]John Molson School of Business, Concordia University, Montreal, QC, Canada; [2]Gina Cody School of Engineering and Computer Science, Concordia University, Montreal, QC, Canada. Contact: navneet.vidyarthi@gmail.com

We study the problem of demand allocation, inventory positioning, and distribution network design for a retailer that seeks to integrate online sales channel into their traditional brick-and-mortar retail channel. The proposed analytical model seeks to locate distribution centers, select stores for online demand fulfillment, assign stores to fulfillment centers, and allocate safety stocks at distribution centers and stores to deal with variability in demands and lead time. We present an MIP formulation and an exact branch-and-cut algorithm. Extensive computations under different cost scenarios and parameter settings confirm the efficiency of our exact algorithm. We conduct sensitivity analyses to understand the impact of variation in cost and model parameters and present managerial insights.

Monday, 11AM–12:15 PM

MB45

CC - Room 207

Developments in First-order Methods in Machine Learning

General Session

Session Chair

Yibo Xu, Clemson University, Clemson, SC

1 Finite-Sum Coupled Compositional Stochastic Optimization: Theory and Applications

Bokun Wang, University of Iowa, Iowa City, IA

This paper studies stochastic optimization for a sum of compositional functions, where the inner-level function of each summand is coupled with the corresponding summation index. We refer to this family of problems as finite-sum coupled compositional optimization (FCCO). It has broad applications in machine learning for optimizing non-convex or convex compositional measures/objectives. Yet, existing algorithms and analysis are restricted in one or other aspects. The contribution of this paper is to provide a comprehensive analysis of a simple stochastic algorithm for both non-convex and convex objectives. The key results are improved oracle complexities with the parallel speed-up} by the moving-average based stochastic estimator with mini-batching.

2 Nonconvex optimization with streaming dependent data

Krishnakumar Balasubramanian, University of California, Davis, Davis, CA

We study a projection-free conditional gradient-type algorithm for constrained nonconvex stochastic optimization problems with Markovian data. In particular, we focus on the case when the transition kernel of the Markov chain is state-dependent. Such stochastic optimization problems arise in various machine learning problems including strategic classification and reinforcement learning. For this problem, we establish that the number of calls to the stochastic first-order oracle and the linear minimization oracle to obtain an appropriately defined ϵ-stationary point, are of the order $\mathcal{O}(1/\epsilon^{2.5})$ and $\mathcal{O}(1/\epsilon^{5.5})$ respectively. We also empirically demonstrate the performance of our algorithm on the problem of strategic classification with neural networks.

3 Distributed Stochastic Inertial-accelerated Methods with Delayed Derivatives for Nonconvex Problems

Yonggui Yan, Rensselaer Polytechnic Institute, Troy, NY, Contact: yany4@rpi.edu

We propose an inertial proximal SsGM for solving nonsmooth nonconvex stochastic optimization problems. The proposed method can have guaranteed convergence even with delayed derivative information in a distributed environment. Convergence rate results are established to three classes of nonconvex problems: weakly-convex nonsmooth problems with a convex regularizer, composite nonconvex problems with a nonsmooth convex regularizer, and smooth nonconvex problems. For each problem class, the convergence rate is $O(1/K^{1/2})$ in the expected value of the gradient norm square, for K iterations. In a distributed environment, the delay effect will decay with the number of iterations for the latter two problem classes. The numerical results on three applications demonstrate the advantages of using the inertial-based acceleration.

4 A Primal-Dual Framework for Smooth, Non-convex Decentralized Optimization

Gabriel Mancino-Ball, Rensselaer Polytechnic Institute, Troy, NY

In this presentation, we will discuss a primal-dual framework for smooth, non-convex decentralized optimization.

Monday, 11AM–12:15 PM

MB46

CC - Room 208

Recent Advances in Smart Transportation

General Session

Session Chair

Xian Yu, University of Michigan, Okemos, MI

1 Optimal Zone Sizing for Equitable Data Sharing of Mobility Providers

Bingqing Liu[1], Farnoosh Namdarpour[2], Joseph Y J Chow[1], [1]New York University, Brooklyn, NY, [2]New York University, Brooklyn, NY

To better manage Mobility-as-a-Service systems, data-sharing between mobility providers and agencies becomes a new challenge. Since demographic data sampling errors are usually larger for minority groups, effectively combining basic zones to design new zoning systems (i.e. districting) is necessary for improving the data reliability of minority groups, ensuring equitable service evaluation and decision-making. The districting problem is formulated as an NP-hard integer programming. We implement a tabu-search-based solution algorithm in the case of New York City, combining more than 2,000 census tracts into around 600 zones, considering minority groups below poverty level, with long commute times (>1h), and with an age above 67. The results show that the combined data margin of error is significantly improved compared with the census-tract-level data.

2 Modeling and Analysis of Shared Street-hail Services

Daniel Vignon, Alexander Sundt, Yafeng Yin, University of Michigan, Ann Arbor, MI, Contact: dvignon@umich.edu

In major US cities, customers are barred from sharing street-hail services. However, with the advent of pooling through e-hailing, we might wonder whether allowing shared street-hails is warranted. This could even the playing field between regular taxis and e-hails since shared e-hails are often allowed but shared street-hails are not. Moreover, it could provide another avenue for congestion management. To evaluate these possibilities, we propose and analyze a model of shared street-hail services. Our analysis allows us to compare shared street-hail to different public and private transportation modes. Then, we evaluate the effect of such a service on congestion, capturing the tradeoffs between frequent stops for pickup and drop-offs and the reduction in the number of vehicles. Lastly, a simulation is proposed to validate our theoretical derivations.

3 Effects of Task-based Incentives on Labor Supply in Ride-sourcing Market

Tianming Liu[1], Zhengtian Xu[2], Daniel Vignon[3], Yafeng Yin[3], Qingyang Li[4], Zhiwei Qin[5], [1]The University of Michigan, Ann Arbor, MI, [2]The George Washington University, Washington, [3]University of Michigan, Ann Arbor, MI, [4]Didi AI Labs, San Jose, CA, [5]DiDi AI Labs, San Jose, CA, Contact: tianmliu@umich.edu

Ride-sourcing companies have been using task-based incentive programs to encourage drivers to extend their working hours. In such programs, a driver receives a certain amount of monetary reward if he/she completes a given task within a given time window. However, despite the popularity of these incentives, little is known about how drivers respond to them in practice, and there is no means to evaluate and optimize the designs systematically. To fill the void, we develop a dynamic discrete choice model that formulates ride-sourcing drivers' working decisions influenced by the task-based incentives and then calibrate it using the real-world data from a ride-sourcing platform. Our results gain insights into the market and welfare effects of the task-based incentive and its various designs.

4 Planning Lane Reversals in Urban Transportation Networks

Salomon Wollenstein-Betech[1], Christos G. Cassandras[1], Ioannis (Yannis) Paschalidis[2], [1]Boston University, Brookline, MA, [2]Boston University, Boston, MA, Contact: salomonw@bu.edu

We study methods to reduce the total travel time of users in a transportation network by reversing the direction of certain lanes in the network. This *lane reversal problem* is NP-hard due to the dependance of users' route selection on the lane direction decision. To address this issue, we propose a convex approximation method that relaxes the objective with a threshold-based function. This approximation is valuable since it finds a global optimum and incorporates additional linear constraints. We test the method using the Eastern Massachusetts network where we see a reduction in travel times of 4.7% by choosing the best 15 reversals. Moreover, we estimate the benefits of lane reversals as a function of the OD demand symmetry. We observe that for asymmetric demands (e.g., evacuations, large events), the reduction in travel times is higher, reaching values of 60%.

Monday, 11AM–12:15 PM

MB48

CC - Room 210

Hyperconnected Logistic Hub Networks

General Session

Session Chair

Benoit Montreuil, ISyE Georgia Tech, Atlanta, GA

Session Chair

Benoit Montreuil, ISyE Georgia Tech, Atlanta, GA

1 Dynamic Parcel Arrival Prediction at Hubs in Logistics Networks

Xinyue Pan[1], Yujia Xu[2], Benoit Montreuil[1], [1]ISyE Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA

High-pace growth of online shopping and induced demand for fast-response on-time parcel delivery are driving logistics service providers in a quest toward improving the efficiency and responsiveness of their logistic hub networks through enhanced agility, smartness, and predictability. To contribute to this quest, we propose a dynamic data-driven algorithm to forecast short-term parcel arrivals at specific logistic hubs in the network, such as arrivals in every 15-minute period over the next 24 hours, enabling fast resource and operations adjustment. The algorithm incorporates live data on the status of parcels already in the network and accounts for not-yet-ordered parcel pickup and delivery mandates. We provide results and insights from empirical experimentation of the proposed algorithm using a megacity parcel logistics case.

2 Dynamic Workforce Scheduling and Deployment in Hyperconnected Logistic Hub Networks

Yujia Xu[1], Benoit Montreuil[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: yujia.xu@gatech.edu

With the development of e-commerce during the Covid-19 pandemic, one of the major challenges for many parcel logistics companies has revealed to be designing reliable and flexible scheduling approaches and algorithms to meet uncertainties of parcel arrivals and manpower availability in logistic hubs. Currently, most labor scheduling is periodic and limited to single facility, thus the number of required workers in each hub is constrained to meet the peak demand with high variance. We here propose dynamic workforce scheduling and deployment mechanisms that are fed with updated data with sensors and dynamically updated parcel arrival predictions at hubs, to spatiotemporally adjust the available workforce across hyperconnected logistic hub networks using a rolling horizon approach. We provide results and analysis based on a megacity-based parcel logistics case.

3 Modular Hyperconnected Parcel Logistics Hub Design

Wencang Bao[1], Sevda Babalou[1], Mingze Li[1], Benoit Montreuil[2], Leon McGinnis[1], Ali Barenji[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: bomsun@gatech.edu

Parcel logistic hubs nowadays require the capability of faster response time, less resource requirements and more flexibility. To address that, we demonstrate the concept of modular design of hyperconnected parcel logistic hubs with the help of standard containers. A case study illustrates how modular design shortens parcel moving distance and improves space and devices utilization by activating and relocating stations dynamically. Simulation is presented to evaluate the feasibility and benefits of modular design.

4 Revenue Management and Capacity Control for Temperature-controlled Storage Facilities

Jana Boerger, He Wang, Benoit Montreuil, Georgia Tech, Atlanta, GA

Cold chain third-party logistics providers (3PL) offer temperature-controlled warehouse storage space and value-added services to their clients. Suppose a client requests a storage service that specifies the contract length, capacity, temperature and revenue. The 3PL can either reject the request or accept it into one of multiple temperature-controlled rooms. Thus, the management of the warehouse capacity can be divided into two parts: the decisions on accepting or rejecting incoming client requests and the decisions on setting temperatures of the storage rooms. The 3PL's objective is to maximize total expected revenue. We propose a sequential decision-making algorithm based on reinforcement learning to address the problem.

Monday, 11AM–12:15 PM

MB49

CC - Room 211

Network Design for Freight Movement

General Session

Session Chair

Himani Ananthula, Kellogg School of Management, Northwestern University, Evansotn, IL

1 **Freight Transportation System in Megacity**

Jihyun Jo, Soundar Kumara, Pennsylvania State University, University Park, PA, Contact: jzj5077@psu.edu

We consider the freight transportation systems in the megacity using the location-routing problem. One of the suggestions for the urban transportation network problem is finding the satellite locations where the freight transfers from normal trucks to city freighters. In this stage, the objective is minimizing cost including fixed cost and operation cost. In addition, we consider that city freighters have their own routes which have multiple locations to visit during the trip and we want to minimize the maximum travel time within the operational area. To solve the problem, we first find the individual freighters' routes using Route First - Partition Second method and then we find the satellite locations from potential sites.

2 **Stochastic Relay Routing Network Design**

Himani Ananthula, Kellogg School of Management, Evanston, IL, Contact: himani.ananthula@kellogg.northwestern.edu

We study the problem of network design with relay points. A relay point is a physical location in the network where shipments can be relayed from one driver to another. Pilot(truck driver) attrition has been a growing concern in the road freight logistics industry; the major reasons being high on-road times, and irregular schedules leading to social disrespect and stigma. Especially in the context of India, the majority of long-haul shipments are still being delivered Point to Point(PtP) by a single driver resulting in high on-road times leading to a terrible lifestyle for pilots. To understand and model the challenges we worked closely with a large platform-based trucking company in India. We formulate the problem as a large-scale MILP and we further demonstrate the advantages due to the flexibility characteristic of the relay network using a covid-inspired labor shock model.

3 **OPTIMAL PLANNINg of WAREHOUSE CAPACITY**

Sundaravalli Narayanaswami, Indian Institute of Management Ahmedabad, Ahmedabad, India. Contact: sundaravallin@iima.ac.in

Our study is on a major Indian container terminal operator. Based on the recent taxation reforms, there has been a significant change in the freight movements in the country, which has impacted the demand distribution, warehouse locations, capacity, and movement of goods. We consider the current locations and capacity of warehouses held by the container operator, and the revised demand profile. An optimization model is developed so that all demands can be met at the least cost. The model is scalable, with a provision to accommodate granular clusters of future demands and incorporates all realistic constraints. Our model and results hold immense managerial relevance to the container operator; from an academic research perspective, our findings are insightful and encouraging to abstract as key learnings. Challenges and limitations of the model are also presented.

Monday, 11AM–12:15 PM

MB50

CC - Room 212

Information Role and Firm Strategies on e-platforms

General Session

Session Chair

Gang Wang, University of Delaware, Newark, DE

1 **The Competition Among Stores with Omnichannel Strategies**

Kaiyu Zhang, Shu He, Cuihong Li, University of Connecticut, Storrs, CT, Contact: kaiyu.zhang@uconn.edu

In the retail industry, online services create substantial benefits for customers and therefore companies who already have offline stores are actively considering omnichannel strategies to expand markets. The launch of an online channel not only affects the focal company's own profitability but also may change its competitive environment. In this study, we empirically investigate the impact of a competitor's entry on the sales performance of a focal store using a dataset from Chinese grocery companies that adopt omnichannel strategies for operation. We leverage the sequential entries of grocery stores in different locations in Beijing, China, and use the staggered difference-in-difference econometric model to estimate the impact. Our study provides important managerial and policy implications for e-commerce companies and platforms.

2 **Impact of Product Links and Sponsorship Disclosure on User Endorsement on Social Media**

Xiaoye Cheng[1], Hillol Bala[2], Xue Tan[2], [1]University of

Delaware, Newark, DE, [2]Indiana University, Bloomington, IN, Contact: xycheng@udel.edu
The inclusion of product links in user-generated content on social media could not only ease product search and purchase for the audience but also boost sales. However, it may cast doubts on social media influencers' (content generators) motive to share helpful information, undermining the audience's trust. This study examines the direct and moderating impacts of using product links on user endorsement (i.e., likes), and the moderating effect of influencer activeness. Through analyzing posts from a social media platform, we find that using product links leads to more likes and negatively moderates the impact of sponsorship disclosure on endorsement. In addition, influencer activeness positively moderates the effects of product links and sponsorship disclosure. This study makes contributions to the user-generated content literature and digital platform designs.

3 Student Depression Detection: An Attention-based Bi-LSTM Approach Using Online and Offline Behavior Data

Guohou Shan[1], Zhe Deng[2], Konstantin Bauman[3], Qian Sun[4], [1]Temple University, Philadelphia, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Fox School of Business, Temple University, Philadelphia, PA, [4]Northwest University, Xi'an, Shaanxi, China. Contact: zhedeng@cmu.edu
Student depression is a frequent and severe mental disorder among college students, after the COVID-19 pandemic especially. It has been widely investigated in clinical trials, but less studied in the field of IS in healthcare, especially on the topic of automatic depression detection. However, methods used in clinical trials are cost-intensive. Automatic depression detection models are promising and effective in reducing costs. The main current related studies have low generalizability while having some flaws such as privacy intrusive of mobile sensor data, and delayed detection using social media data. Cooperating with a large public university, we collect all of students' on-campus online and offline behavioral data and depression levels. Based on that, we design an attention-based bi-LSTM model to automatically detect students' depression in real-time.

4 Dinner at Your Doorstep: Service Innovation Through The Gig Economy in Food Delivery Platforms

Geng Sun[1], Yeongin Kim[2], Yinliang Tan[3], Geoffrey Parker[4], [1]University of Texas Rio Grande Valley, Edinburg, TX, [2]Virginia Commonwealth University, Richmond, VA, [3]Tulane University, New Orleans, LA, [4]Dartmouth College, Hanover, NH, Contact: ykim3@vcu.edu
The online food delivery (OFD) market has experienced rapid growth especially in a time of COVID-19. The OFD business model is a multi-sided marketplace connecting three parties - the restaurants, consumers, and gig-drivers. This paper studies online food delivery platforms such as Uber Eats and DoorDash in the context of multi-sided markets and gig-economy. Our analysis shows that how the platforms adjust their pricing and service strategies critically depends on the strength of the total network effect and confirms that conventional insights from two-sided platforms do not completely carry over to OFD markets. We further show that the introduction of minimum wage regulation may reduce consumer welfare. Overall, our results provide actionable managerial and policy insights on how to seek to strike a balance among the interests of the three parties.

Monday, 11AM–12:15 PM

MB51

M - Santa Fe

Daniel H. Wagner Prize II

Award Session

Session Chair

Margret V. Bjarnadottir, University of Maryland, College Park, MD

Session Chair

Andrew S. Wasser, Carnegie Mellon University, Pittsburgh, PA

1 Human-Centric Parcel Delivery at Deutsche Post with Operations Research and Machine Learning

Ugur Arikan[1], Baris Cem Sal[2], Jonas Witt[2], Thorsten Kranz[1], Severin Schmitt[1], [1]DPDHL / Data Analytics, Bonn, Germany; [2]Deutsche Post DHL Group, Bonn, Germany.
We present our contribution to facilitating transparency features for customers of Deutsche Post's parcel delivery service in Germany. The building blocks for enabling transparency features, such as delivery time windows and live tracking of shipments, are a courier-oriented last-mile routing algorithm and a reliable prediction incorporating the routing output as well as a huge amount of historical shipment data. These algorithms are leading examples of how significant impact can be delivered using operations research and machine learning when human is at the center of decision making.

2 Reshaping National Organ Allocation Policy

Theodore P. Papalexopoulos[1], Dimitris Bertsimas[2], Nikos Trichakis[3], James Alcorn[4], Rebecca Goff[5], Darren Stewart[5], [1]MIT Operations Research Center, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT, Cambridge, MA, [45]United Network for Organ Sharing, Richmond, VA

The Organ Procurement and Transplantation Network (OPTN) is overhauling its organ allocation policies in a generational change, aiming for more efficient and equitable outcomes. We introduce a novel analytical framework to enable dynamic exploration of the efficient frontier of policy options. Jointly with OPTN, we applied our framework to the design of a new allocation policy for lungs, which was eventually approved for implementation. From 2023, all lungs in the U.S. will be allocated according to the said policy, projected to reduce waitlist mortality by >20% compared to current policy.

Monday, 11AM–12:15 PM

MB52

M - Lincoln

Academic Job Panel

Panel Session

Session Chair

Priyank Arora, University of South Carolina, Columbia, SC

1 Moderator

Priyank Arora, University of South Carolina, Columbia, SC

The purpose of this session is to bring visibility to the students, and postdocs looking for academic positions. Panelists from both business and engineering schools will share their experiences. This panel discusses the academic interview process and do's and don'ts associated with the job search.

2 Panelist

Anna Saez de Tejada Cuenca, IESE Business School, Barcelona, Spain.

3 Panelist

Jorge A. Sefair, Arizona State University of Florida, Gainesville, FL

4 Panelist

Jennifer K. Ryan, University of Nebraska–Lincoln, Lincoln, NE

5 Panelist

Yiling Zhang, University of Minnesota, Minneapolis, MN

Monday, 11AM–12:15 PM

MB53

M - Denver

Big Data and Forecasting for Retail and Supply Chains

Contributed Session

Session Chair

Dharmashankar Subramanian, IBM TJ Watson Research Center, Rye Brook, NY

1 A Tree-based Framework to Democratize Large-scale Retail Sales Forecasting with Big Data

Arnoud P. Wellens[1], Robert N. Boute[2], Maximiliano Udenio[3], [1]KU Leuven, Leuven, Belgium; [2]Vlerick Business School, Leuven, Belgium; [3]KU Leuven, Leuven, Belgium. Contact: arnoud.wellens@kuleuven.be

Despite the recent outperformance of machine learning (ML) based methods, simple statistical forecasting techniques remain the standard approach in retail. While these top-performing ML methods are complex to implement, we show how a straightforward implementation of a tree-based method substantially outperforms these traditional forecasting methods. Based on a test set of 4,523 products of a Belgian retailer and a variety of external variables (e.g., promotions), our proposed model improves the forecast accuracy of commonly used statistical methods by up to 20.52%. Using Shapley values, we find that external variables and a limited amount of processed input features (e.g., the rolling mean of sales) are crucial for successful implementation. Finally, with simulation, we investigate how this forecast superiority translates to lower inventory costs.

2 Automating Complex and Distributed Forecasting Tasks for Faster Supply Chain Decisions

Vijay Ekambaram[1], Arindam Jati[1], Satyam Dwivedi[1], Stuart Siegel[2], Brian Quanz[2], Wesley Gifford[2], Pavithra Harsha[3], Chandra Narayanaswami[2], [1]IBM Research, Bangalore, India; [2]IBM Research, Yorktown Heights, NY, [3]IBM Research, Pleasantville, NY

Forecasting is a key AI component that drives various supply chain use cases such as inventory management, markdown optimization, etc. In general, supply chain use cases deal with large-scale data that needs sophisticated distributed forecasting techniques. These techniques involve a lot of complex steps such as pipeline construction, set-up/ execution across multiple distributed environments (ray, spark), HPO, right model selection, backtesting, evaluation, etc. Manually coding and orchestrating these tasks is highly time-consuming and error-prone. To tackle this, we propose our in-house built YAML-driven orchestration engine that automates and eases various complex distributed forecasting tasks for faster supply chain decisions.

3 New-product Demand Forecasting for Long-lived Products

Shanshan Huang[1], Andrew Lim[2], [12]National University of Singapore, Singapore, Singapore.

We consider the problem of demand forecasting for long-lived products when a new product is introduced. We propose a method for estimating the demand for the new product and the impact on the demand for existing products when there are potentially time varying product and global-level covariates and sales data for the new product is not available. We propose a hybrid demand model that combines linear model and choice models to incorporate cannibalization with limited data. When building the choice model, we cluster products with similar characteristics, and build choice models over clusters to address the issue of having the large choice set and no observed “choices” of the new products. This model is easy to calibrate and is applied to data from The Body Shop where it is shown to predict the impact of cannibalization that is missed by traditional regression based methods.

Monday, 11AM–12:15 PM

MB54

M - Marriott 1

Causality and Robustness

General Session

Session Chair

Hongseok Namkoong, 1</sup

1 Confounding-Robust Evaluation and Learning of Counterfactual Risk Assessments

Amanda Coston[1], Ashesh Rambachan[2], Alexandra Chouldechova[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Harvard University, Cambridge, MA

Algorithmic risk assessments are used to inform many high-stakes decisions such as loan approval decisions in consumer lending. These risk assessments are typically counterfactual, predicting the likelihood of an adverse outcome under a proposed decision (e.g., ``loan approval”). A key challenge is that there may be unobserved confounding factors that affected both historical treatment decisions and outcomes. We develop an interpretable outcome model of unobserved confounding under which the both the prediction target and predictive performance metrics of a given risk assessment are partially identified. We develop develop doubly-robust methods to estimate bounds on the predictive performance metrics of a given risk assessment, and a two-stage learning procedure to predict identifiable upper and lower bounds on the prediction target.

2 Improving Inference from Simple Instruments Through Compliance Estimation

Stephen Coussens[1], Jann Spiess[2], [1]Columbia Public Health, New York, NY, [2]Stanford Graduate School of Business, Stanford, CA, Contact: jspiess@stanford.edu

We study how to improve the efficiency of instrumental variables (IV) estimates by exploiting the predictable variation in the strength of the instrument. In the case where both the treatment and instrument are binary and the instrument is independent of baseline covariates, we study weighting each observation according to its estimated compliance. The resulting estimator can leverage machine learning to estimate compliance as a function of baseline covariates. We derive the large-sample properties of a specific implementation of a weighted IV estimator in the potential outcomes and local average treatment effect (LATE) frameworks, and provide tools for inference that remain valid even when the weights are estimated nonparametrically.

3 The S-value: Evaluating Stability with Respect to Distributional Shifts

Dominik Rothenhaeusler, 1</sup

Common statistical measures of uncertainty such as p-values and confidence intervals quantify the uncertainty due to sampling. However, sampling is not the only source of uncertainty. In practice, distributions change between locations and across time. This makes it difficult to gather knowledge that transfers across data sets. We propose a measure of instability that quantifies the distributional instability of a statistical parameter with respect to Kullback-Leibler divergence. In addition, we quantify the instability of parameters with respect to directional or variable-specific shifts. Measuring instability with respect to directional shifts can be used to detect the type of shifts a parameter is sensitive to. We discuss how such knowledge can inform data collection for improved estimation of statistical parameters under shifted distributions.

4 Identification and Estimation of Causal Peer Effects Using Double Negative Controls for Unmeasured Network Confounding

Naoki Egami, Columbia University, NY

Scientists have been interested in estimating causal peer effects. However, it is well known that identification and estimation of causal peer effects are challenging in observational studies for two reasons. The first is the identification challenge due to unmeasured network confounding, e.g., homophily bias. The second issue is network dependence of observations. In this article, we establish a framework that leverages a pair of negative control outcome and exposure variables (double negative controls) to nonparametrically identify causal peer effects in the presence of unmeasured network confounding. We propose a generalized method of moments estimator, and establish its consistency and asymptotic normality under an assumption about [illegible]-network dependence. Finally, we provide a network heteroskedasticity and autocorrelation consistent variance estimator.

Monday, 11AM–12:15 PM

MB55

M - Marriott 2

Queues with Matching

General Session

Session Chair

Martin Zubeldia, University of Minnesota, Minneapolis, MN

1 Insensitvity in The Adan-weiss Model

Runhan Xie[1], Kristen Gardner[2], Rhonda L. Righter[3], [1]University of California-Berkeley, Berkeley, CA, [2]Amherst College, Amherst, MA, [3]University of California-Berkeley, Berkeley, CA, Contact: runhan_xie@berkeley.edu

We consider the M/G/K/K loss model with heterogeneous service distributions and server compatibilities (each server can only work on a subset of job types), first presented in Adan and Weiss (2012). We present an alternative proof of the stationary distributions for the assign-to-the-longest-idle-server (ALIS) model as well as the random assignment model. We model this loss system as a different queueing system that is easier to analyze and has the insensitivity property (under ALIS) that leads us to conclude the insensitivity of the original model (under ALIS). We also consider an extension in which an arriving job uses all available compatible servers, as opposed to the original Adan-Weiss model where an arriving job uses only the longest idling compatible server.

2 Matching Impatient Demand and Supply

Angelos Aveklouris[1], Levi DeValve[2], Amy R. Ward[3], [1]University of Chicago Booth School of Business, Chicago, IL, [2]University of Chicago, Chicago, IL, [3]The University of Chicago Booth School of Business, Chicago, IL

Service platforms must determine rules for matching heterogeneous demand and supply that arrive randomly over time and may be lost if forced to wait too long for a match. Our objective is to maximize the cumulative value of matches, minus costs incurred when demand and supply wait. Based on a fluid model approximation, we propose a discrete review matching policy that is asymptotically optimal. We further show that when the patience time distributions have increasing hazard rate functions, a state-independent priority policy, that ranks the edges on the bipartite graph connecting demand and supply, is asymptotically optimal. A key insight from this analysis is that the ranking critically depends on the patience time distributions, and may be different for different distributions even if they have the same mean.

3 Dynamic Matching: A Queueing Perspective

Süleyman Kerimov[1,2], Itai Ashlagi[3], Itai Gurvich[4], [1]Stanford University, Stanford, CA, [2]Rice University, Houston, TX, [3]Stanford University, Stanford, CA, [4]Northwestern University, Kellogg School of Management, Evanston,, IL

We study centralized dynamic matching markets with finitely many agent types and heterogeneous match values. An inherent trade-off arises between short- and long-term value. A social planner may delay match decisions to thicken the market and increase match opportunities to generate high value. This inevitably compromises short-term objectives, and the planner may match greedily to maximize short-term value. A matching policy is hindsight optimal if the policy can (nearly) maximize the total value simultaneously at all times. We first establish that in multi-way networks, where a match can include more than two agent types, a simple periodic clearing policy with a carefully chosen period length is hindsight optimal. Interestingly, in two-way networks, where any match includes two agent types, suitably designed greedy policies also achieve hindsight optimality.

4 Matching Queues with Abandonments in Quantum Switches: Stability and Throughput Analysis

Martin Zubeldia[1], Siva Theja Maguluri[2], Prakirt Raj

Jhunjhunwala[3], [1]University of Minnesota, Minneapolis, MN, [2]ISyE Georgia Tech, Atlanta, GA, [3]Georgia Institute of Technology, Atlanta, GA, Contact: mar.zubeldia@gmail.com

Inspired by quantum switches, we consider a discrete-time multi-way matching system with two classes of arrivals: requests for entangled qubits between two nodes, and entangled qubits from each node (which can decohere and abandon after some time). We study a simple system consisting of two types of requests and three types of qubits (dubbed the W-topology) operating under a Max-Weight policy. In this setting, we show that Max-Weight is throughput optimal, and that its stability region is larger than the convex hull of the throughputs that can be achieved by non-idling policies when the requests are infinitely backlogged. Moreover, despite the use of Max-Weight on the requests queues, we show that there can be a counterintuitive behavior in the system: the longest requests queue can have a positive drift for some time even if the overall system is stable.

Monday, 11AM–12:15 PM

MB56

M - Marriott 3

Consequential Sequential Decisions

General Session

Session Chair

Nathan Kallus, Cornell University, Long Island City, NY

Session Chair

Masatoshi Uehara, New York, NY

1 Discounting in Markov Chain Estimation

Ethan Che, Jing Dong, Columbia University, New York, NY, Contact: ewc2119@columbia.edu

Discounting can be viewed as a perturbation to improve the ergodicity of the Markov chain by imposing more regular regenerations. It can improve the estimation efficiency in Markov chain estimation tasks. On the other hand, the perturbation can also lead to estimation bias, which imposes an efficiency-accuracy tradeoff. In this paper, we apply the Wasserstein ergodicity framework to investigate the efficiency-accuracy tradeoff for discounting in two important estimation tasks: steady-state estimation and estimating the solution to the Poisson equation. Our results quantifies the overall benefit of discounting and provide guidance on choosing the appropriate discount factors in these estimation tasks.

2 Presenter

Nathan Kallus, Cornell University, Long Island City, NY

The fundamental problem of causal inference prevents identifying how many might be harmed by an intervention. If, in an A/B test, half of users click/buy/watch/renew, whether exposed to recommendation algorithm A or B, it could be because the change impacts no one, because the change benefits half the user population and harms the other half, or something in between. While unknowable, this impact is clearly of material to the decision to implement a change or not, whether for fairness or operational concerns. We therefore derive the tightest-possible (i.e., sharp) bounds we can make on the fraction negatively affected given data with only factual observations, whether experimental or observational. Since the bounds involve unknown functions, we develop a robust inference algorithm that is largely invariant to how and how fast these functions are learned.

3 Adaptive Discretization for Adversarial Lipschitz Bandits

Chara Podimata[1], Aleksandrs Slivkins[2], [1]UC Berkeley, Berkeley, CA, [2]Microsoft Corporation, Washington, Contact: charapod@gmail.com

Lipschitz bandits is a prominent version of multi-armed bandits that studies large, structured action spaces such as the [0,1] interval, where similar actions are guaranteed to have similar rewards. A central theme here is the adaptive discretization of the action space, which gradually "zooms in" on the more promising regions thereof. The goal is to take advantage of "nicer" problem instances while retaining near-optimal worst-case performance. While the stochastic version of the problem is well-understood, the general version with adversarial rewards is not. We provide the first algorithm for adaptive discretization in the adversarial version and derive instance-dependent regret bounds. In particular, we recover the worst-case optimal regret bound for the adversarial version, and the instance-dependent regret bound for the stochastic version.

4 Experimentation Platform and Learning Treatment Effects in Panels

Vivek Farias[1], Andrew A. Li[2], Tianyi Peng[3], [1]MIT, Cambridge, MA, [2]CMU Tepper, Pittsburgh, PA, [3]MIT, Boston, MA, Contact: tianyi@mit.edu

Recent years have observed an increased interest in deploying experimentation platforms in different industry sectors, of which the central challenge is to estimate the effects of various policies using log data. This problem, namely, causal inference with panel data, in fact lies in the core of econometrics. The following is a fundamental version of the problem: let M* be a low-rank matrix and E be a noise matrix. For a 'treatment' matrix Z, we observe O with O_{ij} := M_{ij} + E_{ij} + T_{ij}Z_{ij}, where T_{ij} are unknown treatment effects. The problem requires estimating ⍰*, i.e., the average of T over Z. This paper establishes a framework to allow rate-optimal recovery of ⍰* for general Z and E, which are the first of their type in this general setting. In collaborating with a leading retailer, this framework is implemented in Mexico, significantly improving existing methods.

Monday, 11AM–12:15 PM

MB57

M - Marriott 4

QSR Best Refereed Paper Competition

Award Session

Session Chair

Yisha Xiang, Texas Tech University, Lubbock, TX

Session Chair

Yili Hong, Virginia Polytechnic Institute, Blacksburg, VA

Session Chair

Kamran Paynabar, ISyE Georgia Tech, Atlanta, GA

1 Award Presenter

Bo Shen[1], Zhenyu James Kong[2], [1]New Jersey Institute of Technology, Newark, NJ, [2]Virginia Tech, Blacksburg, VA

Anomaly detection aims to identify the true anomalies from a given set of data instances. Unsupervised anomaly detection algorithms are applied to an unlabeled dataset by producing a ranked list based on anomaly scores. Unfortunately, due to the inherent limitations, many of the top-ranked instances by unsupervised algorithms are not anomalies or not interesting from an application perspective, which leads to high false-positive rates. Active anomaly discovery (AAD) is proposed to overcome this deficiency, which sequentially selects instances to get the labeling information and incorporate it into the anomaly detection algorithm to improve the detection accuracy. However, labeling is often costly. Therefore, the way to balance detection accuracy and labeling cost is essential. Along this line, this paper proposes a novel AAD method to achieve the goal. Our approach is based on the state-of-the-art unsupervised anomaly detection algorithm, namely, Isolation Forest, as the baseline anomaly detector to extract features. Thereafter, the sparsity of the extracted features is utilized to adjust the anomaly detector so that it can focus on more important features for anomaly detection. To enforce the sparsity of the features and subsequent improvement of the detection accuracy, a new algorithm based on online gradient descent, namely, Sparse Approximated Linear Anomaly Discovery (SALAD), is proposed with its theoretical Regret analysis. Extensive experiments on both open-source and additive manufacturing datasets demonstrate that the proposed algorithm significantly outperforms the state-of-the-art algorithms for anomaly detection.

2 Federated Multi-output Gaussian Process

Seokhyun Chung, Raed Al Kontar, University of Michigan, Ann Arbor, MI, Contact: seokhc@umich.edu

Multi-output Gaussian process (MGP) regression plays an important role in the integrative analysis of different but interrelated systems/units. Existing MGP approaches assume that data from all units is collected and stored at a central location. This requires massive computing and storage power at the central location, induces significant communication traffic due to raw data exchange, and comprises privacy of units. However, recent advances in Internet of Things technologies, which have tremendously increased edge computing power, pose a significant opportunity to address such challenges. In this paper, we propose FedMGP, a general federated analytics (FA) framework to learn an MGP in a decentralized manner that utilizes edge computing power to distribute model learning efforts. Specifically, we propose a hierarchical modeling approach where an MGP is built upon shared global latent functions. We then develop a variational inference FA algorithm that overcomes the need to share raw data. Instead, collaborative learning is achieved by only sharing global latent function statistics. Comprehensive simulation and case studies highlight the superior predictive performance and versatility of FedMGP, achieved while distributing computing and storage demands, reducing communication burden, fostering privacy, and personalizing analysis.

3 Multi-source transfer learning through regularized multi-output Gaussian convolution process

Chao Wang, University of Iowa, Iowa City, IA

Multi-output Gaussian process (MGP) has been attracting increasing attention as a transfer learning method to model multiple outputs. Despite its high flexibility and generality, MGP still faces two critical challenges when applied to transfer learning: negative transfer and domain inconsistency. To tackle these critical challenges, we propose a regularized MGP modeling framework with domain adaptation.

Statistical properties of the proposed method are provided to guarantee the performance. Both simulation and real case studies demonstrate the effectiveness of our method in dealing with the two challenges.

4 Physics-informed statistical learning and prediction for nonlinear dynamical systems

Xinchao Liu[1], Xiao Liu[1], Tulin Kaman[1], Guang Lin[2], [1]University of Arkansas, Fayetteville, AR, [2]Purdue University, West Lafayette, IN, Contact: xl037@uark.edu

Nonlinear Dynamical Systems are widely found in an extremely wide spectrum of engineering and scientific applications. This work proposes a physics-informed statistical approach capable of (i) learning nonlinear system dynamics by utilizing experimental or observational data generated from a nonlinear system as well as the underlying governing physics, and (ii) predicting system dynamics with reasonable accuracy and a computational speed much faster than numerical methods. The proposed approach obtains the reduced-order model from the full-order governing equations. A function-to-function regression, based on multivariate Functional Principal Component Analysis, is proposed to establish the mapping between external forcing and system dynamics, while a multivariate Gaussian Process is used to capture the relationship between parameters and external forcing. In the application example, the proposed approach is applied to predict aircraft nose skin deformation after UAV (Unmanned Aerial Vehicle) collisions at different impact attitudes (i.e., pitch, yaw and roll degrees). It is shown that the proposed physics-informed statistical model can achieve a 12% out-of-sample mean relative error, and is more than 1,000 times faster than Finite Element Analysis (FEA). Computer code and sample data have been made available.

Monday, 11AM–12:15 PM

MB59

M - Marriott 6

Data Science for Cybersecurity in Industry 4.0

General Session

Session Chair

Akash Tiwari, College Station, TX

Session Chair

Satish Bukkapatnam, Texas A&M University, College Station, TX

Session Chair

Dan Li, Clemson University, Greenville, SC

1 Who Would Attack My 3D Printer?

Gary Pike, Auburn University, Auburn, AL

With the ever-increasing use of Additive Manufacturing (AM) in aerospace, automotive, and other sectors, it is critical to further our understanding of AM security. While numerous peer-reviewed publications investigate a variety of technical attack and defense measures of this manufacturing technology, the question remains, who would attack my 3D-printer? In this paper, we identify potential adversaries. For each adversary, we ascertain their motivations, capabilities, and potential for collusion.

2 Cybersecurity Assurance Techniques for Controllers in Metal Additive Manufacturing

Akash Tiwari[1], Satish Bukkapatnam[2], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: akash.tiwari@tamu.edu

Closed-loop process control in manufacturing require open access to the manufacturing controllers. Physical signatures captured by sensors attached to manufacturing machines are used to send control signals to the open manufacturing controller. Access to manufacturing controllers for closed-loop control opens up new attack surfaces in the cyber-domain making manufacturing machines vulnerable to cyberattacks. A novel statistical analysis procedure is develop making use of information from OPC communication protocol in the cyber-domain and sensor side-channels in the physical domain. The procedure is able to detect and mitigate attacks on manufacturing controllers for metal additive manufacturing process.

3 Minimal subset learning in federated smart manufacturing

Ridwan Olabiyi, Arizona State University, Tempe, AZ

We develop an approach for heterogeneous federated learning(HFL) in advanced manufacturing where heterogeneity at each local agent arisesfrom the process conditions, material properties, operators, and sensors. Weinvestigate the minimal information, referred to as sufficient statistics, andthe utility of local models required to update the HFL optimally.

Monday, 11AM–12:15 PM

MB60

M - Marriott 7

Advances in Machine Learning and Statistics for the Automotive Industry

General Session

Session Chair

Arman Sabbaghi, Purdue University, West Lafayette, IN

1 **Investigating Users' Preferences in Adaptive Driving Styles for Level 2 Driving Automation**

Zahra Sajedinia[1], Mia Dong[2], Vidya Krishnamoorthy[2], Gaojian Huang[1], Zhaobo Zheng[1], Teruhisa Misu[1], Kumar Akash[1], [1]Honda Research Institute, San Jose, CA, [2]San Jose State University, San Jose, CA, Contact: zsajedi@gmail.com

Users prefer different styles (more conservative or aggressive) for their autonomous vehicle (AV) to drive. Predicting a user's preferred driving style and takeover behavior is essential for an efficient and comfortable driving experience. In this research, we ran an experiment in which participants were asked to complete six automated drives and post-drive surveys in a virtual reality environment. First, we analyze the surveys to understand the effects of different automatic driving styles on users. Then, we propose linear and generalized linear mixed effect models for predicting the user's preference and takeover actions under different conditions. Our analysis suggests that trust, scenario, and pressing brakes play an important role in determining users' preferences and takeover actions.

2 **CARPAL: Confidence-Aware Intent Recognition for Parallel Autonomy**

Xin Huang[1], Stephen G. McGill[2], Jonathan A. DeCastro[2], Luke Fletcher[2], John J. Leonard[1], Brian C. Williams[1], Guy Rosman[2], [1]Massachusetts Institute of Technology, CAMBRIDGE, MA, [2]Toyota Research Institute, CAMBRIDGE, MA

Predicting driver intentions is a crucial task for advanced driver assistance systems. Traditional confidence measures on predictions often ignore the way predicted trajectories affect downstream decisions for safe driving. We propose a novel multi-task intent recognition neural network that predicts not only probabilistic driver trajectories, but also utility statistics associated with the predictions for a given downstream task. We further improve the robustness of our system by considering uncertainties in downstream planning tasks that may lead to unsafe decisions. We test our online system on a realistic urban driving dataset, and demonstrate its advantage in terms of recall and fall-out, and demonstrate its effectiveness in intervention and warning use cases.

Monday, 11AM–12:15 PM

MB61

M - Marriott 8

Grid Optimization GO Competition: Competitors

General Session

Session Chair

Richard Paul O'Neill, ARPA-E, Silver Spring, MD

1 **Open-source Tools for Solving Grid Optimization Problems**

Carleton Coffrin, Los Alamos National Laboratory, los Alamos, NM

Each iteration of the Grid Optimization (GO) Competition has pressed the boundary of what is possible for large scale nonlinear optimization methods. A key feature of each of these competitions is the "ARPA-e Benchmark" solver, which provides a baseline of solution quality for the competition problem and is also made available as open-source software after the conclusion of each competition. In this talk we report on lessons learned in developing the ARPA-e Benchmark algorithm. In particular we will highlight how confronting the challenging large scale optimization problems presented by the Grid Optimization Competition has spurred significant improvements in open-source tools for solving AC optimal power flow problems and large-scale nonlinear programs more broadly.

2 **Convex Relaxations and Integer Rounding Heuristics for The Grid Optimization Competition**

Hassan Lionel Hijazi, Los Alamos National Laboratory, Los Alamos, NM

In the MoM round of the GO Competition, there are no hardware, time, or algorithm constraints. More importantly, all the datasets are publicly available. New rules call for a new strategy. In this talk, we will go over the new approach used for this round including the use of convex relaxations and mixed-integer solvers.

3 **Solving Security-constrained Acopf Problems in The Go2 Competition**

Daniel Bienstock[1], Richard Waltz[2], Bo Yang[1], [1]Columbia University, New York, NY, [2]Artelys, Los Angeles, CA

The security-constrained ACOPF problem is a nonlinear, nonconvex problem with integer variables arising in the operation of power grids. The GO competition introduced a comprehensive formulation and very large, realistic, or real-life instances. We describe our approach which relied on dimensionality reduction and the Knitro nonlinear programming solver, which placed no. 2 in the competition.

4 GO-SNIP Decomposition and Contingency Selection Strategies for GO Competition Challenge 2

Frank E. Curtis[1], Ermin Wei[2], [1]Lehigh University, Bethlehem, PA, [2]Northwestern University, Evansto, IL

We present the decomposition, contingency selection, and other strategies employed by our team, GO-SNIP, for the GO Competition, Challenge 2. We describe our experiences handling the discrete decisions in the problem formulation, focusing on which aspects of the formulation had a more significant impact on solution quality and which had little effect. We present the results of numerical experiments beyond those used in the competition itself.

Monday, 11AM–12:15 PM

MB62

M - Marriott 9

Climate Change Adaptation of the Electric Grid

General Session

Session Chair

Line Roald, University of Wisconsin - Madison, Madison, WI

1 Optimizing Operations of Networked Microgrids in Response to Severe Contingencies

David M. Fobes, Russell Bent, Harsha Nagarajan, Los Alamos National Laboratory, Los Alamos, NM

Over the past few decades, an increasing number of extreme weather events have had significant impacts on the electric grid [1]. In response, microgrids have become an important part of the conversation with regards to increasing the resilience and reliability of the grid due to their inherent flexibility and autonomous capabilities, but open-source tools to analyze their capabilities are still in their infancy. In this talk we will introduce PowerModelsONM.jl, a new library for optimizing the operations of microgrids and analyzing the benefits of a variety of operational constraints, such as microgrid networking, enforced radiality, etc., in various situations, like the types of extreme contingencies that might arise in response to climate change. [1] V. Acovino, "The Biggest Problem Facing the U.S. Electric Grid Isn't Demand. It's Climate Change." *NPR*, 24 Nov. 2021.

2 Improving Power Grid Resiliency with Bi-objective Stochastic Integer Optimization

Ramsey Rossmann, University of Wisconsin–Madison, MADISON, WI, Contact: rossmann2@wisc.edu

Designing a power grid that is both efficient on average and resilient to extreme weather events is a critical challenge. Traditional stochastic programming approaches to this are highly sensitive to sampling error due to the presence of low probability events with very high impacts. Stochastic programming also fails to account for system goals changing under extreme conditions. For example, when the power grid faces extreme weather the goal shifts to minimizing load shed, with little concern for cost. We present a bi-objective modeling approach that addresses these issues and illustrate it in the context of capacity planning in the electric grid. By having an objective that explicitly focuses on load shed in extreme temperature scenarios, we achieve better solutions with smaller sample sizes. We also show the importance of spatial correlation in temperature samples.

3 Computational Methods for Optimizing The Mitigation of Wildfire Ignition Risk for Electric Power Networks

Alyssa Kody[1], Daniel Molzahn[2], [1]Argonne National Laboratory, Lemont, IL, [2]Georgia Institute of Technology, Ann Arbor, MI

As future climate conditions are predicted to be more conducive to wildfires, ignition prevention is increasingly crucial. In the western United States, some of the most destructive wildfires has been ignited via electric power systems. To reduce the risk of ignition in the short-term, power system operators temporarily de-energize high-risk lines during "Public Safety Power Shutoff" events. In the long-term, utilities are investing in infrastructure to reduce ignition risks (e.g., undergrounding lines and installing distributed energy resources to lessen the impacts of line de-energizations). The associated operation and planning optimization problems are challenging large-scale mixed-integer programs. We assess various problem formulations and solution algorithms with the aim of improving computational tractability while achieving accurate results.

4 Managing Power Systems-Induced Wildfire Risks Using Optimal Scheduled Shutoffs

Ahmed Zamzam[1], Bai Cui[2], Ayla Astudillo[1], [1]National Renewable Energy Laboratory, Golden, CO, [2]National Renewable Energy Laboratory, Lisle, IL, Contact: ahmed.zamzam@nrel.gov

The increasing demands for electricity and the increase in extreme weather events are putting unprecedented pressure on our electric grids leading to component failures, which might ignite wildfires. This talk focuses on balancing the reliability of power networks and the risk of wildfire ignition by optimizing the operational schedule of transmission networks considering time-varying risk measures including exogenous and operational factors. Energy storage systems are considered to deliver power during peak wildfire hours and enable temporal load shifting. A mixed-integer linear program is formulated that maximizes a weighted sum of the served power demand and the reduction in grid-induced wildfire risk. The results demonstrate the ability of optimized energy storage operations to significantly reduce wildfire risk without considerable load shedding.

Monday, 11AM–12:15 PM

MB63

M - Marriott 10

Optimization for Sustainable Chemical and Energy Systems II

General Session

Session Chair

Jaffer Ghouse, 1</sup

Session Chair

Alexander Dowling, University of Notre Dame, Notre Dame, IN

1 Generalized Disjunctive Programming in IDAES Framework: Conceptual Design of Ultra-Supercritical Power Plant Integrated with Thermal Energy Storage

Soraya Rawlings[1], Naresh Susarla[2], Jaffer H. Ghouse[2], John Siirola[3], David Miller[2], [1]Sandia National Laboratories, Livermore, CA, [2]National Energy Technology Laboratory, Pittsburgh, PA, [3]Sandia National Laboratories, Albuquerque, NM

In this work, we demonstrate the use of Generalized Disjunctive Programming using rigorous models from IDAES for the solution of conceptual design problems applied to advanced energy systems. In this study, we develop two superstructure models of an ultra-supercritical power plant integrated with a thermal energy storage (TES) system during charge and discharge operation modes. We solve the two superstructures to determine the optimal storage equipment size, operating conditions, and selection of process stream connections within the TES and the power plant, while minimizing the total cost of the integrated system. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525.

2 A Complementarity-based Vapor-liquid Equilibrium Formulation for Equation-oriented Simulation and Optimization

Vibhav Dabadghao[1], Jaffer H. Ghouse[2], Lorenz T. Biegler[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]National Energy Technology Laboratory, Pittsburgh, PA, Contact: vdabadgh@andrew.cmu.edu

We present a novel equation-oriented formulation for single-stage flash which uses smooth approximations of complementarities to handle phase-changes systematically. Moreover, the formulation leverages properties of derivatives of the cubic equation of state to identify the appropriate phase. A performance comparison reveals significant improvements in tractability and speed over previous works. We embed the proposed formulation into a tray distillation column and demonstrate its optimization for an air separation mixture. Specifically, the reboiler duty is minimized while ensuring that purity constraints for the top and bottom products are satisfied. To demonstrate the handling of missing phases, we present several case studies with differing minimum purity specifications for the top and bottom products.

3 Nonlinear Reactor Design Optimization with Embedded Microkinetic Information

Kanishka Ghosh, Alexander Dowling, University of Notre Dame, Notre Dame, IN, Contact: kghosh@nd.edu

In this work, we demonstrate tractable reduced-order kinetic (ROK) modeling approaches for catalytic oligomerization in shale gas processing. We assemble a library of candidate ROK models and find that quality of fit, thermodynamic consistency, and model identifiability are all key metrics to train and select ROK models. Using a subset of the best ROK models, we optimize the temperatures in staged packed bed reactors to maximize conversions to heavier alkenes. We find that optimal temperature profiles are qualitatively consistent across ROK models. Through first-order uncertainty propagation, we find that parametric uncertainty induces less than a 10% deviation in the optimization objective compared to a 22% difference induced by ROK model choice. This highlights the importance of quantifying model-form uncertainty in multiscale reactor design and optimization.

4 Optimal Design Formulations for Families of Similar Processes with Applications in Energy Systems

Georgia Stinchfield[1], Carl Laird[2], John Siirola[3], Miguel

Zamarripa[4], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Fayetteville, AR, [3]Sandia National Laboratories, Albuquerque, NM, [4]NETL, Pittsburgh, PA

Rapid, cost-effective deployment of green-energy and carbon capture systems is important for curbing carbon emissions. Applied to carbon capture from energy systems, we seek to design a family of similar processes to cover the range of design characteristics (flue gas feed properties, CO2 capture percentage, etc.). We optimize a process family by designing a subset of unit operations to manufacture and use across the design range, exploiting opportunities for shared components, taking advantage of economies of learning and numbers, reducing up-front design costs, and enabling more rapid manufacturing and deployment.

Monday, 11AM–12:15 PM

MB64

M - Indiana A

Matchmaking in Two-sided Marketplaces

General Session

Session Chair

Peng Shi, University of Southern California, Los Angeles, CA

Session Chair

Musa Eren Celdir, Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA

1 **Two-sided Assortment Optimization] {two-sided Assortment Optimization with Simultaneous and Sequential Matches**

Ignacio Rios[1], Alfredo Torrico[2], Victor Verdugo[3], [1]The University of Texas at Dallas, Richardson, TX, [2]Polytechnique Montreal, Montreal, QC, Canada; [3]Universidad de O'Higgins, Rancagua, Chile. Contact: ignacio.rios.u@gmail.com

We study the two-sided assortment problem recently introduced by Rios et al. (2021). A platform must choose an assortment of profiles to show each user on each side of the market in each period. Users can either like/dislike as many profiles as they want, and a match occurs if two users see and like each other, potentially in different periods. The platform's goal is to maximize the expected number of matches generated. We provide algorithms and performance guarantees for different variants of the problem. We show that if matches can only be formed sequentially, there is an approximation guarantee of \(1-1/e\). For the case where simultaneous matches are allowed, we provide a constant factor approximation. Finally, we numerically show that allowing simultaneous matches leads to a higher number of matches, but the improvement is small relative to the case with sequential matches.

2 **Learning Equilibria in Matching Markets from Bandit Feedback**

Meena Jagadeesan[1], Alexander Wei[1], Yixin Wang[2], Michael I. Jordan[1], Jacob Steinhardt[1], [1]UC Berkeley, Berkeley, CA, [2]University of Michigan, Ann Arbor, MI, Contact: awei@berkeley.edu

Large-scale, two-sided matching platforms aim to align market outcomes with user preferences while learning these preferences from data. But since preferences are inherently uncertain during learning, the classical notion of stability is unattainable. To bridge this gap, we develop a framework and algorithms for learning stable market outcomes under uncertainty. For matching with transferable utilities, we design an incentive-aware learning objective to capture the distance of a market outcome from equilibrium. We then analyze the complexity of learning in terms of preference structure, casting learning as a bandit problem. We show the optimism principle applies to a primal-dual formulation of matching with transfers and yields near-optimal regret bounds. Our work takes a first step toward elucidating when and how stability can arise in data-driven marketplaces.

3 **Popularity Bias in Online Dating Platforms: Theory and Empirical Evidence**

Musa Eren Celdir[1], Soo-Haeng Cho[2], Elina Hwang[3], [1]Carnegie Mellon University, Tepper School of Business, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]University of Washington-Foster School of Business, Seattle, WA, Contact: mceldir@andrew.cmu.edu

Motivated by the empirical evidence from a major online dating platform, we study the incentives for an online dating platform to adopt recommendation algorithms favoring popular users and examine whether removing such popularity bias in recommendations would improve match outcomes. We model the platform's recommendations and users' subsequent interactions with a three-stage matching game and build a predictive model that estimates users' behavior to validate our results. We find that the recommendations that maximize the platform's revenue and those that maximize the number of successful matches are not necessarily at odds, even though the former leads to a higher bias against unpopular users. Unbiased recommendations result in significantly lower revenue and fewer matches when users' implicit cost of evaluating incoming messages is low.

Monday, 11AM–12:15 PM

MB65

M - Indiana B

Data-driven Market Design

General Session

Session Chair

Aleksandrs Smilgins, Denmark.

1 Treasury Auction Format

Aleksandrs Smilgins[1], Saša Pekeč[2], [1]Copenhagen Business School, Frederiksberg, Denmark; [2]Duke University, Durham, NC, Contact: asm.eco@cbs.dk

The choice of auction format for government bond auctions varies by country, with uniform or discriminatory sealed-bid auctions with preapproved bidders (Primary Dealers) being the most prevalent. We compare performance of Danish and Swedish government bond auctions, and how it relates to the auction pricing rule: Denmark uses uniform pricing, while Sweden uses discriminatory pricing. Additionally, we develop models to estimate and predict the distribution of the auction price(s) in these auctions.

2 Market Design for Combinatorial Financial Contracts

Xintong Wang[1], David M. Pennock[2], Nikhil Devanur[3], David Rothschild[4], Michael Wellman[5], [1]Harvard University, Cambridge, MA, [2]Rutgers University, Plainsboro, NJ, [3]Microsoft Research, Redmond, VA, [4]Microsoft Research, New York City, NY, [5]University of Michigan, Ann Arbor, MI, Contact: xintongw@seas.harvard.edu

Standard financial exchanges operate separate, independent continuous double auctions to trade contracts of different features, even for those related to the same underlying variable (e.g., financial options written on the same asset but with different strikes). Such independent design can introduce arbitrage opportunities and lead to the thin market problem. We take options and prediction markets as examples, and design computationally efficient mechanisms that consolidate logically related markets. We then generalize to *combinatorial options markets* that enable agents to express belief about future correlations among variables. We discuss the complexity of clearing such markets and propose a constraint generation algorithm to find the optimal clearing. Empirical analysis on options data demonstrates the improved market efficiency of our proposed designs.

3 Computing Bayes Nash Equilibrium Strategies in Auction Games Via Gradient Dynamics

Maximilian Fichtl[1], Matthais Oberlechner[2], Martin Bichler[3], [1]Technical University of Munich, matthias.oberlechner@tum.de, Germany; [2]Technical University of Munich, Garching b. München, Germany; [3]Technical University of Munich, Garching B. München, Germany. Contact: max.fichtl@tum.de

We introduce algorithms for computing distributional strategies in auction games by applying methods from online convex optimization to a discretized version of the games. One advantage of distributional strategies is that the expected utility of agents becomes linear in their strategies. This makes it possible to draw on results from the literature on online learning - in particular, if our algorithm converges, it necessarily converges to a Bayes Nash equilibrium of the discrete game. Importantly, we prove estimates on the loss observed by the agents when they play the computed strategies in the original continuous game. In a large number of experiments, we provide empirical evidence that our method approximates analytical Bayes Nash equilibria closely in a wide variety of auction games, often within a few minutes, or even seconds when agents are symmetric.

4 Data-Driven Contract Design

Justin Burkett, Georgia Institute of Technology, Atlanta, GA

We propose a prior-free model of moral hazard wherein the principal's beliefs about the agent's production technology are characterized by revealed preference data. Prior to contracting with the risk-neutral agent, the risk-neutral principal observes the outcome of a finite number of experiments, each of which consists of a contract and the distribution of output associated with the agent's best response to that contract (effort cost is unobserved). She views any technology that rationalizes this data as plausible, and evaluates contracts according to their guaranteed expected payoff against the set of rationalizable technologies. In this environment, robustly optimal contracts augment the contracts in the experimental data with equity payments. We make no assumptions about the agent's technology beyond rationalizability of the revealed preference data.

Monday, 11AM–12:15 PM

MB66

M - Indiana C

Electric Charging Stations Management

General Session

Session Chair
Luce Brotcorne, INRIA, Villeneuve-D'ascq, France.

1 Optimal Location Determination of Electric Vehicle Charging Stations: A Case Study on Highways in Turkey

Ibrahim Tumay Gulbahar, Abdullah Gul University, Kayseri, Turkey. Contact: ibrahim.gulbahar@agu.edu.tr

Increase in the use of electric vehicles (EV) has supported the development of necessary infrastructure and by-products, especially EV charging stations. The main purpose is to determine the possible charging station locations of EVs that can be established in the short and medium term. To achieve the main purpose, the number of electric vehicles that will hit the roads by 2030 is forecasted. After that, optimum location determination has been done for the installation of EV charging stations by mathematical modeling approaches. Accordingly to traffic density, potential charging station locations are determined by the given mathematical model. The study is conducted on the most popular highways in Turkey. The reason behind this is although the inner-city usage is more than the intercity usage, the charging process becomes an issue on the intercity drives.

2 Optimal Location of Charging Stations for Electric Delivery Trucks for The Utilization of Renewable Energy

Kazuki Ueda[1], Hiroshi Morita[2], [1]OSAKA UNIVERCITY, SUITA, Japan; [2]Osaka University, Suita, Osaka, Japan. Contact: morita@ist.osaka-u.ac.jp

Various studies have been conducted on electric vehicle routing problems. In most of them, delivery routes have been considered focusing on the cruising range of electric vehicles. In recent years, with the spread of solar power generation, the market price of electricity during the daytime is lower than that during the nighttime, and a delivery plan that effectively utilizes electricity and minimizes charging costs is needed to cope with this situation. In this paper, we examine the optimal arrangement of charging stations to realize such delivery.

3 Electric Vehicle Charger Placement Optimization for Intercity and Tourism Trips Considering a Mixed Infrastructure of Level 2 and Dc Fast Chargers

Amirali Soltanpour[1], Mohammadreza Kavianipour[1], Alireza Rostami[1], Cara Bonshak[1], Mehrnaz Ghamami[2], Ali Zockaie[1], Robert Jackson[3], [1]Michigan State University, East Lansing, MI, [2]Michigan State University, Okemos, MI, [3]Michigan Department of Environment, Great Lakes, and Energy, Lansing, MI, Contact: soltanpo@msu.edu

Electric vehicles (EV) are a sustainable substitution for conventional vehicles reducing emissions and fossil fuel dependence. However, alleviating EV's range anxiety requires significant investment in infrastructure. This study proposes an integrated modeling framework to find the optimal location and number of chargers in a combined infrastructure of level 2 and DC fast chargers in an intercity network around Lake Michigan. The main contribution of this study is capturing the variety of travel and charging behaviors and their interconnections. The model minimizes total system costs, including charger, queuing, and detour costs. A metaheuristic algorithm is developed to solve the proposed computationally complex optimization model.

Monday, 11AM–12:15 PM

MB67

M - Indiana D
Innovation and Algorithm Advances in Online Marketplace
General Session

Session Chair
Max Shen, CA

Session Chair
Mengxin Wang, University of California-Berkeley, Albany, CA

1 Multi-Objective Assortment Optimization

Zhen Chen[1], Heng Zhang[2], Hongmin Li[1], Scott Webster[1], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, AZ, Contact: hengzhang24@asu.edu

We study assortment optimization where the objective function is a linear combination of several terms. Each term takes the form of a convex function of a sum weighted by purchase probabilities, which are governed by certain choice models. This generic form includes many objectives that can be of practical interest such as revenue, market share, risk, utility (when the choice model belongs to the generalized extreme value family), and concave costs, etc. We show that despite the non-linearity of the assortment optimization problem, one can recast it into a single purchase-probability-weighted sum of pseudo revenues, where the pseudo revenue of an item depend on the original terms in the multi-

objective assortment problem and the optimal assortment. This reformulation allows us to design efficient algorithms to solve the multi-objective assortment optimization problem.

2 A Customer Choice Model of Impulse Buying in Social Commerce

Yuan Guo, Fernando Bernstein, Duke University, Durham, NC, Contact: yuan.guo1@duke.edu

Social commerce integrates user interactions and user-generated content with commercial activities in social media platforms. A social media user's on-site purchase decision involves a transformation of the mindset from "social" to "shopping" stimulated by the impulse to buy upon seeing. We propose a novel choice model that captures users' impulsive behavior and limited attention while browsing products in social media platforms. We consider a seller's product display problem on a product page and examine two strategies to sell through social media: "shop now" and "buy now". We characterize the optimal display set and selling strategy based on the impact of impulsiveness on product preferences and on the pattern of attention decay. We also explore how social commerce can leverage influencers.

3 Multi-item Online Order Fulfillment in a Two-layer Network

Yanyang Zhao[1], Linwei Xin[2], Xinshang Wang[3], [1]University of Chicago Booth School of Business, Chicago, IL, [2]University of Chicago, Chicago, IL, [3]Alibaba Inc, Rotterdam, Contact: alexzhao@chicagobooth.edu

Today, while e-retailers are building more warehouses to offer faster delivery service than ever, the associated fulfillment costs have skyrocketed over the past decade. We study the problem of minimizing fulfillment costs, in which an e-retailer must decide in real-time which warehouse(s) will fulfill each order, subject to warehouses' inventory constraints. We focus on an RDC-FDC distribution network that major e-retailers have implemented in practice. We analyze the performance of a simple myopic policy, which chooses the least expensive fulfillment option for each order. We provide theoretical bounds on the performance ratio of the myopic policy compared with an optimal policy. Moreover, we extend our study to the setting in which demand forecasting is available and prove the asymptotic optimality of a LP rounding policy.

4 Content Promotion for Online Content Platforms with The Diffusion Effect

yunduan Lin[1], Mengxin Wang[2], Zuo-Jun Max Shen[3], Heng Zhang[4], Renyu (Philip) Zhang[5], [1]UC Berkeley, Berkeley, CA, [2]University of California-Berkeley, Albany, CA, [3]University of California Berkeley, Berkeley, CA, [4]Arizona State University, Tempe, AZ, [5]The Chinese University of Hong Kong, Hong Kong, China. Contact: yunduan_lin@berkeley.edu

Content promotion policies are playing an increasingly important role in improving content consumption and user engagement for online content platforms. However, a frequently used promotion policy generally neglects employing the diffusion effect within a crowd of users. In this paper, we study the candidate generation and promotion optimization problem for online content through incorporating the diffusion effect. We also investigate ways to use the content adoption data to estimate the diffusion effect and to optimize the content promotion decision. We not only highlight the essential differences between the diffusion of online content and that of physical products but also provide actionable insights for online content platforms to substantially improve the effectiveness of a content promotion policy by leveraging our diffusion model.

Monday, 11AM–12:15 PM

MB68

M - Indiana E

Design and Operation of Ridesharing Platforms

General Session

Session Chair

Hongyao Ma, Columbia University, New York, NY

Session Chair

Francisco Castro, 1988, New York, NY

1 Electric Vehicle Capacity Planning

Francisco Castro[1], Sushil Varma[2], Siva Theja Maguluri[3], [1]UCLA Anderson School of Management, Los Angeles, CA, [2]Georgia Institute of Technology, Atlanta, GA, [3]ISyE Georgia Tech, Atlanta, GA

We study the optimal EV fleet sizing problem in a spatial, stochastic setting and quantify the trade-off between the percentage of dropped demand, fleet size, battery capacity, and the density of charging stations. The system operator can choose to dispatch an EV to meet incoming demand, but he can also send EVs to charging stations. The objective is to maximize the long-run fraction of met demand. We develop a two-sided queueing system that captures the key features of the more complex spatial system: spatial friction, charging and discharging of EVs, and stochastic customer arrivals. We establish a staffing scaling that is unique to the spatial EV dynamics. Compared to standard spatial staffing scalings, ours has a higher nominal term, but its buffer can vary between 1/2 and 2/3 depending on the vehicles' battery pack, charger density, and the discharge/charge rate ratio.

2 Presenter
Chenkai Yu, 1</sup

3 Presenter
Hongyao Ma, Columbia University, New York, NY

4 Presenter
J Massey Cashore, Cornell, Ithaca, NY

Monday, 11AM–12:15 PM

MB69

M - Indiana F

Recent Developments in Platforms and Learning

General Session

Session Chair
Jiding Zhang, 1</sup

1 Equilibrium Analysis for Ridesharing and Ride-hailing Platforms in a Coupled Morning-evening Commute Framework

Wei Gu[1], Maged Dessouky[1], Jong-Shi Pang[1], Michael Zhang[2], [1]University of Southern California, Los Angeles, CA, [2]University of California, Davis, Davis, CA, Contact: weig@usc.edu

In this study, we develop a general equilibrium model to capture the influence of the emerging ridesharing and ride-hailing platforms on traffic congestion and travelers' choice behavior in a coupled morning-evening commute. Drivers can pick up or drop off passengers en route, and passengers are allowed to switch between ridesharing and ride-hailing services. The model is formulated as a mixed complementarity problem. Then the existence of an equilibrium solution is investigated, and we provide conditions on the model parameters under which the equilibrium will be unique. The proposed model is validated with numerical experiments.

2 Risk-Aware Linear Bandits: Theory and Applications in Smart Order Routing

Jingwei Ji[1], Renyuan Xu[2], Ruihao Zhu[3], [1]University of Southern California, LA, CA, [2]University of Southern California, Los Angeles, CA, [3]Purdue Krannert School of Management, Chicago, IL, Contact: jingweij@usc.edu

Motivated by practical considerations in machine learning for financial decision-making, such as risk-aversion and large action space, we initiate the study of risk-aware linear bandits. Specifically, we consider regret minimization under the mean-variance measure when facing actions whose rewards can be expressed as linear functions of unknown parameters. Driven by the variance-minimizing G-optimal design, we propose the Risk-Aware Explore-then-Commit (RISE) algorithm and the Risk-Aware Successive Elimination (RISE++) algorithm. Then, we rigorously analyze their regret upper bounds to show that, by leveraging the linear structure, the algorithms can dramatically reduce the regret when compared to existing methods. Finally, we demonstrate the performance of the algorithms by conducting numerical experiments in a synthetic smart order routing setup.

3 Dynamic Pricing and Toll Charging for Carpooling Platforms in High-occupancy Toll Lane Systems

Hang Gao[1], Wei Gu[2], Michael Zhang[1], Maged M. Dessouky[2], [1]University of California-Davis, Davis, CA, [2]University of Southern California, Los Angeles, CA, Contact: hangao@ucdavis.edu

High-occupancy toll (HOT) lanes, as high-occupancy vehicle (HOV) lanes that permit solo drivers to use them with a charge, play an important role in reducing congestion in the morning commute. In this study, we formulate the morning commute problem with mixed traffic flows on HOT lanes as Linear Complementary Systems (LCS). Analytical model is then developed to set the dynamic prices for carpooling platforms and dynamic toll charges on HOT lanes to avoid queueing. Based on the data from the Caltrans Performance Measurement System (PeMS), the proposed LCS model and analytical model are validated in case studies.

Monday, 11AM–12:15 PM

MB70

M - Indiana G

Advancing Machine Learning with Modern Optimization Methods

General Session

Session Chair
Leonard Boussioux, MIT, Cambridge, MA

Session Chair
Vassilis Digalakis, Massachusetts Institute of Technology, CAMBRIDGE, MA

1 **Neural Networks for Complete Sensitivity Analysis of a Family of Combinatorial Optimization Problems**

Tyler Perini[1], M. Can Camur[1], Joey Huchette[2], Andrew J. Schaefer[1], [1]Rice University, Houston, TX, [2]Rice University, Mountain View, CA, Contact: tyler.perini@rice.edu

Practically efficient methods for computing dual bounds can determine the success of standard optimization algorithms. Network problems, such as minimum spanning tree and max flow/min cut, are a structural bridge between linear programs and integer programs. Our work explores how deep learning can be used to learn dual bounds for network problems. Our methods are based on (partially- and fully-) convex NNs; we also explore the limitations of such an approach. Preliminary results indicate that this approach may generalize to other network problem classes, and we close with a discussion of future directions.

2 **Post-Processing Tree Ensembles**

Brian Liu, Massachusetts Institute of Technology, Cambridge, MA

Tree ensembles combine many decision trees into a stronger model; a model that can grow to be very large. The number of nodes in a decision tree increases exponentially with tree-depth and ensembles can consist of thousands of deep trees. Post-processing tree ensembles to a more parsimonious form can greatly improve memory footprint and interpretability. We develop ForestPrune a post-processing framework that removes redundant depth layers from tree ensembles. The algorithm is highly scalable and can compactify ensembles 10-fold with marginal performance loss.
ForestPrune sweeps through each tree in an ensemble and trims the depth of the tree according to a regularized optimization criterion. The framework is flexible and can adopt regularization penalties to encourage node sparsity, feature sparsity, or shape constraints on the post-processed ensemble.

3 **A Robust Optimization Approach to Deep Learning**

Kimberly Villalobos Carballo[1], Dimitris Bertsimas[2], Dick den Hertog[3], Xavier Boix[4], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]University of Amsterdam, Amsterdam, Netherlands; [4]Massachusetts Institute of Technology, Cambridge, MA, Contact: kimvc@mit.edu

Many state-of-the-art adversarial training methods leverage upper bounds of the adversarial loss to provide security guarantees. Yet, these methods require computations at each training step that cannot be incorporated in the gradient for backpropagation. We introduce a more principled approach to adversarial training based on a closed form solution of an upper bound of the adversarial loss, which is facilitated by modern tools from robust optimization. We derive two new methods with our approach. The first one (aRUB) obtains an approximate upper bound of the adversarial loss, while the second one (RUB) computes an exact upper bound of the adversarial loss. Across multiple datasets we demonstrate the effectiveness of our approach -- RUB is more robust than state-of-the-art methods for larger perturbations, while aRUB matches their performance for small perturbations.

Monday, 11AM–12:15 PM

MB71

M - Arizona
Computational Methods
General Session

Session Chair

David L. Woodruff, University of California-Davis, Davis, CA

1 **An Introduction to Mpi-sspy and Recent Updates**

David L. Woodruff, University of California-Davis, Davis, CA

The mpi-sppy software library is intended to support finding bounds and solutions to a class of optimization problems with uncertainty. In this talk we will describe the architecture and discuss some recent developments with particular attention paid to confidence intervals. The python library is available for download from the github site: https://github.com/Pyomo/mpi-sppy

2 **Presenter**

Jean-Paul Watson, Lawrence Livermore National Laboratory

3 **Diagnosis and Explanation of Ill Conditioned Basis Matrices**

Ed Klotz, Gurobi Optimization, Incline Village, NV, Contact: klotz@gurobi.com

Ill conditioning in LP and MIP models remains a challenge for optimization practitioners. Several LP and MIP solvers offer functionality that provides explanations of infeasibility, but so far none have offered similar functionality to provide concise explanations of infeasibility. In this talk we will describe a method based on the reciprocal relationship between ill conditioning and distance to singularity of a matrix to derive a certificate of ill conditioning. The certificate can then be used to filter out rows or columns of the matrix, resulting in a focused explanation of the cause of the ill conditioning. We will show results with this method on some models drawn from practical sources.

4 Redistricting with Optimization

Robert Ashford, Optimization Direct, Inc., Harrington Park, NJ

The US Census Bureau conducts a full census of all states in the USA every ten years. By law the data collected must be used to redistrict each state for the election of representatives to the US Congress, State Senate and House and City wards. This is an expensive and politically fraught process often involving significant litigation. Optimization has been proposed as a tool in this process, but the MIP models are too difficult to formulate and too hard to solve to have been used before. We describe new model formulations and solution strategies with our ODH|CPLEX optimizer. We show the results of their use in Virginia, Michigan and Arkansas. We further describe their use in redistricting the City of Pine Bluff and practical issues that need to be considered.

Monday, 11AM–12:15 PM

MB72

M - California

Best Student Paper Award in Social Media Analytics

Award Session

Session Chair

Wenqi Shen, Virginia Tech, Blacksburg, VA

Fair Assortment Planning

Qinyi Chen, Negin Golrezaei, Fransisca Susan, Edy Baskoro, MIT, Cambridge, MA

Many online platforms, such as social media sites, employ algorithms that feature items (contents) with the highest popularity, while offering too little visibility to the rest of the items. In this work, we study a fair assortment planning problem, where any two items with similar merits receive similar visibility. We propose a framework to find near-optimal solutions to this problem, using the Ellipsoid method and a separation oracle to its dual. We then develop two approximate separation oracles, resulting in a 1/2-approx. algorithm and an FPTAS for our problem. Finally, we conduct a case study on the MovieLens dataset, demonstrating the efficacy of our algorithms.

Online Review Censorship

Aida Sanatizadeh[1], Yuheng Hu[1], Gordon Burtch[2], Kevin Hong[3], [1]University of Illinois at Chicago, Chicago, IL, [2]Boston University, Boston, MA, [3]University of Miami, Miami, FL

Ample anecdotal evidence in the media notes that many businesses seek to ‘silence’ negative reviews, e.g., via legal threat. Despite attention toward this issue, we are aware of no systematic analyses addressing it. We address that gap here, leveraging review data from TripAdvisor.com. First, we estimate that ~1% of truthful reviews are deleted within 6 months of posting, and that negative reviews are significantly more likely to be deleted, consistent with a mechanism of censorship. The effect is substantial; we estimate that a 1-star decrease in rating valence is associated with an approximate 25% (0.25 pp) increase in the probability of deletion. Second, we examine how freedom of expression (FoE) in a country associate with characteristics of (uncensored) online reviews. We find that FoE associates with larger review volumes, lower review valence, and faster review posting. We discuss implications for online ratings platforms, consumers, and research opportunities.

How Do Pictures Shape Our “Liking”? a Perspective from Stimulus-Organism-Response Model

Xinyao Wang[1], Yifan Yu[2], Jinghua Huang[1], Yong Tan[2], [1]Tsinghua University, Beijing, China; [2]University of Washington, Seattle, WA

Despite the massive amount of pictures embedded in online content, how pictures affect people’s liking remains understudied. Using the Stimulus-Organism-Response (SOR) model, the current work explores this question in the context of the catering industry. Using data from dianping.com, one of the largest online review platforms in China, we combine manual tagging and machine learning approaches to measure picture-evoked affective and cognitive states. Leveraging a hierarchical generalized linear model, we find that the domain-related and visual aesthetics features of pictures significantly affect valence, arousal, and perceived calorie content, further influencing liking behavior.

Content Promotion for Online Content Platforms with the Diffusion Effect

yunduan Lin[1], Mengxin Wang[1], Zuo-Jun Max Shen[1], Heng

Zhang[2], Renyu Zhang[3], Renyu Zhang[3], [1]UC Berkeley, Albany, CA, [2]Arizona State University, Tempe, AZ, [3]The Chinese University of Hong Kong, Hong Kong, Hong Kong.

Content promotion policies are playing an important role in improving content consumption for online content platforms. However, a frequently used promotion policy generally neglects employing the diffusion effect within users. We study the candidate generation and promotion optimization problem for online content through incorporating the diffusion effect. We also investigate ways to use the adoption data to estimate the diffusion effect. We not only highlight the differences of diffusion between online content and physical goods but also provide actionable insights for platforms to improve the effectiveness of content promotion policy by leveraging our diffusion model.

Monday, 11AM–12:15 PM

MB73

M - Colorado

Marketplace Operations and Analytics

General Session

Session Chair

Wenchang Zhang, 1</sup

1 Labor Cost Free-riding in The Gig Economy

Zhen Lian, Cornell University, NEW YORK, NY

We propose a theory of gig economies in which workers participate in a shared labor pool utilized by multiple firms. Since firms share the same pool of workers, they face a trade-off in setting pay rates; high pay rates are necessary to maintain a large worker pool and thus reduce the likelihood of lost demand, but they also lower a firm's profit margin. We prove that larger firms pay more than smaller firms in the resulting pay equilibrium.

2 Dynamic Relocations in Carsharing Networks

Mahsa Hosseini[1], Gonzalo Romero[2], Joseph Milner[1], [1]University of Toronto, Toronto, ON, Canada; [2]Rotman, University of Toronto, Toronto, ON, Canada. Contact: mahsa.hosseini@rotman.utoronto.ca

We propose a novel dynamic car relocation policy for a carsharing network. The policy is derived from a reformulation of the LP fluid model approximation of the dynamic problem. We project the full-dimensional fluid approximation onto the lower-dimensional space of relocation decisions only. The reformulation uncovers structural properties that are interpretable using absorbing Markov chain concepts and allows us to write the gradient of the relocation decisions in closed form. Our policy exploits these gradients to make dynamic car relocation decisions. We provide extensive numerical results on hundreds of random networks where our policy outperforms the standard static policy by more than 23% on average. Moreover, in the time-varying setting, our policy provides a percentual improvement over the static policy of over 3% on average.

3 Courier Dispatch in On-demand Delivery

Mingliu Chen[1], Ming Hu[2], [1]Columbia University, New York, NY, [2]University of Toronto, Minneapolis, MN, Contact: mc5006@columbia.edu

We study a courier dispatching problem in an on-demand delivery system where customers are sensitive to delay. Specifically, we evaluate the effect of temporal pooling by comparing systems using the dedicated strategy, where only one order is delivered per trip, vs. the pooling strategy, where a batch of consecutive orders is delivered on each trip. We capture the courier delivery system's spatial dimension by assuming that following a Poisson process, demand arises at a uniformly generated point within a service region, as a generalization of the circular city model. With the same objective of revenue maximization, we find that the dispatching strategy depends critically on customers' patience level, the size of the service region, and whether the firm can endogenize the demand.

4 Managing Traffic Safety for a Meal Delivery Platform: Penalizing The Platform or Its Independent Contractor Drivers?

Wenchang Zhang[1], Christopher S. Tang[2], liu ming[3], Yue Cheng[4], [1]Kelley School of Business, Indiana University, Bloomington, IN, [2]University of California-Los Angeles, Los Angeles, CA, [3]Chinese University of Hong Kong, Shenzen, Chengdu, [4]Peking University, Nanshan, China. Contact: wenczhan@iu.edu

The meal-delivery industry is highly competitive; platforms are aggressive in quoting their estimated delivery times to improve customer satisfaction. To avoid getting penalized by the platform due to late deliveries, drivers are sometimes forced to drive at excessive speeds to complete orders, causing traffic accidents. We are interested in the role of government regulations in improving traffic safety and the platform's and drivers' responses to these regulations. We devise a Stackelberg game-theoretic model to solve for the government's optimal penalty structure for delivery-related accidents. We show that increasing the penalty on the platform prolongs the platform's quoted delivery time, which improves driver safety. By contrast, increasing the penalty on drivers leads to a shorter delivery time, making the delivery more hazardous for drivers.

Monday, 11AM–12:15 PM

MB74

M - Florida

Decentralized Insurance and Risk Sharing

General Session

Session Chair

Runhuan Feng, University of Illinois at Urbana-Champaign, Frankfurt am Main

1 Pricing by Stake in Defi Insurance

Mao Li, University of Illinois at Urbana-Champaign, Urbana, IL

The traditional approach to pricing in the insurance industry is based on historical claims data. In the DeFi insurance market, decentralized alternatives to pricing have been proposed and implemented. A common feature of these pricing rules is that risk assessors are invited to stake tokens against the underlying assets of their insurance products. A stake can be viewed as a collateral for a bet on the safety of the underlying assets. Hence, we shall refer to these rules as pricing by stake. In this talk, I will discuss the commonalities of pricing rules by stake observed in the market and analyze whether such rules can be effective to reflect the true riskiness of the insurance products.

2 Collaborative Insurance Sustainability and Network Structure

Arthur Charpentier, Philipp Ratz, Universite du Quebec a Montreal, Montreal, QC, Canada. Contact: ratz.philipp@courrier.uqam.ca

The P2P economy has been growing with the advent of the Internet, with well known brands such as Uber or Airbnb being examples thereof. In the insurance sector the approach is still in its infancy, but some companies have started to explore P2P-based collaborative insurance products. In this paper, describe and analyse such a P2P product, with some reciprocal risk sharing contracts. Here, we consider the case where policyholders still have an insurance contract, but the first self-insurance layer, below the deductible, can be shared with friends. We study the impact of the shape of the network on the risk reduction. We consider also some optimal setting of the reciprocal commitments, and discuss the introduction of contracts with friends of friends to mitigate some possible drawbacks of having people without enough connections to exchange risks.

3 DISTRIBUTED INSURANCE

Runhuan Feng[1], Mao Li[2], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, Contact: rfeng@illinois.edu

Traditional insurance businesses are often concentrated on a small set of insurers with large capitalization in markets around the world. While tight regulations of the insurance industry are well-intended to protect the interests of policyholders and ensure market stability, the legal compliance and capital requirements create prohibitively high barriers that prevent retail investors or small companies from entering the market. The advancement of distributed ledger technology has enabled a wide range of decentralized business models ranging from lending/borrowing, leveraged trading, to derivatives. Inspired by peer-to-peer service models, we propose the first of its kind distributed insurance model, where risks and rewards can be spread in a large distributed network of retail investors, as opposed to the concentration of market power in current markets.

Monday, 11AM–12:15 PM

MB75

M - Illinois

Crowdfunding and FinTech Platforms

General Session

Session Chair

Zhuoxin Li, Boston College, MA

1 The Economic Value of Charitable Gifts

Xue Tan[1], shengsheng xiao[2], Christopher Olivola[3], [1]Indiana University, Bloomington, IN, [2]Shanghai University of Finance and Economics, Shanghai, China; [3]Carnegie Mellon University, Pittsburgh, PA, Contact: janetan@iu.edu

People budget for expenses in charitable giving and gifts for friends and family in two segregate mental accounts. How would people categorize a charitable gift that also allows the recipient to contribute to charities? We designed two studies to understand the economic value of charitable gifts that feature both the dimension of charity and the dimension of gifts. Our research context is the charitable gift cards offered by an online crowdfunding platform.

2 Information Disclosure and Lender Behaviors
Jiayu Yao[1], Kai Lu[2], Mingfeng Lin[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of Science and Technology of China, Hefei, China. Contact: jyao@gatech.edu
We study the effect of showing information about peer behavior on decision-making in the context of online peer-to-peer lending (P2P lending). Using a website design change on one of the largest P2P lending platforms as well as complimentary online experiments, we find that when detailed information about peer behaviors is available, lenders spend more time on making decisions, but their likelihood of picking paid loans does not increase. Our study provides implications for information disclosure theory and market design.

3 Is Kindness The Magical Spell? The Role of Information and Reciprocity in Revenue-sharing Crowdfunding
Behrooz Pourghannad[1], Guangwen (Crystal) Kong[2], Laurens G. Debo[3], [1]Lazaridis School of Business & Economic, Waterloo, ON, Canada; [2]Temple University, Wynnewood, PA, [3]Dartmouth College, Hanover, NH
We consider an entrepreneur funding his project from investors through a revenue-sharing crowdfunding campaign. The early investor (insider) has a social tie with the entrepreneur and is informed about the future revenue of the entrepreneur's project. The investor who arrives later (outsider) is uninformed about the future revenue of the entrepreneur's project and makes an investment after observing the insider's investment. We show that the existence of reciprocity may lead in the condition in which the separating equilibrium does not exist.

4 Dynamics of Open Innovation: The Case of Cryptocurrency Forking
Vasundhara Sharma, McCombs School of Business, Austin, TX
The majority of cryptocurrencies follows an open innovation model, wherein the open boundaries facilitate copying (forking) the codebase and creating new products, which may compete with the parents for user demand and developer attention. We study how these substitutes impact the demand and the development activities for the parent cryptocurrency. Parents with only transaction capabilities experience a negative impact on demand. However, coins enabled with platform capabilities such as Ether witness increased demand in the long term, which can be attributed to the network effects associated with services and applications tied to these coins and compatibility with the competing forked products. Our results underscore the competitive dynamics of open innovation and provide managerial insights for firms assessing open models for product development.

Monday, 11AM–12:15 PM

MB76

M - Michigan
Building Supply Chains for Production Uncertainty
General Session

Session Chair
Aadhaar Chaturvedi, University of Auckland, AUCKLAND, New Zealand.

1 Effect of Yield Uncertainty on Production Location
Aadhaar Chaturvedi, University of Auckland
In this paper we investigate the effect of positive correlation in production yield of substitutable products on to the manufacturer's profits. On one hand positive correlation decreases profits because of supply demand mismatch. However, on the other hand, increased correlation can increase upstream competition, thus reducing manufacturer's input cost. Taking into account both these effects we study how different information structures can impact manufacturer's profits and its decision on production location.

2 Transitioning Toward VUCA-ready Sustainable Supply Chains: A Systematic Literature Review of Barriers and Tensions
Sunny Kareem, University of Auckland, Auckland, New Zealand. Contact: s.kareem@auckland.ac.nz
Sustainable supply chains (SSCs) as open systems are constantly forced to operate under turbulence, risk (both known and unknowns), and uncertainty (unknown unknowns). A VUCA (volatile, uncertain, complex, ambiguous) environment, e.g., Covid-19, has created unprecedented sustainability issues in global supply chains. As a result, barriers, tensions, and costly trade-offs stem from sustainability agendas versus cost-efficiency, productivity, and profitability topics. We offer a comprehensive systematic literature review on barriers and tensions to analyse the transition towards VUCA-ready SSCs. We also offer nine systematically developed future research agendas which will help contribute to the knowledge creation on SSCs and VUCA-ready SCs.

3 Supply Chain Risk Management Under Nondisclosure Agreements

Xi Shan[1], Chenglin Zhang[2], [1]Bemidji State University, Bemidji, MN, [2]Southwestern University of Finance and Economics, Chengdu, China.

In this paper, we consider the influence of non-disclosure agreements on the classic problem in the literature that a downstream firm sources from different unreliable suppliers. The downstream firm's ordering decision is significantly different when non-disclosure agreements are enforced.

Monday, 11AM–12:15 PM

MB77

M - Texas

Frontiers of Behavioral Operations

General Session

Session Chair

Yanchong (Karen) Zheng, Massachusetts Institute of Technology, Cambridge, MA

1 To Earmark or to Non-earmark? The Role of Control, Transparency, Salience and Warm-glow

Ozalp Ozer[1], Gloria Urrea[2], Sebastian Villa[3], [1]Amazon, Richardson, TX, [2]University of Colorado Boulder, Boulder, CO, [3]Indiana University, Bloomingotn, IN

Empirical evidence of how earmarking influences donors is scarce. We investigate how, when and why earmarking affects donors' decisions, as well as four mechanisms potentially driving the earmarking effect (i.e., control, operational transparency, salience, warm-glow). We consider three important decisions donors make: preference between earmarking and non-earmarking, decision on whether to donate or not and donation amount. We design three online experiments that allow us to quantify and disentangle the effect of earmarking on donors' decisions and investigate the role of the four mechanisms in fundraising. Our findings provide clear insights for how charities can design fundraising campaigns more effectively and suggest when to leverage earmarking and the four mechanisms depending on the charity's fundraising goals.

2 Chatbot Aversion in Service Systems: Reasons and Remedies

Evgeny Kagan[1], Maqbool Dada[2], Brett Hathaway[2], [1]Johns Hopkins Carey Business School, Washington, [2]Johns Hopkins Carey Business School, Baltimore, MD, Contact: dada@jhu.edu

Recent advances in AI/ML technology have enabled rapid adoption of chatbot technologies. To be able to successfully deploy chatbots firms need to understand the behavioral underpinnings of the consumers' willingness to use chatbot technology. We study chatbot adoption decisions using online experiments. In the first study we examine how adoption is affected by the features of the chatbot encounter, namely the speed of the chatbot, its failure rate, and the length of the queue following chatbot failure. In the second study we examine the mechanisms driving chatbot aversion. Finally, in the third study we propose and test some remedies to increase chatbot adoption.

3 The Effects of Compensation Structure on Consumption Behavior

Paige Tsai, Ryan Buell, Harvard Business School, Boston, MA, Contact: ptsai@hbs.edu

We study how the consumption behavior of individuals changes based on the source and nature of their compensation. Although research on mental accounting has previously revealed that people mentally encode their financial activities differently based on the source of their income, research to-date has yet to explore precisely how people treat labor income from a secondary labor income source, or how consumption varies with compensation structure. We further examine whether features of a labor income source affect consumption behavior across various expenditure categories. By investigating these questions, we intend to better understand how operations and compensation can be structured to drive employee wellbeing and performance.

4 The Effects of CSR Performance and Price on Purchasing Decisions

Junhao Yu[1], Tim Kraft[1], Robert Handfield[1], Rejaul Hasan[2], Marguerite Moore[2], [1]NC State - Poole College of Management, Raleigh, NC, [2]NC State, Raleigh, NC, Contact: tckraft@ncsu.edu

This paper uses online behavioral studies to examine how communicating supply chain corporate social responsibility (CSR) performance influences consumers' purchase intentions. Specifically, we investigate the effects of transparency and CSR performance (i.e., both good and bad evaluations) on consumers' willingness to buy. To better understand the factors influencing our results, we examine the mediation effects through consumers' perception of pricing fairness and product desirability and reveal how the impact of price paid for similar products and retail price of the focal product moderate these effects.

Monday, 11AM–12:15 PM

MB78

M - Utah
Social Media and Digital Platforms
General Session

Session Chair
Aravinda Garimella, University Of Illinois - Urbana-Champaign, Seattle, WA

1 **The Production and Consumption of Social Media**
Apostolos Filippas[1], John Joseph Horton[2], Elliot Lipnowski[3], [1]Fordham University, New York, NY, [2]MIT Sloan, Cambridge, MA, [3]Columbia University, New York, NY, Contact: apostolosfilippas@gmail.com
We model social media as collections of users producing and consuming content. Users value consuming content but, due to scarce attention, they may not value all content from other users. Users also value receiving attention, creating the incentive to attract an audience by producing valuable content, but also through attention bartering—users mutually becoming each others' audience. Attention bartering shapes substantially the patterns of production and consumption on social media, explains key features of social media behavior and platform decision-making, and yields sharp predictions that are consistent with data we collect from #EconTwitter.

2 **Cascading Effect of Award Winning Reviews in Online Review Platforms**
Rajan Mishra[1], Wreetabrata Kar[2], Warut Khern-am-nuai[3], Karthik Kannan[1], [1]Purdue University, West Lafayette, IN, [2]Krannert School of Management, Purdue University, West Lafayette, IN, [3]McGill University, Montreal, QC, Canada. Contact: mishra92@purdue.edu
In this paper, we study whether an incentive mechanism, namely an award-winning (AW) review: (i) affects the subsequent review contributions of users, who haven't won such an award, but have consumed an AW review; (ii) leads to more consistent review writing behavior of such users? We exploit a quasi-experiment design for our setting to estimate the impact of consuming an AW review by comparing users who consumed an AW review (treatment group) to those who never saw any AW review (control). Our evidence shows that there is a positive effect of consuming the AW reviews on users' subsequent review writing behavior. First, users write more reviews. Second, reviews written after consuming the AW review are of higher quality and more neutral in their ratings. Users who consume the AW reviews become more consistent in their review writing behavior.

3 **Frugality Versus Thrifty: The Gender Difference in Saving Behavior**
Ying Bao[1], Alex Yao Yao[2], Chen Gong[3], Michael He Jia[4], [1]University of Illinois at Urbana and Champaign, Champaign, IL, [2]San Diego State University, San Diego, CA, [3]Nanjing University of Science and Technology, Nanjing, China; [4]Hong Kong University, Hong Kong, Hong Kong.
This research focuses on how gender is correlated with 's saving behaviors - frugality or thriftiness - by leveraging a unique dataset from a major social media platform. Through analyzing over 12,000 posts on social media using machine learning algorithms and textual analysis, our results suggest males tend to be *more frugal,* as they are more anti-consumption focused, and their saving behaviors are often related to "DIY", and "homemade"; while females tend to be *thriftier*, as they are more pro-consumption focused and save through collecting "coupons", and "sales" information. We supplement our analysis with an experiment to show the generalization across different cultures and explore the underlying mechanism. Our findings highlight how sellers can use marketing communications to increase the salience of the product features such as long lifetime or deep discount.

4 **Increasing Consumer Engagement with Firm-generated Social Media Content: The Role of Images and Words**
Eugene Pavlov[1], Natalie Mizik[2], [1]University of Miami, Miami, FL, [2]University of Washington, Seattle, WA
We study how text and visual components of firm social media communications impact user engagement. First, we quantify the emotional loading of text and images. We use four emotion modalities as predictors of visual emotion: (1) elements of design (low-level features) such as color, texture, shape, lines, curves, corners, edges, and orientation; (2) high-level objects (e.g., adventure, action, leisure, danger, etc.); (3) human facial expressions; and (4) pixel text. Our model's accuracy exceeds 80%. Next, we analyze engagement (retweeting) with 1.3M firm-generated tweets. We find significant heterogeneity by category, with positive and high-Arousal images being the most engaging for quick-service restaurants and negative images being the most engaging for charities/non-profits.

Monday, 11AM–12:15 PM

MB79

JWM - Room 201
TIMES Best Dissertation Award
Award Session

Session Chair
Gizem Korpeoglu, Eindhoven University of Technology, Eindhoven, Netherlands.

Session Chair
Hyunwoo Park, Seoul National University, Gwanak-gu, Korea, Republic of.

Session Chair
Janne Kettunen, The George Washington University, Washington

1 **Rethinking Supply Chains: Technology, Coordination, and Sustainability in Modern Operations Management**
Philippe Blaettchen, Bayes Business School (formerly Cass), City, University of London, London, United Kingdom.

2 **Initial Coin Offerings and Asset Tokenization**
Jingxing (Rowena) Gan, Cox School of Business, Southern Methodist University, Dallas, TX, Contact: jingxingg@smu.edu
Initial coin offerings (ICOs) are an innovative early-stage fundraising method for blockchain-based startups. Due to their decentralized nature, ICOs are highly flexible, which makes them less well-guided and well-regulated than traditional fundraising methods. This dissertation provides valuable managerial insights to responsible blockchain-based startups by analyzing commonly seen approaches and exploring how firms with various goals can utilize each approach. In particular, we model tokenization of physical products and platform service, and interactions between design elements such as token price, ICO cap, platform commission, token retention, etc.

3 **An Operational Analysis of Innovative Transportation Technologies**
Neda Mirzaeian, University of Texas at Dallas, Dallas, TX

Monday, 11AM–12:15 PM

MB80

JWM - Room 202
Human, Machines, and Algorithms Session 4
General Session

Session Chair
John Patrick Lalor, University of Notre Dame, Notre Dame, IN

1 **Inventory Decision Biases in The Field: Evidence from a Pharmacy Retail Chain**
Yixin Iris Wang[1], Jun Li[2], Stephen Leider[3], [1]Gies College of Business, University of Illinois at Urbana-Champaign, Champaign, IL, [2]Ross School of Business, University of Michigan, Ann Arbor, MI, [3]University of Michigan, Ann Arbor, MI
Managers sometimes deviate from the ordering quantities recommended by the decision support system. Using historical data from a pharmacy chain, we investigate the drivers of store managers' manual adjustment decisions and identify several behavioral biases. We thus propose to revise the replenishment system and include an additional confirmation stage to alleviate the biases and test the effects in the field.

2 **A Case for Humans-in-the-loop: Decisions in The Presence of Misestimated Algorithmic Scores**
Maria De-Arteaga[1], Riccardo Fogliato[2], Alexandra Chouldechova[2], [1]The University of Texas at Austin, Austin, TX, [2]Carnegie Mellon University, Pittsburgh, PA
We study the adoption of an algorithmic tool used to help decisions in child maltreatment hotline screenings. By taking advantage of an implementation glitch, we investigate corrective overrides: whether decision makers are more likely to override algorithmic recommendations when the tool misestimates the score. We find that, after the deployment of the tool, decisions became better aligned with algorithmic assessments, but human adherence to recommendation was less likely when the displayed score was misestimated as a result of the glitch. We also observe that racial and socio-economic disparities resulting from algorithmic-informed decisions were substantially smaller than those associated with the algorithm in isolation. Together, these results show that human discretionary power can mitigate the risks of algorithmic errors and reduce disparities.

3 **The Effect of Artificial Intelligence Interpretability on Managerial Decision Making**
Onur Altintas[1], Abraham Seidmann[2], Bin Gu[1], [1]Boston

University, Boston, MA, [2]Boston University, Newton, MA

Many important business decisions are now made through an "algorithm-in-the-loop" process, where AI models inform and guide decision-makers in complex situations. There are some controversial findings on the human-algorithm interactions from the interpretability perspective for some specific tasks. In our study, we empirically investigate the longitudinal effect of different interpretability types on AI adoption, trust, and user performance in a common business context. Our initial results show the need for a more detailed investigation of the various concepts presented in the literature.

4 Assessing Users' Ability to Modify and Communicate Ai Models' Decision Boundaries Via Alow-code, Rules-based Approach

David Piorkowski[1], INGE VEJSBJERG[2], Owen Cornec[1], Elizabeth Daly[2], Rahul Nair[3], [1]IBM, Yorktown Heights, NY, [2]IBM, Dublin, Ireland; [3]IBM Research, Dublin, Ireland.

In real-world applications initial development of ML models includes detailed analysis by a data scientist. However, models may need to be retrained with new data and additionally, models may need to be updated to adhere to new rules or logic. This presents the challenge of communicating model changes after retraining, in particular when the role of the data scientist may be less in depth than originally and model editing to take into account new business logic. AIMEE (AI Model Explorer and Editor tool) addresses these challenges providing interactive methods to edit rule sets, visualize decision boundaries, and generate interpretable comparisons of models. We conducted an extensive user study and our findings showed participants were able to effectively create rules to modify decision boundaries and successfully report their modifications to outside stakeholders.

Monday, 11AM–12:15 PM

MB81

JWM - Room 203

OR/MS in Industry Practice - II

General Session

Session Chair

Richard Schrade, Automation Intelligence, Atlanta, GA

1 System for Product Availability Buffering for Omnichannel Retail

Xiaowei Bao[1], Zuochun Tang[2], Yihua Li[2], [1]IBM, Portland, OR, [2]IBM, San Francisco, CA

We propose a constraint-based optimization system to determine the product availability buffering to optimize the inventory usage in omni-channel retail. It takes into consideration demand, supply, and order data from different channels, models the relevant cost and risk components, then use an optimization engine to search for the optimal buffering according to the customer-provided core business objectives, such as increasing the revenue by exposing more store inventory online, ensuring high service levels by limiting cancellations, reducing the cost of rescheduling orders, and so on.

2 An Mip-based Heuristic for Regionalized Warehouse Site Selection

Soovin Yoon, Amazon, Seattle, WA, Contact: yoon57@wisc.edu

Amazon's outbound network continues to grow to serve increasing customer demand. We solve a capacitated facility location problem that recommends the optimal number, building type, and location of new warehouses to fulfill forecasted demand with minimum cost. We propose a 3-stage MIP-based heuristic which makes decisions sequentially while decomposing the problem into region-specific subproblems. This framework enables us to solve large-scale instances, and associate region-specific parameters to create realistic outbound flows.

Monday, 11AM–12:15 PM

MB82

JWM - Room 204

Identifying and Handling Microaggressions at Work

Panel Session

Session Chair

Angelika Leskovskaya, SMU Cox School of Business, Dallas, TX

1 Moderator

Angelika Leskovskaya, SMU Cox School of Business, Dallas, TX

Whether or not we would like to admit it, but we all carry bias. Our biases evolve over time as we are influenced daily by our family and friends, experiences, media, work, and the world around us. As adults we can become less aware of our own biases, which can create unintentional discriminatory responses toward others, also known as microaggressions. Bias and microaggressions occur everywhere, even in the workplace. The goal of the discussion is to uncover our biases and move to change them and it turn reduce the potential for microaggressions. Are we ready to courageously and honestly confront our biases?

2 **Panelist**
Karen T. Hicklin, University of Florida, Gainesville, FL

3 **Panelist**
Michele Pfund, Arizona State University, Gilbert, AZ

4 **Panelist**
Maria Vlasiou, Eindhoven University of Technology, Eindhoven, Netherlands.

5 **Panelist**
Lauren Rhue, University of Maryland, College Park, MD, Contact: lrhue@umd.edu

Monday, 11AM–12:15 PM

MB83

JWM - Room 205
spORts IV
General Session

Session Chair
Stephen Hill, University of North Carolina-Wilmington, Wilmington, NC

1 **Multifactor Analysis for NFL Draft Prospect Evaluation**
Jesse Pietz[1], Joseph Wilck[2], [1]U.S. Air Force Academy, Monument, CO, [2]William & Mary, Williamsburg, VA
Each year National Football League (NFL) teams spend millions of dollars and countless hours to evaluate prospective players in preparation for the league's amateur draft. Despite this large investment, the difference between observed and expected performance of drafted players is quite large. This talk evaluates the rate at which teams successfully identify high-performing players and presents a multifactor analysis for NFL draft prospect evaluation. We explore the situations where teams may be able to use this approach to improve their odds of a successful draft outcome.

2 **An Overview of in Game Win Probability Models**
Stephen Hill, University of North Carolina-Wilmington, Wilmington, NC
In this presentation, in game win probability models are described. Such models are used to estimate the probability that a team with win a game or match at any point the game. Such models are used across a variety of sports. Directions for future research are provided.

3 **Latent Dirichlet Allocation for Sport Social Media**
Liz Wanless, Ohio University, Athens, OH
This paper presents the application of natural language processing (NLP) probabilistic topic modeling algorithm, Latent Dirichlet Allocation (LDA; Blei et al., 2003), to identify latent sport consumer conversation topics in brand-affiliated Twitter data. Specifically, this paper leveraged LDA to derive how consumers discussed the WNBA on Twitter over the course of the 2020 season. Eighteen topics arose encapsulating both social justice and on-court performance.

Monday, 11AM–12:15 PM

MB84

JWM - Room 206
Applications of Simulation and Optimization
Contributed Session

Session Chair
Hamid Mozafari, Michigan State University, East Lansing, MI

1 **Optimizing Decisions for Formal Small-scale Surface Mines in Peru**
Fatih Aranoglu, Colorado School of Mines, Golden, CO, Contact: aranoglu@mines.edu
In this paper, we examine the dynamics of small-scale surface mining in the Puno department of Peru for formalized mines, as well as mines undergoing the formalization process. To this end, we simulate the mining process starting from ore extraction to the final product (i.e., dore) using systems dynamics modeling. An optimization model is then built that optimizes decisions regarding mining legislation and practices to maximize the ``reported'' (i.e., formal) amount of gold production and therefore maximize government's total gaining from formal mines' activities as well as taxation, while also minimizing environmental and health issues due to mercury use. The optimal decisions and resulting insights are discussed.

2 Extending Generalized Disjunctive Programming to Model Hierarchical Systems

Hector D. Perez[1], Seolhee Cho[1], Ignacio E. Grossmann[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: hperezpa@andrew.cmu.edu

We present an extension to Generalized Disjunctive Programming (GDP) to model hierarchical systems via nested disjunctions. We denote these more general GDP models as Nested GDPs (NGDPs). NGDPs are compared to their equivalent single-level GDP formulations. Reformulations to algebraic optimization models of NGDPs and the equivalent single-level GDPs are formalized. The two approaches are compared in terms of model tightness and size (number of discrete and continuous variables, and constraints). Computational results are presented with examples from the areas of process flowsheet synthesis and optimization of electric power expansion planning. The results show the value in using NGDPs to systematically model and solve real-world problems.

3 Impacts of Covid-19 Pandemic on Fleet Asset Management and Operations

Hamid Mozafari[1], Amirali Soltanpour[2], Farish Jazlan[2], Mehrnaz Ghamami[3], Ali Zockaie[4], [1]Michigan State University, East Lansing, MI, [2]Michigan State University, East Lansing, MI, [3]Michigan State University, Okemos, MI, [4]Michigan State University, Okemos, MI, Contact: mozafar1@msu.edu

COVID-19 pandemic considerably impacted various operations and altered the trip patterns, requiring modified fleet operations. This study aims to capture the impacts of the pandemic on fleet operations and find optimum fleet composition pre and during pandemics minimizing the costs, including maintenance, operation, fuel, and societal emissions cost. The fleet asset and operation data from Michigan State University are analyzed during the COVID-19 pandemic and pre-COVID. A fleet optimization model is developed with EPA's MOVES embedded to estimate emissions to capture the required pandemic-related modification. The model demonstrates the required asset modifications, including alternative fuel options, to ensure efficient fleet operations.

4 Asset Prioritization for Electric Power Transmission Maintenance Planning

Ashfaque A. Mohib[1], Al Tamimi[2], Ehsan Salari[1], Mehmet Bayram Yildirim[3], [1]Wichita State University, Wichita, KS, [2]Sunflower Electric Power Corporation, Wichita, KS, [3]Wichita State University, Wichita, KS, Contact: aamohib@shockers.wichita.edu

This paper proposes an asset prioritization model to aid in the electric transmission planning process by assessing a set of weighted criteria leading to an optimized set of alternative actions. A weighted hierarchical prioritization scheme utilizing Analytic Hierarchy Process (AHP), was developed using the factors in the literature review and also inputs from industry experts. A Mixed Integer Linear Programming (MILP) asset management model is used to determine the optimal solution for transmission line maintenance and replacement plan by prioritizing the aging assets given a limited budget over the planning horizon.

Monday, 11AM–12:15 PM

MB85

JWM - Room 207

Writing Successful NSF CAREER Proposals

Panel Session

1 Moderator

Ruiwei Jiang, University of Michigan, Ann Arbor, MI

This panel session will feature three NSF CAREER Award winners and a past NSF program director. In expectation of an active discussion together with the audience, we will introduce the three CAREER winners, including their background, research areas, and experience with the NSF CAREER program. We will also invite the past NSF program director to share his perspectives from "the other side of the table." We will then open up for questions from either the moderator or the audience. We strongly encourage anyone who is interested to submit a NSF CAREER proposal in the near future to attend the discussion.

2 Moderator

Marla Lavanya, U of Illinois at Urbana-Champaign, Urbana, IL

3 Panelist

Austin Buchanan, Oklahoma State University, Stillwater, OK

4 Panelist

Yury Dvorkin, New York University, Brooklyn, NY

5 Panelist

Giulia Pedrielli, Arizona State University, Scottsdale, AZ

Monday, 11AM–12:15 PM

MB86

JWM - Room 208

Emerging Technologies and Analytics for Sustainable Aviation

General Session

Session Chair

Sebastian Birolini, University of Bergamo, Dalmine (BG), Italy.

1 **Competing on Emissions Charges**

Nicole Adler[1], Gianmarco Andreana[2], Gerben de Jong[1], [1]Hebrew University of Jerusalem, Jerusalem, Israel; [2]University of Bergamo, Bergamo, Italy. Contact: gianmarco.andreana@unibg.it

We develop a two-stage game to evaluate how airlines compete in response to environmental policies imposed at both, national and supra-national levels, by aviation regulatory bodies. In the first stage, regulators choose environmental charges in order to maximize the social welfare of their jurisdiction, while in the second stage airlines compete for profits by setting frequencies, fares and by managing their fleet. Specifically, airlines may decide to absorb the environmental charges, replace their fleet with new and less polluting aircraft, change the utilization and deployment of their fleet, or adapt fares and frequencies. To show how our game can be used to analyse market equilibria in aviation, we apply our model to a representative global network.

2 **Electric Aircraft Charging Network Design for Regional Routes: A Novel Mathematical Formulation and Kernel Search Heuristic**

Mattia Cattaneo[1], Sebastian Birolini[2], Alan Kinene[3], Tobias Granberg[3], [1]University of Bergamo, Bergamo, Italy; [2]University of Bergamo, Dalmine (BG), Italy; [3]Linköping University, Norrkoping, Sweden. Contact: mattia.cattaneo@unibg.it

This paper proposes an optimization model to support the strategic design of charging networks for electric aircraft as a key enabling factor to prepare for and take full advantage of aviation electrification. The model, named Electric Aircraft Charging Network for Regional Routes (EACN-REG), defines a network of airports and flight paths to optimally trade-off the number of charging bases (and associated investment costs) with connectivity and population coverage targets typical of regional routes serving remote regions. Due to scaling and computational challenges, we propose a Kernel Search heuristic and illustrate how it can solve large cases in short computational time (within 2 hours), outperforming exact branch-and-cut algorithms with a tightened formulation. A real-world application to Sweden then demonstrates the practical insights of the EACN-REG.

3 **Flight Scheduling of Electric Aircraft for Subsidized Routes**

Sebastian Birolini[1], Alan Kinene[2], [1]University of Bergamo, Dalmine (BG), Italy; [2]Linköping University, Norrköping, Sweden. Contact: sebastian.birolini@unibg.it

In this paper, we develop an optimization framework in support of the design of electric aircraft networks to provide thin routes serving remote regions. We first develop a quadratic optimization model to estimate the geographical distribution of air transport demand from airport aggregated data, based on demand generation and allocation properties. We then formulate a multi-objective integrated flight scheduling and fleet assignment model for all-electric aircraft using a time-space-energy approach, which trades off passengers' welfare and the system-wide cost of subsidization. By considering a real-world case study of Sweden, we demonstrate the benefits of the proposed approach and highlight its major insights—in terms of fleet size, sizing of charging facilities, flight scheduling and fleet assignment, with a comparison to conventional and mixed networks.

Monday, 11AM–12:15 PM

MB87

JWM - Room 209

Flight Planning and Demand/Capacity Balancing

General Session

Session Chair

Peng Wei, George Washington University, Washington

1 **Formal Methods and Tools for Unmanned Air-traffic Management Protocols**

Sayan Mitra, University of Illinois at Urbana Champaign, Urbana, IL

The key concept for safe and efficient traffic management for Unmanned Aircraft Systems (UAS) is the notion of operation volume (OV). An OV is a 4-dimensional block of airspace and time, and can be used for planning, deconfliction, and traffic management. While there are several traffic-level simulators, we are lacking a framework for reasoning about OVs for heterogeneous air vehicles. We present SkyTrakx—a software toolkit for simulation and verification of UTM scenarios based on OVs. We show how existing verification

tools, Dafny and Dione, can assist in automatically checking key protocol properties. Second, we show how the OVs can be computed for quadcopters and fixed-wing aircraft using reachability analysis. Finally, we show that SkyTrakx can be used to simulate complex scenarios involving heterogeneous vehicles, for workload and response delays analysis.

2 Airline Schedule Design by Incorporating Cannibalization Effect

Keji Wei[1], Fan Xiao[2], Yufeng Cao[3], Zhe Liang[2], [1]CAE, Grapevine, TX, [2]Tongji University, Shanghai, China; [3]Shanghai Jiao Tong University, Shanghai, China. Contact: kejiwei3@gmail.com

Cannibalization exists in airline industry. It happens when one itinerary is much more attractive than the other: It can then lead to the more attractive one being full at the expense of the others that might end up empty. We have designed an integrated schedule model by explicitly considering cannibalization by involving nearby itineraries being decayed each other. Based on this MINLP model, we have designed the McCormick cuts and corresponding solution approach to make the case solvable in a limited time. We have also done a series of test to validate the benefits of this approach comparing to all previous existing methods.

3 A Market-based and Policy-based Competitor-aware Conditional Forecasting Method

Tim Yuxuan Lu, Massachusetts Institute of Technology, Cambridge, MA, Contact: lutim@mit.edu

The proliferation of OTA, implementation of the NDC, and removal of fare class restrictions promote price transparency and amplify price competition. Forecasting demand based on observations and predictions of competitors' offerings can benefit airlines significantly. We propose a market-based and policy-based competitor-aware conditional forecaster, which predicts competitors' policies based on historical policy observations and then explicitly constructs forecasts based on actual and predicted competitors' policies. With the proposed forecaster, forecast accuracy can be improved, and fare class forecasts can be dynamically adjusted according to competitors' offerings. The concept, methodology, process, and preliminary results are shared.

4 A Review and Outlook of Different Settings of Flight Planning and Traffic Flow Management

Peng Wei, George Washington University, Washington, DC, Contact: pwei@gwu.edu

The speaker will review and present different settings of flight planning and traffic flow management in both conventional air traffic and emerging air traffic operations. The focuses will be the roles of decentralized flight operators and the centralized traffic manager in these settings. Finally, the speaker will highlight the trends of these settings in conventional air traffic operations and emerging air traffic operations, as well as the benefits and costs of these settings.

Monday, 11AM–12:15 PM

MB97

CC - Exhibit Hall E

RAS Interactive Session

Poster Session

Session Chair

Clark Cheng, Norfolk Southern Corporation

1 Improving Flat Switching Processes

Roger William Baugher, TrAnalytics, LLC, Johns Creek, GA

2 Interactive Car Routing Tool

Andy Yoon, Norfolk Southern Corporation, Suwanee, GA

Norfolk Southern's interactive car routing tool reads traffic data and finds the optimal block route and associate train route based on current, historical, or future operation plan. It simulates railroad operations and quantifies the potential impact of any operating plan changes prior to implementation.

3 Modeling Terminal Operations

Roger William Baugher, TrAnalytics, LLC, Johns Creek, GA

When justifying capital investments in a hump or flat yard or when appraising how a yard would be impacted by operating plan changes, there are few general-purpose simulation tools available to the analyst. One such model has been used by the presenter to analyze numerous yards, including hump and flat switching operations. The model is composed of an AnyLogic simulation engine interfacing with Excel for input and data collection. As a quality check, yard movements can be animated as they progress through the facility.In this presentation, the study of an intermodal facility will be demonstrated, including the animation and the interface.

4 Yard Planner

Jeremiah Dirnberger, Wabtec, Jacksonville, FL

Yard Planner provides end-to-end decision support for classification yard operations, by allowing the visualization and monitoring of each yard's state and generating consistent process plans. User modifications are easily entered and new plans using those inputs are quickly generated. Worklists and inventory updates are seamlessly executed in this foundational tool for Yard Automation.

5 Rail Express

Carl D. Van Dyke[1], Roger Baugher[2], [1]TransNetOpt, West Windsor, NJ, [2]TrAnalytics, Johns Creek, GA

6 Advanced Locomotive Technology and Rail Infrastructure Optimization System (ALTRIOS)

Tyler Dick, U of Illinois at Urbana-Champaign, Urbana, IL

7 Exhaust Vent Analysis (EVA)

Bryan Gabric, Yasha Zeinali, BNSF, Ft. Worth, TX

Monitoring train engine condition has the utmost importance in railway industry since it is the most critical and expensive component of a train. Flooding the exhaust vent after a heavy rain is one of the severe incidents which could leave permanent damages to the train engines. Unfortunately, this incident happens more frequently for the engines that are parked in the yards. To prevent, the exhaust vent of parked engines should be monitored very frequently to make sure they are covered properly.In this project, a pipeline is produced in which videos captured by flying drones over a yard are processed using computer vision algorithms and deep learning object detection techniques. The utilized models identify engine plate number, its global/railroad location, and its exhaust vent status, and report all engines that have an uncovered exhaust vent, if any. The OCR and object localization models yielded excellent practical performance.

8 Service Design Schedule Viewer

Brandi Wood, Wabtec, Melbourne, FL

Service Design Schedule Viewer is a web-based railroad simulator providing detailed analytics about predicted rail traffic performance. It enables users to experiment with multiple scenarios for different operating plans and make informed choices through detailed analytics. It connects long-term planning and day of operations using train characteristics and topology models.

Monday, 11AM–12:15 PM

MB98

CC - Exhibit Hall E

RAS Poster Session

Poster Session

Session Chair

Pengling Wang, Tongji University, China.

1 Tram Trajectory Optimization Incorporating Disjunctive Time Constraints from Traffic Lights

Zhuang Xiao[1], Pengling Wang[2], Qingyuan Wang[3], Pengfei Sun[3], Xiaoyun Feng[3], [1]Southwest Jiatong University, Chengdu, China; [2]Tongji University, Shanghai, China; [3]Southwest Jiaotong University, Chengdu, China.

Trams operate on dedicated tracks, but they should interact with other traffic participants, e.g., cars, buses and pedestrians, at intersections. At these intersections, traffic flows are controlled by traffic lights, where trams are only allowed to cross in disjunctive green time windows (GTWs). This removes traffic conflicts, but tram operations are often blocked by red lights, leading to frequent decelerations and re-accelerations that increase operational energy consumption. We study the tram trajectory optimization problem with consideration of disjunctive GTWs as well as general operational constraints that refer to speed and time limits from a pre-set timetable. Our ultimate goal is to find an driving strategy to drive trams in an energy-efficient and punctual manner, while respecting to time constraints of disjunctive GTWs. We develop an integer linear model to describe the time constraints of disjunctive GTWs. Binary variables are assigned to each feasible GTW to denote whether the tram crosses the specific GTW or not. Additional linear constraints are enforced to ensure that trams may cross a traffic light only once, i.e., only through a single GTW at a time. A mixed-integer nonlinear program (MINLP) is then assembled incorporating the integer linear model, in which a cost function is formulated to minimize energy consumption of the traction propulsion system.Global optimization approaches for MINLP often require that the problem is convex after integer variables are relaxed. This is often not the case, which consequently leads to heavy computational burden. To address computational challenge of solving the MINLP, we instead propose suboptimal solutions. We reformulate the MINLP as a tractable nonlinear program (NLP) by replacing the integrality constraint with a smooth nonlinear function penalized into the cost function. A large enough penalty can ensure satisfaction of the integrality constraint, which motivates us to propose a two-loop algorithm to recover a solution of the original MINLP. The outer loop is responsible for increasing penalty parameter using a homotopy, and the resulting NLP is solved by a computationally efficient sequential quadratic programming (SQP) algorithm in an inner loop. The procedure is repeated until the integrality constraint is satisfied and the SQP is converged. The performance of the proposed approach is investigated on different scenarios using real-life tram data. Results show that the method is able to generate energy-efficient driving trajectories incorporating time constraint of traffic lights, while crossing traffic lights in effective GTWs without unnecessary decelerations and re-accelerations. This approach can be practically used for driver assistant system or automatic tram operation system.

2 Macroscopic Modeling and Control of Reversible Tracks in Railway Delay Management During Partial Blockages

Bowen Gao, Dongxiu Ou, Decun Dong, Yuqing Ji, Tongji University, Shanghai, China

Appropriate use of station tracks can effectively slow down the spread of delays when facing a large disruption. Current studies of double-line railways regard the use of station tracks in both directions of operation as independent. In reality, stations have crossovers allowing trains running in one direction to use the station tracks in the other direction, which provides a completely new way of thinking about the use of the tracks in disruption scenarios. This paper modeled the reversible tracks in the railway field during a partial blockage by building a MILP model. A rolling horizon approach was designed to cope with the uncertainty of the blockage end time and the solving challenge in real time.

3 Timetable Optimization for Sharing-Corridor Metro Lines under Virtual Coupling

Jianhao Ge, Pengling Wang, Xiaofang Xiao, Tongji University, Shanghai, China.

A method is proposed to apply virtual coupling technology to the sharing-corridor metro lines to solve the problem of capacity bottleneck. A mixed integer linear programming model is built to optimize the train timetable of sharing-corridor lines under the assumption of using the virtual coupling technology, fully taking into account the constraints related to train timetabling, virtual coupling technology, and passenger assignment, with the objective to improve the service quality. The experiments on Shanghai Metro Line 3 and Line 4 are implemented to verify the effectiveness on transportation capacity and passenger service quality of the proposed model using virtual coupling technology.

4 Mixed Transport Strategy for Freight and Passenger Transportation in Metro Systems during Off-peak Hours

Yutao Ye[1], Junhua Guo[2], Lixin Yan[2], [1]Tongji University, Shanghai, China; [2]East China Jiaotong University, Shanghai, China.

This paper proposes a mixed transport strategy for freight and passenger transportation in metro systems during off-peak hours. The definition of the mixed transport strategy is proposed and fixed and flexible loading modes are considered under different volume of passenger flow. Then, a mathematical model of the mixed transport strategy is proposed and solved by an improved variable neighborhood search algorithm. Case studies demonstrate the performance and applicability of the proposed algorithm, and the mixed transport strategy is discussed under different delivery distances, passenger flows and metro network types.

5 A Human-computer Interaction-based Method for Line Plan Adjustment of China High-speed Railway

Cheng Bai, Tongji University, Shanghai, China.

We expound the human-computer relationship in the adjustment of line plan, which indicates the necessity of methods that consider human and computer equally important. From the perspective of the matching of line plan and passenger flows, several key indicators are listed. Then, a human-computer interaction-based method for railway passenger line plan adjustment is proposed. A corresponding decision support system is also developed. A case study is performed to illustrate the applications of the system and the results show that it can realize the cycle of line plan adjustment and evaluation feedback effectively, which can offer supporting information for railway bureaus.

6 Real-Time Prediction of Employee Workload in Digital Railway Control Rooms

Léon Sobrie[1], Marijn Verschelde[2], Bart Roets[3], [1]Ghent University, Ghent, Belgium; [2]IÉSEG School of Management, Lille, France; [3]Infrabel, Brussels, Belgium. Contact: leon.sobrie@ugent.be

Even in digitized environments, human workload can reach critical levels. Previous research demonstrates the detrimental nature of workload peaks and lows, especially in environments where real-time decision-making is paramount. We investigate the workload in such an environment: the digital control rooms of Infrabel, Belgium's railway infrastructure company. We utilize an expert-validated real-world dataset to create a machine learning model for the control room operator's workload. A business application deploys the model's predictions to provide operational intelligence and decision support for the supervisor.

7 Remaining Useful Life Prediction of Railroad Components in Amtrak using Conditional Probability Survival Models

Mamadou Seck, Amtrak, Washington

With the rapid rise of Industry 4.0, it can be realized that a collaboration betweenhuman and machine intelligence creates more value in terms of running an efficientprocess. Such advancements in technology can be exploited in railroad maintenanceactivities as maintenance represents a significant portion of the life-cycle costs of ahigh-speed rail. The huge expense attributes to the fact that railroad maintenanceplays an important role in the reliability of the railroad systems and the safe travelof passengers and crews. At the same time, implementing the right strategy canreduce maintenance costs without compromising reliability. This research aims tocontribute to the use of advanced decision-making models to increase the efficiencyof maintenance planning for Amtrak railroad components. Taking advantage ofadvanced statistical and machine learning techniques, Predictive Maintenance(PdM) can be implemented as such maintenance strategy identifies the right windowof opportunity to perform maintenance thereby reducing the overall maintenancecosts. This PdM strategy makes the transition from a reactive maintenance systemto Prognostic Health Management (PHM) system with the help of predictiveanalytics. In predictive analytics, the important metric for PdM is called RemainingUseful Life (RUL) prediction which predicts how long a component or systemsurvives thereby appropriate action is taken before it fails. There are several researchworks exist in the literature for doing predictive maintenance on railroadcomponents using the RUL estimate. For example, the research work 'A predictivebasedmaintenance approach for rolling stock vehicles' by Roberto Nappi et. al.,deals with applying Machine Learning algorithms for RUL prediction on rollingstock vehicle components in the Italian Railways Network by performing thedegradation analysis. In this study, a contribution focused on survival analysis ismade by collecting Time to Failure (TTF) data from Amtrak's Work ManagementSystem (WMS) database for components in the truck system. To model the RULprediction with the nature of data collected, survival analysis is performed by fittingthe data to the appropriate distribution to which the data fit the most. In this work,Weibull distribution is chosen by analyzing the Goodness-of-fit measures. In thecase of survival analysis, the RUL was computed from the conditional probabilityvalues of the distribution. For a case study, The RUL prediction model is applied fora particular component, Wheelset, of the truck system for a specific type of rollingstock technology and this model finds the conditional remaining life of themechanical component given that the component has survived up to current time.The model can be generalized for predicting the RUL values of other mechanicalcomponents and technologies.

8 Analyzing passenger and train conductor feedback data in Amtrak railroad operation using Text Mining: Mechanical Issue Centric

Subramanian Ramasamy, Amtrak, Railway Express Agency, Washington, DC

For a few years, the realization of the importance present in unstructured data israpidly growing. The reason is that unstructured data contain some valuableinformation that is not captured generally in structured data. Such unstructured data,in the form of texts, can be helpful in improving the performance of a system. Butthe drawback with unstructured data is that it is not easily interpretable and difficultto capture the right context to perform analysis. Hence, text mining, an automaticmethod of extracting the necessary information from the text data comes useful byimplementing advanced statistical and machine learning techniques. For a smoothand efficient railroad operation, the trainsets must operate with minimal mechanicalissues and address issues beforehand. Some of the Key Performance Indicators(KPIs) for addressing such issues are delays in on-time performance (OTP) andcustomer satisfaction index (CSI) during their travel. In terms of delay reports,Amtrak uses an OTP monitoring and reporting system that restores delay recordsclassified and reported by train Conductors using the Electronic Delay Reporting(eDR) system. The corporation collects customer satisfaction records from surveysand consolidates the feedback to generate Amtrak Customer Satisfaction Index (CSI)reports across its service network. The literature related to the application of textmining techniques for railroad applications suggests some application of semanticanalysis in the railroad industry. For example, in the paper 'Analytics and big datarailpublic transportation is a leader' by L. Henry, sentiment analysis for capturingthe sentiment of the passengers to gauge public attitude towards the railway agenciesis studied. Although, to the best of our knowledge, no research work in the RailroadTransportation System (RTS) literature exists on capturing passenger service qualityperception with reference to mechanical issues of rolling stock equipment using textdata mining. The contribution of this work is to perform a text mining analysis onvarious records like the customer comments and the conductor statements andcapture the mechanical-centric issues that induced these comments. In this work, theright selection of a subset of mechanical components that heavily impacts theperformance of the trainset is chosen by implementing Natural Language Processing(NLP) technique on such text datasets. In this study, a correlation analysis is carriedout for customer comfort ratings to see the impact of mechanical issues on customerdiscomfort. We performed the contingency correlation analysis and from the results,it was identified that the mechanical issues have a strong positive relationship withcustomer discomfort. In addition, the important subset of components is identifiedfrom the text mining process. A correlation analysis suggests how much theperformance indicators such as delays, and customer comfort get impacted due tomechanical issues.

9 Preliminary analysis on implementing Optimal Replacement Policy using the estimated Remaining Useful Life values for Amtrak mechanical components

Keivan Ghoseiri, National Railroad Passenger Corporation (Amtrak), Clarksville, MD

In railroad networks, a smooth and efficient system of operations is crucial as itprovides a multitude of benefits to the organization such as safety, and reduction inoverall expenses like the life cost of trainsets. Out of various aspects that contributeto the life-cycle costs of an asset, maintenance plays a significant role as it not onlyensures safety to the passengers but also improves the system's reliability. Normallyin the Predictive Maintenance of mechanical systems, one of the important metricsis having a reliable estimation of the Remaining Useful Life (RUL) of a component.This estimate gives the railroad a time window of opportunity during which theappropriate maintenance activity can be performed thereby significantly reducingthe cost of an asset. But determining the 'right' window of opportunity is importantbecause having just the information about RUL estimation does not provide thedetails of performing the maintenance at the right time leading to either overdoingthe maintenance activity or doing the maintenance while it's too late. Hence,identifying the right time window of opportunity is an important and challengingtask to implement a robust Predictive Maintenance strategy. The research works inthe literature so far have provided various variants on formulating an optimal policyfor maintenance optimization. For example, the research work 'Train-setAssignment Optimization with Predictive Maintenance' by Meng-Ju Wu et. al.,formulated a predictive maintenance optimization problem in which they consideredminimizing daily maintenance costs and monthly maintenance costs along withminimizing the accumulative operating days of the trainset. In this study, acontribution is made by considering an objective of cost minimization along withbringing the remaining useful life estimates into consideration. For that, there shouldbe a Decision Support System (DSS) that involves the RUL prediction model in theloop. The DSS provides prescriptive analytics that conveys the best action to takewhich maximizes the reliability while minimizing certain costs. In this study, a DSSis modeled using an optimization problem formulation to support the optimizedmaintenance strategies based on the predicted RUL values. The model recommendsoptimal maintenance strategies for repair or replacement of the components at theright time by minimizing the maintenance cost and revenue lost subjected tosatisfying technical and policy constraints. These maintenance costs typicallycomprise Predictive Maintenance costs, Corrective Maintenance costs, andOperative disruption costs. The results of our generalized optimization model showthat this method has the potential to be extended to other railroad mechanicalcomponents to achieve an overall system-wide optimized Predictive Maintenancemodel.

10 Train Dwell Time Evaluation at High-Passenger-Volume Stations with a Reliability Perspective

Natchaya Tortainchai, University College London, London, United Kingdom.

Train dwell time is complicated and depends on many factors. One of the dominantfactors is passenger volume. High passenger volume on a platform always causes trains to stoplonger and consequently delay the service. This research develops a data-driven approach witha large amount of London Underground's actual train operation data to evaluate train dwelltimes on Victoria line which is one of the most crowded lines of London Underground'ssystem. In the morning peak of the northbound service of Victoria line, Victoria stationbecomes a critical station that determines the line capacity due to the extended dwell time atthe platform. Victoria station is a good case study for developing approaches to evaluate dwelltimes at high-passenger-volume stations since it is a high-passenger-volume station whichtrains arriving at the station are often full, resulting in extremely long dwell times frompassengers boarding and alighting process.The dwell times at high-passenger-volume stations are sensitive to passengermovements and contain high variations. Many studies found that the dwell times at highpassenger-volume stations are difficult to be predicted accurately with dwell time models. Theconventional approach to set a dwell time in the train timetable is using the value calculatedfrom the prediction model, or from the calculation of historical data. In the reliabilityperspective, it is important to set an appropriate dwell time which is achievable by mostservices. Since dwell time in the crowded stations is too complicated to be predicted precisely,"how about dwell time is set without using dwell time prediction model?", but the target dwelltime is specified first in the timetable. This research considers uncertain perspective of the dwell time evaluation and proposesthe bivariate probability functions to evaluate the likelihood of achieving the target dwell timeat different passenger volume levels. The research contributed to the final evaluation to balancebetween dwell time reliability and passenger volume level. The balance between theseperformances is indefinite and depends on the service policy. This research developedevaluation based on London Underground's Business Case Development. Passengermanagement strategies were examined with the analytical model and showed that reducing 2%of the passenger volume can increase the service reliability by 22%.

UNREGISTERED Train delay propagations: what should be paid attention to?

Ping Huang, Shu Liu, Francesco Corman, ETH Zurich, Zurich, Switzerland.

Accurate estimation of the train delay propagation is significantly essential for timetable rescheduling, vehicle connection, and passenger transferring. Because of the straightforward interpretation of graph and network to train operations, train delay propagation is generally modeled by graph or network models (e.g., timed event graphs, and Bayesian networks), where the nodes of the model describe train events (e.g., arrival, passage, and departure), and the arcs between nodes represent the train running and dwelling process. However, these models cannot discern the importance of train events (i.e., the impacts of train events on delay propagation). For instance, the train events significantly impact the delay propagation when they are closer or the recovery time in sections/stations is shorter. To address this problem, we propose a train delay propagation model based on Graph Attention Network (GAT) to capture the different impacts of train events. The GAT model uses an attention mechanism on the graph neural network to assign weights to different nodes, enabling the proposed delay propagation model to depend more significantly on nodes with larger weights than the whole network or the most adjacent nodes. The proposed GAT model is expected to improve the accuracy of the train delay propagation modeling.

Monday, 12:30 PM–1:45 PM

MC01

CC - Room 101

Various Studies for Robust Artificial Intelligence

General Session

Session Chair

SEOUNG Bum Kim, Korea University, Seoul, Korea, Republic of.

1 Out-of-distribution Detection Using Distance-aware Uncertainty Estimation

Jiyoon Lee, Seoung Bum Kim, Korea University, Seoul, Korea, Republic of. Contact: jiyoonlee@korea.ac.kr

Existing algorithms assume that training and testing data are drawn from the same classes and feature spaces. However, the more realistic scenario poses a risk that unknown classes which were not present during training may appear on the testing. For instance, while monitoring equipment status based on collected data, new defects which are not defined in advance may appear. New defects must be classified into an unknown class to take appropriate action. Therefore, we propose a distance-aware uncertainty estimation method to classify out-of-distribution inputs based on uncertainty. The estimated uncertainty information is used as an indicator of identifying unknown classes. We conduct a simulation study to demonstrate the usefulness of our method.

2 Self-supervised Learning for Anomaly Detection on Multivariate Sensor Data

Chunghyup Mok[1], Mingu Kwak[2], Seoung Bum Kim[1], [1]Korea University, Seoul, Korea, Republic of; [2]Georgia Institute of Technology, Atlanta, GA, Contact: mokch@korea.ac.kr

As manufacturing processes become more complex, anomaly detection becomes increasingly important. Therefore, multiple sensor data for each process is collected and used for anomaly detection. Because most of the collected data is normal, anomaly detection requires the design of learning methods without anomaly data. In this study, we propose a self-supervised learning framework that can learn without labels. First, we learn self-supervised representations using contrastive learning with an effective augmentation method for multivariate sensor data. Then, we use the trained representations to increase the performance of the anomaly detection models. The superiority of the proposed model was demonstrated by experiments with real-world data collected from manufacturing systems.

3 Open-Set Human Activity Recognition Using Mixup Triplet-Based Deep Metric Learning

Minjung Lee, Insung Baek, Sangmin Kim, Taeyeon Kim, Hyeryeong Oh, Leekyung Yoo, Seoung Bum Kim, Industrial and Management Engineering, Korea University, Seoul, Korea, Republic of. Contact: leemj2520@korea.ac.kr

The main objective of human activity recognition (HAR) is to classify predefined human physical actions. In a real-world scenario, undefined activities may appear in human activities. Thus, an open-set recognizer that can detect an unknown class is required for HAR. However, open-set HAR is challenging because of the small variability of inter-classes. To address this issue, we propose a new open-set HAR algorithm based on a deep metric learning with linearly interpolated triplets. On the embedded features using the metric learning, thresholds based on Mahalanobis distances are used for the open-set recognition. Experiments with the benchmark HAR dataset show that the proposed method improves the performance of detecting unknown classes without degrading the accuracy of known classes.

4 **Physics Informed Data Analytics for Industrial Applications**

Jihoon Kang[1], SEOUNG Bum Kim[2], [1]The Tech University of Korea, Siheung Si, Korea, Republic of; [2]Korea University, Seoul, Korea, Republic of.

Physics based models, such as the governing equations, are generally used to understand and express the rule of nature, and they are still applicable to many engineering fields. This research proposes a analytical framework for incorporating physics based models into machine learning algorithms, demonstrating that hybrid approach show higher performance especially when observed data are quantitatively limited and uncertain to the real rule of nature. Effectiveness of proposed idea can be examined through some application cases such as a modelling of sea erosion phenomenon and an optimization problem in friction stir weling process.

Monday, 12:30 PM–1:45 PM

MC02

CC - Room 102

Advances in Responsible AI: From Theory to Practice

General Session

Session Chair

Kinjal Basu, LinkedIn Corporation, Austin, TX

1 **Inclusive Search and Recommendations**

Nadia Fawaz, Pinterest, Palo Alto, CA

To truly bring everyone the inspiration to create a life they love, Pinterest is committed to content diversity and to developing inclusive search and recommendation engines. A top request we hear from Pinners is that they want to feel represented in the product. This is why we built the skin tone range and hair pattern technologies. These machine learning technologies are paving the way for more inclusive inspirations in Search and our augmented reality technology Try-On, and driving advances for more diverse recommendations across the platform. Developing inclusive AI in production requires an iterative and collaborative approach. We have learned the importance of building inclusive systems by design, of measuring to make progress, and of leveraging both artificial and human intelligence. We recognize that these challenges are multi-disciplinary, not just technical.

2 **Equity Analysis in Policy: The Case for a Systems-perspective**

Osonde Osoba, CA

Policy systems (e.g. public health, criminal justice, welfare services) involve decisions on human subjects. Human-focused decision-making typically raises questions about equity. Doing grounded research & analysis to address a multivalent concept like equity comes with significant challenges. This talk will discuss a sample instantiation of an equity-focused policy research program and highlight some challenges we found that motivated a more systems-analytic perspective on equity analysis. Applying this systems-analytic approach served as a fertile framing for more recent work on modeling society-level wealth inequity and some of its primary structural enablers.

3 **Fairness and Non-universal Data - How Differential Missingness Leads to Outcome Disparities and What We Can Do**

Nil-Jana Akpinar, Carnegie Mellon University, Pittsburgh, PA, Contact: nakpinar@andrew.cmu.edu

Machine learning models are prone to suffer from outcome disparities across racial, ethnic, gender, or intersectional groups which can lead to long-lasting adverse effects for already vulnerable populations. In many cases, the culprit for disparate outcomes is biased training data with information deficiency in one of the groups which can take the form of less training data, biased prediction targets or differential noise in features. Previous work has not directly addressed the problem of differentially missing features that can not be readily imputed. Especially in settings with administrative data, information is often only available for subpopulations. We bridge this gap by providing a characterization of the impact of differential missingness on inequity of outcomes across various metrics. As an example, we consider the child welfare screening task.

Monday, 12:30 PM–1:45 PM

MC03

CC - Room 103

Data Mining Impacts

General Session

Session Chair
Subodha Kumar, Fox School of Business, Temple University, Philadelphia, PA

Session Chair
Rakesh Reddy Mallipeddi, Tulane University, New Orleans, LA

1 Impact of The Interplay Between Review Number and Average Rating in Digital Platforms: An Empirical Study

Samayita Guha[1], Naveen Kumar[2], Subodha Kumar[1], Joydeep Srivastava[1], [1]Fox School of Business, Temple University, Philadelphia, PA, [2]University of Washington, Bothell, Norman, OK

Consumers use information such as reviews and ratings of businesses and service providers from online review platforms to make their purchase decision. Hence, all types of businesses maintain their presence on online review platforms to improve their performance. To make their presence felt strongly among other competitors on online review platforms, the businesses need to understand which review characteristic has more influence on consumer purchase decision and in what ways. In this context, it becomes important to understand the interplay between both average rating and number of reviews. To study this interaction empirically, we use a data set about restaurants that are present on Yelp platform. The answer to our research question will help restaurants in allocating their resources more effectively to improve the number of reviews and improve their rating.

2 The Impact of "Word-of-mouth" on The Prescription Practice in India During The Covid-19 Pandemic

Lakshminarayana Nittala[1], Sezgin Ayabakan[2], Subodha Kumar[2], Dileep Unnikrishnan[3], Dileep Raman[3], [1]University of Dayton, Dayton, OH, [2]Fox School of Business, Temple University, Philadelphia, PA, [3]Cloudphysician, Bengaluru, India. Contact: ayabakan@temple.edu

We examine the role of social media in influencing physicians' prescription practices during a healthcare disaster, the COVID-19 pandemic. Our analysis of prescription data from Cloudphysician, the largest Tele-Intensive Care Unit service provider in India, shows that social media chatter increases the prescription rate of remdesivir, especially when it was deemed scientifically proven ineffective against COVID-19. We also find that public desperation for drug procurement, social media user characteristics (number of followers), and positive sentiments of messages shared (joy and trust) have a significant association with remdesivir prescription rate. Our study provides theoretical and practical insights regarding how social media platforms and policymakers should design response strategies in a broader disaster management context.

3 The Effects of ESG Violations on Firm Value

Rakesh Reddy Mallipeddi[1], Subodha Kumar[2], Arvind Mahajan[3], [1]Tulane University, New Orleans, LA, [2]Fox School of Business, Temple University, Philadelphia, PA, [3]Texas A&M University, College Station, TX

In this study, we examine the effects of violations related to the environment, social, and governance (ESG) issues on a firm's financial performance.

Monday, 12:30 PM–1:45 PM

MC04

CC - Room 104
Computational Social Science During COVID-19
General Session

Session Chair
Mayank Kejriwal, University of Southern California, Marina del Rey, CA

1 Multilayer Networks with Higher-order Interaction Reveal The Impact of Collective Behavior on Epidemic Dynamics

Jinming Wan, Changqing Cheng, Binghamton University, Binghamton, NY, Contact: jwan8@binghamton.edu

We present a multi-layer network model, which comprises of two physical layers that symbolize two isolated communities and one social layer that encapsulates the social influence of agents from these two isolated communities, to delineate the epidemic spreading dynamics. High-order interaction in the form of simplicial complexes on the social influence layer is adopted to elucidate the behavior imitation and change of individual agents. This model offers a one-of-its-kind platform to articulate the interaction between physically isolated communities and the ensuing coevolution of behavior change and spreading dynamics. The analytical insights harnessed therefrom provide compelling guidelines on coordinated response and policy design to enhance the preparedness for future epidemics.

2 How Women Promote Greater Social Responsibility on Social Media

Xiang Li[1], Kejia Hu[2], Huibin Du[3], [1]Tianjin University, TianJin, China; [2]Vanderbilt University, Nashville, TN, [3]Tianjin

University, Tianjin, China. Contact: lixiang4016@163.com
As social media has become the primary vehicle for information and communication, much discussion has unfolded about its risks in enabling the spread of misinformation and social irresponsibility. An even more interesting question is which particular participants have the highest likelihood of driving increased social responsibility via social media. Studies have demonstrated that women take more social responsibility as corporate leaders than men do. However, whether women as individuals beyond corporations have a greater impact in the spread of social responsibility on social media has not been studied. This paper evaluates women's voices in communicating social responsibility on social media and how this communication contributes to women's empowerment.

3 Science Gateway for Evidence-Based COVID-19 Publication Analytics

Xiyao Cheng[1], Rolande Oruche[1], Eric Milman[2], Chaitra Kulkarni[3], Kerk Kee[2], Prasad Calyam[1], Hariharan Regunath[1], [1]University of Missouri, Columbia, MO, [2]Texas Tech University, Lubbock, TX, [3]Texas Tech University, Lubbok, TX

The advent of the COVID-19 pandemic has brought about the critical problem of data deluge in medical literature. Medical researchers are having to spend much time finding publications to find clinical solutions. We present a novel science gateway viz., KnowCOVID-19 that we have developed to integrate an evidence-based recommender with a chatbot interface viz., Vidura Advisor to perform knowledge discovery on relevant literature archives and serve queries of users. KnowCOVID-19 comprises of three main modules: (i) evidence-based filtering that observes domain specific topics across a given corpus of literature and classifies the filtered information according to a clinical category, (ii) social filtering scheme that allows diverse experts with similar objectives to collaborate to jointly find answers to critical clinical questions.

4 Understanding Covid-19 Impacts Through Conditional Inference and Regression Analysis on Survey Data

Ke Shen, University of Southern California, CA

The impacts of COVID-19 were not just limited to health, but were also socio-economic in scope. Based on analyses of survey data, it is now well recognized that multiple socio-demographic factors may play important roles in social phenomena such as vaccine hesitancy. In this talk, I will cover several such analyses based on Gallup COVID-specific survey data. The first study aims to quantify the associations between socio-demographic variables and vaccine acceptance (VA) in the US. The study also uses a conditional inference tree to quantify the conditional effects of relevant variables on VA. I will also cover other studies that made similar use of survey data and used regression analysis. I will conclude the talk by discussing the lessons learned, as well as the potential of using rigorous computational social science methods for gaining a better understanding of COVID-19.

Monday, 12:30 PM–1:45 PM

MC05

CC - Room 105
Interpretable Machine Learning for Social Good
General Session

Session Chair
Shixiang Zhu, Carnegie Mellon University, Marietta, GA

1 Developing Data Trust Models in a Community-based Analytics Center

David Gurzick, Hood College, Frederick, MD, Contact: gurzick@hood.edu

With increasing attention towards the use of data-driven methods to provide evidence of impact, community organizations often find engaging with an institution with developed data skills to be strategically aligned to their quest to serve the social good. Yet, partnering with an institution that services the data-needs of multiple organizations brings concerns regarding proprietary or protected information, handling data discrepancies, and public access to combined data sources. We report on the multidisciplinary challenges faced, and decisions made, in crafting data trust models for a community analytics center. Dynamics between the informational intents of the organizations owning the datasets, their professional cultures, and the complexities of the data they possess became compelling factors influencing the sociotechnical design of the data trust models.

2 Understanding and Analyzing the Strengths and Weaknesses of Corporate Social Actions

Jie LI[1], Peter Tashman[2], Joseph Gonzales[3], Asil Oztekin[1], [1]University of Massachusetts Lowell, Lowell, MA, [2]University of Massachusetts Lowell, Lowell, MA, [3]University of Massachusetts Lowell, Lowell, MA

With increasing public attention on corporate social responsibility, companies doing "harm" or "good" to society have eminently impacted the brand image, consumer perception, and investment decisions. This paper investigates the lead-lag association between the strengths and weaknesses of corporate social actions among publicly traded US companies. We use Kinder Lydenburg Domini Ratings Data and company annual reports of S&P 500 companies from 2010 to 2018. We identify and summarize the firm's CSR-related strategy from annual reports using Natural Language Processing. Furthermore, we proposed an exploratory factor analysis for dimension reduction. And using structural equation modeling to test whether detrimental performance ratings of environmental, social and governance (ESG) in one context leads to the exemplary performance of ESG rating in others.

3 A Data-centric Approach to Model Human Behavior Dynamics Under Extreme Weather Events Using Large-scale Mobility Data

Zhiyuan Wei[1], Sayanti Mukherjee[2], [1]University at Buffalo – The State University of New York, Buffalo, NY, [2]University at Buffalo - The State University of New York, Buffalo, NY, Contact: zwei7@buffalo.edu

Understanding the spatiotemporal dynamics of population's behavior under natural disasters is critical for emergency management. Unlike the traditional approaches that rely heavily on surveys with low population coverage, this paper aims to develop a data-centric framework to analyze human activity patterns across socially vulnerable communities under disaster using large-scale mobility data. To examine the social inequity in access to essential services, we formulate a dynamic mobility network based on maximum entropy theory. The framework is applied to Harris County (TX) during the 2021 Winter Storm Uri. We find that people living in low-income areas have a significant mobility reduction to essential facilities such as grocery stores, compared to those in high-income areas. This framework could help decision makers equitably allocate essential reliefs.

Monday, 12:30 PM–1:45 PM

MC06

CC - Room 106

Statistical Methods for Fine-grained Data

General Session

Session Chair

Gourab Mukherjee, University of Southern California, Los Angeles, CA

1 Joint Modeling of Playing Time and Purchase Propensity in Massively Multiplayer Online Role-Playing Games

Gourab Mukherjee, University of Southern California, Los Angeles, CA

Managers of Multiplayer Online Role-Playing Games (MORPGs) rely on predictions of key player responses to design timely interventions for monetization and player retention. However, longitudinal data from these digital products pose several predictive challenges. For instance, the existence of online communities or guilds in these games complicate prediction since players who are part of the same guild have correlated behaviors. Here, we propose a novel statistical framework that incorporates both dependence across players, via focal player's social connections with their friends, as well as time varying guild effects on the future playing behavior. On large-scale data from a popular MORPG, the proposed framework provides superior predictions of key player responses over competing methods.

2 FIXING BAD MARRIAGES - when SHOULD FIRMS REASSIGN SALES REP?

Wreetabrata Kar, Krannert School of Management, Purdue University, West Lafayette, IN

Most B2B firms often reassign customers, systematically and proactively, to sales reps hoping that the benefit of better matching will outweigh the cost of new relationship-building. Despite proactive reassignment being a common practice, researchers have largely overlooked studying what factors could be driving the effects of such reassignment. In this research, we study a pseudo-field experiment where a large, multi-national manufacturing firm engaged in a major proactive reassignment. By leveraging machine learning, we show proactive reassignment is often counterproductive when reassigned rep is a new hire. The estimated individual-level causal effects for each customer afford us the ability to trace out better proactive reassignment, such that we improve firm revenue in the post-treatment period by approximately 8% compared to the decisions made by the firm.

3 Understanding Early Adoption of Hybrid Cars via a New Multinomial Probit Model with Multiple Network Weights

Bikram Karmakar, University of Florida, Gainesville, FL

Modeling demand for durable products such as cars is challenging as we do not have repeated purchases for most customers. One way to try and overcome this data scarcity is to pool information across similar customers. We implement such a pooling strategy by proposing a new multinomial probit model that simultaneously accommodates different network structures among customers by connecting them through multiple weighted networks. Unlike the traditional multinomial spatial probit, our model links consumer connectedness to their preference and marketing mix coefficients so that each subset of the parameter vector is correlated in a unique way. We propose and implement a novel Monte-Carlo Expectation-Maximization (MCEM) based approach to parameter estimation that significantly increases the number of consumers and choice alternatives that the model can handle. Our method modifies the computationally expensive E-step in the classical EM algorithm by a fast Gibbs sampling based evaluation. Further, it implements the M-step using a fast back-fitting method that iteratively fits weighted regressions based on associated similarity matrices for each subset of the coefficients. We establish the convergence properties of the proposed MCEM algorithm, present computational perspectives on the scalability of the proposed method, and provide a distributed computing-based implementation.

Monday, 12:30 PM–1:45 PM

MC07

CC - Room 107

Data Mining for Sustainability and Resilience in Energy Sector

General Session

Session Chair

Feng Qiu, 1</sup

1 Mining Electricity Customer Outage Data

Feng Qiu, Argonne National Laboratory, Lemont, IL

Electricity customer outage is a fundamental measurement for power system service performance. In this talk, we will discuss a large-scale customer outage database and introduce a number of statistical analysis that aims to discover the intrinsic factors that have impacts on outages. We will synchronize the data set with weather information and census database and attempt to reveal the relationship between various factors and outages.

2 LASSO-Based Multiple-Line Outage Identification in Partially Observable Power Systems

Xiaozhou Yang, 1</sup

Phasor measurement units (PMUs) create ample real-time monitoring opportunities for power systems, e.g., line outage detection and identification. Current research on identification has limited success with multiple-line outages and partial PMU observability. In this work, we use the AC power flow model to group lines into minimal diagnosable clusters based on their outage signatures. Identification is then formulated into an underdetermined sparse regression problem. Tested on the IEEE 39-bus system, the method is 93% and 80% accurate for single- and double-line outages. Our study suggests that the AC model is better at capturing signal patterns, and sacrificing some precision could improve identification accuracy.

3 Multi-Agent Deep Reinforcement Learning for Scalable Powergrid Control

Zhaojian Li, 1</sup

In this talk, I will present an efficient multi-agent deep reinforcement learning algorithm for cooperative controls in powergrids. Specifically, the decentralized inverter-based secondary voltage control problem in distributed generators (DGs) is considered and formulated as a cooperative multi-agent reinforcement learning (MARL) problem. I will then talk about a novel on-policy MARL algorithm, PowerNet, in which each agent (DG) learns a control policy based on (sub-)global reward but local states and encoded communication messages from its neighbors. Techniques including spatial discount factor and differential, learning-based communication is employed to foster the collaboration among the neighbors. Experimental results on our developed PGSim environment demonstrate promising performance of the proposed framework.

4 A Reinforcement Learning Method to Accelerate The Benders Decomposition in Stochastic Unit Commitment

Nur Banu Altinpulluk[1], Murat Yildirim[1], Paritosh Ramanan[2], [1]Wayne State University, Detroit, MI, [2]Georgia Institute of Technology, Atlanta, GA, Contact: nurbanu@wayne.edu

Stochastic unit commitment (SUC) is a fundamental optimization problem in power systems with significant computational challenges, which are exacerbated by increasing grid complexity, and operational uncertainty. Evidently, effective SUC solution methodologies play a pivotal role in ensuring competitiveness and reliability. In this talk, we propose a hybrid reinforcement learning and optimization approach for the SUC problem. Our approach accelerates Benders decomposition algorithm by leveraging reinforcement learning to intelligently select a subset of Benders optimality cuts to yield the fastest convergence. We demonstrate that our approach provides significant solution time improvements over traditional Benders decomposition approaches.

Monday, 12:30 PM–1:45 PM

MC08

CC - Room 108
Deep Learning/Machine Learning II
Contributed Session

Session Chair
Yuexi Wang, University of Chicago Booth School of Business, Chicago, IL

1 **When Artificial Intelligence Meets Collective Human Intelligence: An Information Systems Perspective and Research Agenda**

Jiayuan Tian[1], Liangfei Qiu[2], [1]University of Florida, Gainesville, FL, [2]University of Florida Warrington College of Business Administration, Gainesville, FL

Artificial intelligence has been a trending topic in the information systems community. Meanwhile, human intelligence is irreplaceable and makes contributions to decision-making processes. I will present recent IS studies on both artificial intelligence and human intelligence.

2 **Evaluation of Faithfulness of Interpretation Algorithms for Machine Learning Model in Natural Language Processing Task**

Hikaru Sato, Yutaro Yamaguchi, Osaka University, Suita-shi, Japan.

The decision mechanisms of complex machine learning models make it difficult for humans to understand their predictions. In recent years, a lot of interpretation algorithms for complex machine learning models have been proposed. However, a quantitative evaluation method for those algorithms is not established yet. In this study, we propose an evaluation method based on whether the users feel the output explanations as reasonable or not in QA tasks, where each dataset consists of a text, a question, and a correct answer annotated by humans. We evaluate interpretation algorithms by checking whether they correctly recognize the annotated part as important or not. In addition, we analyze the characteristics of datasets by examining the relationship between the correct response rate of the model and the correct response rate of the interpretation algorithm.

3 **Multi-task Learning for Regression with Multivariate Time-series**

Soomin Lee[1], hyein kim[2], Jeongin Koo[3], Dongil Kim[1], [1]Chungnam National University, Daejeon, Korea, Republic of; [2]Korea Institute of Industrial Technology, Cheonan-si, Korea, Republic of; [3]Korea Institute of Industrial Technology, Cheonan, Korea, Republic of.

Multi-task learning (MTL), one of learning paradigms in machine learning, is a concept for learning related tasks at the same time. We propose the MTL-based regression model with multivariate time-series data. The proposed method employs an LSTM-based and CNN-based model composed of skip connections between shared-layers and task-specific layers. We used two UCI open dataset and a real-world dataset for empirical study. In experiments, we compared the performance of the proposed method and several baselines. The experimental results showed that the proposed method has better performance with an efficient model capacity.

4 **Adversarial Bayesian Simulation**

Yuexi Wang, Veronika Rockova, University of Chicago Booth School of Business, Chicago, IL, Contact: yuexi.wang@chicagobooth.edu

In the absence of tractable likelihoods, Bayesians often resort to approximate Bayesian computation (ABC) for inference. Our work bridges ABC with deep neural implicit samplers based on generative adversarial networks (GANs), both of which compare aspects of observed and fake data to simulate from posteriors and likelihoods, respectively. We develop a Bayesian GAN sampler that directly targets the posterior, which is driven by a deterministic mapping learned on the ABC reference by conditional GANs. We propose two local refinements using (1) data-driven proposals with importance reweighing, and (2) variational Bayes. We show the total variation distance between the true and approximate posteriors converges to zero for certain neural networks. Our simulation study shows highly competitive performance relative to other likelihood-free posterior simulators.

Monday, 12:30 PM–1:45 PM

MC09

CC - Room 109
Making Sense of AI Flash Session
Flash Session

Session Chair
Salih Tutun, Washington University in St. Louis, Chesterfield, MO

1 **Chains of Interpretation in Learning Algorithms**

Nicholas Berente, Hong Guo, John Patrick Lalor, University of Notre Dame, Notre Dame, IN

We draw on the literature from strategic transparency, explanation, and interpretation in management decision making to generate theory for understanding the logic of learning algorithms in organizational contexts. We generate a framework that we describe in terms of "chains of interpretation" according to a continuum of abstraction and granularity, and relating to the human, the algorithm, or both. This framework makes a variety of distinctions, including (1) opacity - the degree to which the logic of an algorithm can be codified and made explicit; (2) transparency - decisions to make the specification of models available; (3) explainability - which is the description or codification of models for a particular audience; and (3) interpretability - which involves human comprehensibility of algorithmic logic. Drawing on this framework, we derive propositions.

2 Decision Transformers in Operations

Joren Gijsbrechts, Belgium.

Deep Transformer models have become widely used in Natural Language Processing and Computer Vision applications. Recently, however, they have found their way into sequential decision-making problems. We tested the performance of the so-called Decision Transformer and report on its strenghts and limitations.

3 Can Your Hear Me? Social Cost of Youtube'S Anti-spam Policy on The Deaf Community

Junyuan Ke, Weiguang Wang, University of Rochester, Rochester, NY

As spams become prevalent in online platforms, anti-spam policies are widely adopted while the social cost of such actions is often overlooked. We study YouTube's removal of Community Caption due to anti-spamming policies on the productivity and audience engagement of creators. We specifically examine deaf and hard of hearing (DHH) creators on YouTube whose content rely on self-uploaded captions assisted by the community. We observe a 19.4% reduction in production frequency and a 57.8% reduction in audience engagement for YouTube deaf creators who adopted community captions. Meanwhile, video length and number of comments dropped significantly, probably due to the extra cost of captioning.

4 FORMING EFFECTIVE HUMAN-AI TEAMS: BUILDING MACHINE LEARNING MODELs that COMPLEMENT THE CAPABILITIEs of MULTIPLE EXPERTS

Patrick Hemmer, Karlsruhe Institute of Technology, Karlsruhe, Germany. Contact: patrick.hemmer@kit.edu

Machine learning (ML) models are increasingly used in domains that involve working together with human experts. Here, it can be advantageous to defer certain instances to an expert when they are difficult to predict for the ML model. In this work, we propose an approach that trains a classification model to complement the capabilities of multiple experts. By jointly training a classifier together with an allocation system, the classifier learns to accurately predict instances that are difficult for the experts, while the allocation system learns to pass each instance to the most suitable team member. We show the efficacy of our approach in multiple experiments with "synthetic" and real-world experts.

5 Causal Inference for High Stakes Decisions

Harsh Parikh, Durham, NC

Many fundamental problems affecting the care of critically ill patients have challenges such as estimating the effects of at-risk medical conditions or treatments because the treatment and medical conditions entangled. In this work, we present a framework for interpretable estimation of causal effects for critically ill patients under complex conditions -- not enough high-quality high-dimensional data in observational study, and inability to conduct RCTs. We apply this framework to a problem affecting ICU patients, namely the effect of seizure-like brain activities on long-term outcomes where interpretability is critical for troubleshooting.

6 Modeling and Correcting Bias in Sequential Evaluation

Jingyan Wang, Ashwin Pananjady, Georgia Institute of Technology, Atlanta, GA, Contact: jingyan1216@gmail.com

We consider the problem of sequential evaluation, where an evaluator observes candidates in a sequence and assigns scores to these candidates in an online, irrevocable fashion. We propose a natural model for the evaluator's rating process that captures the bias in such settings, and conduct crowdsourcing experiments to demonstrate various facets of our model. We propose a near-linear time, online algorithm to correct the sequential bias, and prove theoretical guarantees of our algorithm in terms of two canonical ranking metrics, matched with lower bounds demonstrating optimality in a certain sense. Our algorithm outperforms the de facto method of using the rankings induced by the reported scores.

7 Vaccine Allocation Approximation Guarantees for Curbing Outbreaks

Jeffrey Keithley, Akash Choudhuri, Bijaya Adhikari, Sriram Pemmaraju, University of Iowa, Iowa City, IA

We seek to develop near-optimal strategies for timely vaccine allocation to reduce the burden of pandemics. While preventative vaccine allocation is important, effective vaccine allocations in a non-preemptive setting are crucial to stem further damage. We expect to attack these problems by taking advantage of the possible submodularity of the objective function for meta-population models. We expect the problem structure we expose to lead to insights that advance the scalability of vaccine allocation algorithms as we explore various spatial and temporal settings. Our experimental analysis is driven by human mobility datasets, which we utilize through meta-population disease models.

8 Addressing The Data Driven Issues in Federated Learning

Elaheh Jafarigol[1], Theodore B. Trafalis[2], [1]University of Oklahoma, Norman, OK, [2]University of Oklahoma, Norman, OK, Contact: elaheh.jafarigol@ou.edu

There is a burgeoning demand for Federated Learning(FL) and it has great potential in being the solution to environmental-friendly AI and ML at scale. FL is a broad term in data privacy that includes different aspects of data collection, storage, analysis, and communication in a decentralized information system, in which the data centers can not disclose their data for learning purposes. FL is a collaborative learning process between a group of distributed devices referred to as clients, coordinated by a central server. This presentation is an overview of components of FL and our suggested methods for addressing data-related issues in FL.

9 The Maker Framework for Inference and Modelling with Imperfect Data

Jian-Bo Yang[1], Dong-Ling Xu[2], [1]The University of Manchester, Manchester, United Kingdom; [2]Manchester University, Manchester, NJ, Contact: jian-bo.yang@manchester.ac.uk

Maximum likelihood evidential reasoning (MAKER) framework is introduced for inference and modelling with imperfect data. MAKER is established to enable a data-driven intelligent process for modelling probabilistic relationships between system output and multiple inputs. Relationships between output and single inputs and interdependence among inputs are characterised by probability distributions, coined as evidence and acquired from imperfect data via likelihood data analysis. System output is inferred by combination of multiple pieces of evidence acquired from given input values. Parameters of this reasoning process are optimised to maximise the likelihood of true state in system output. A numerical example in healthcare and a case study in human wellbeing analysis are analysed to demonstrate MAKER.

10 MentalMR: Human-centered Framework for Empowering Psychological Understanding

Salih Tutun[1], Gorden Li[1], Yuxiang Wu[1], Ali Tosyali[2], Marina Johnson[3], [1]Washington University in St. Louis, Chesterfield, MO, [2]Rochester Institute of Technology, Rochester, NY, [3]Montclair State University, Montclair, NJ, Contact: salihtutun@wustl.edu

Nowadays, artificial intelligence (AI) offers promising and efficient ways to predict the classification of samples. However, the outcomes of misclassification are serious, and sometimes unaffordable in the medical field. Hence, the goal is to develop an ethical, responsible, socially responsive, and efficient AI solution when dealing with predictions in the medical field. In this research, we propose a responsible AI framework. In the framework, we generated the images by using tSNE, convolution neural networks, and explainable AI approaches for reducing privacy and bias and increasing diagnoses and interpretability. Therefore, we showed how the generated images help to diagnose mental disorders by looking at the images with both high accuracy and high interpretability with accuracy higher than 90 percent even if the experts do not know ML algorithms.

Monday, 12:30 PM–1:45 PM

MC10

CC - Room 110
Network Analytics
General Session

Session Chair
John Rios, University of Georgia, Iowa City, IA

1 How Has Covid-19 Shaken up The Global Supply Chain Networks?—The Role of Geography and Firm Performance

John Rios[1], Mingyue Sun[2], Kang Zhao[2], Suyong Song[2], Elaheh Seyedalikhani[2], [1]University of Georgia, Athens, GA, [2]University of Iowa, Iowa City, IA, Contact: johrios@gmail.com

Maximizing firm value is the ultimate goal of the managers and shareholders. A strong and stable supplier-customer relationship creates value for both trade parties, leading to higher returns for investors of the partner firms. This research implements a dynamic actor-oriented model to analyze the evolution of supply chain networks across different years. We study how various company features (like location or financial performance) and external disruption events (like the COVID-19 pandemic) affect the formation of new ties between business partners and the elimination of existing links. Our results can help to understand how companies decide to start businesses with new customers and suppliers or to stop trading with their current ones.

2 A Clustering Method for Bipartite Network Event Sequences

Aaron Schecter, University of Georgia, Athens, GA

The widespread availability of digital trace data provides new opportunities for understanding human behaviors at a large scale. Sequences of behavior, captured when individuals interface with an information system, can be analyzed to uncover behavioral trends and tendencies. Rather than assume homogeneity among actors, this study introduces a method for identifying subsets within a bipartite network that exhibit similar temporal behavior. This method extends existing methods to account for multiple actor and relation types, and new criteria for evaluating the clustering fit are introduced. Results on synthetic data are discussed.

3 A Privacy-preserving Learning and Control Framework for Demand Response in Power Networks

Sivaranjani Seetharaman, Vipul K. Sharma, Purdue University, West Lafayette, IN, Contact: sseetha@purdue.edu

Demand response (DR) has emerged as a promising paradigm to enhance grid reliability under uncertain renewable generation in future decarbonized power grids by aggregating and shaping the power consumption of consumers' flexible loads such as heating, cooling, and electric vehicle charging at a large-scale. However, typical DR approaches require a large amount of information regarding consumer behavior to guarantee consumer comfort and power constraints while providing meaningful DR potential. In this talk, we will present a safe learning-based optimization and control framework for DR with tradeoffs between consumer privacy and demand response potential that can be tuned according to consumer preference, while being scalable to large-scale networks with thousands of DR consumers.

Monday, 12:30 PM–1:45 PM

MC11

CC - Room 111

Big Data and Deep Learning in Healthcare

Contributed Session

Session Chair

Zhongyuan Chen, Purdue University, West Lafayette, IN

1 An Automated Ontology-based Algorithm to Map Free-text Chief Complaints in Emergency Departments

Neelam Balasubramanian, Mohammad Samie Tootooni, Loyola University Chicago, Maywood, IL, Contact: nbalasubramanian@luc.edu

Emergency Department (ED) chief complaints (CC) are an underutilized source of information about the patient that is available as soon as the patient checks in. Transforming these free-text CCs into structured data enables them to be used in early decision-making in the ED and results in improved patient outcomes and resource management. We proposed a fully automated algorithm, which maps CCs to a previously published structured list. We used the open SNOMED CT coding system to reduce site-specificity. We initially introduced a natural language processing (NLP) heuristic algorithm to create a bag-of-codes SCT-Bank. We then extracted NLP latent concepts from each CC and assigned them to their best-matching categories in the structured list. We compared the results with the existing semi-automated algorithms using data from two distinct institutions.

2 Impact of Institutional Variability and Correlated Multi-level Factors on Post Heart Transplant Survivability Via Statistical Multitask Cox Model

Amanat Ur Rahman[1], Xiaoyu Chen[2], Monica Gentili[2], Jaimin Trivedi[3], [1]University of Louisville, Louisville, KY, [2]University of Louisville, Louisville, KY, [3]University of Louisville, Louisville, KY

For patients with end-stage heart failure, heart transplantation is the gold standard therapy. However, due to donor organ shortage achieving long-term survival is critical. Quantitatively understanding the factors which affect post heart transplant survivability can serve as a basis for further study to reduce mortality rate. Existing studies correlated center volumes with 1-year survivability rate but multi-level factors, such as patient level risk factors, county-level geospatial parameters and socioeconomic factors have not been well studied. This research aims to quantify the contributions of such factors to the 1-year survivability rate by proposing a novel statistical multi-task cox (MTC) model.

3 Mitigating Emergency Department Overcrowding Using Deep Learning

Abdulaziz Ahmed[1], James Booth[2], Amit Lakshmikant Chaudhary[2], Brittany F. Lindsey[2], [1]University of Alabama Birmingham, Birmingham, AL, [2]University of Alabama

Birmingham, Birmingham, AL, Contact: aahmed2@uab.edu
This study presents a deep learning framework to mitigate the problem of emergency overcrowding in hospitals.

4 Data-guided Treatment Recommendation with Feature Scores

Zhongyuan Chen, Purdue University, West Lafayette, IN
We consider the utility of high dimensional genomic-clinical data and nonparametric methods for making cancer treatment recommendations. This builds upon the framework of the individualized treatment rule but we aim to overcome their method's limitations when the method encounters a large number of covariates and an issue of model misspecification. We tackle this problem using a dimension reduction method, Sliced Inverse Regression. With the features obtained from SIR, a simple visualization is used to compare different treatment options and present the recommended treatment. We derive the consistency and the convergence rate of the proposed recommendation approach through a value function. The effectiveness of the proposed approach is demonstrated through simulation studies and the promising results from a real-data example of the treatment of multiple myeloma.

Monday, 12:30 PM–1:45 PM

MC12

CC - Room 113

Data-science for Securing Industrial Cyber-Physical Systems

Joint Session

Session Chair

Dan Li, Clemson University, Greenville, SC

Session Chair

Akash Tiwari, College Station, TX

1 Toward a Cyber-physical Security Range for Manufacturing

Madison Evans, Gregory T. Purdy, Auburn University, Auburn, AL
As manufacturers continue to integrate Industry 4.0 technologies across their systems, the cyber-physical security of these connected facilities becomes more challenging. Despite this shift, there are limited approaches available for evaluating the security of manufacturing systems. This presentation describes a cyber-physical manufacturing range (CpMR) that can be used to meet this need. The proposed CpMR consists of both physical and virtual systems in a networked environment. The virtual component is used to model attacks prior to implementation on the physical system. Together these systems allow for the demonstration and impact analysis of attacks as well as the evaluation of defense mechanisms for manufacturing systems.

2 Generation of Synthetic Production Data with a CNC Simulator Platform

Kyle S. Saleeby, Thomas Feldhausen, Oak Ridge National Laboratory, Knoxville, TN, Contact: saleebyks@ornl.gov
Connected manufacturing processes and equipment provide an increasingly complex surface for cybersecurity exploits. While active process monitoring methods provide a means of attack detection, true production data for model training is expensive and difficult to obtain. Software digital twins have been shown to provide realistic synthetic data but lack characteristic performance attributes that impact the physical process. This research investigates the use of an identical hardware training simulator for a commercial CNC controller platform to provide production-equivalent synthetic data. Data quality, similarity, and suitability for modeling are evaluated for active anomaly detection applications. Other uses for training simulators are proposed as a viable cybersecurity development platform.

3 Multi-agent Coordinated Search-and-rescue Exploration Under Adversarial Communication

Arnab Bhattacharya, Pacific Northwest National Laboratory, Richland, WA
Adversarial interference can severely hinder the performance of agents in a multi-agent system (MAS), particularly for tasks when communication with a centralized control center may not be feasible. An example of such task is the "*search and rescue*" mission, where the agents need to collaboratively explore a physical domain to locate missing assets in the shortest possible time. The key challenges here are that the location of the missing assets are not known a *priori*, and the number of assets is small relative to the exploration area. Using simulation, we demonstrate that the adversarial behavior for such a use case can significantly increase the time taken by the agents to complete their mission. We then propose a threat mitigation approach, that can limit the performance deterioration in MAS that such adversaries can trigger.

Monday, 12:30 PM–1:45 PM

MC13

CC - Room 114

Network Optimization and Applications

Joint Session

Session Chair

Hamidreza Validi, Rice University, Houston, TX

Session Chair

Brandon Alston, Rice University, Houston, TX

1 Mixed Integer Linear Optimization Formulations for Learning Optimal Binary Classification Trees

Brandon Alston, Hamidreza Validi, Illya V. Hicks, Rice University, Houston, TX, Contact: bca3@rice.edu

Decision trees are powerful tools for classification and regression that attract many researchers working in the burgeoning area of machine learning. A binary classification decision tree has two types of vertices: (i) branching vertices at which datapoints are assessed on a set of discrete features and have exactly two children; and (ii) leaf vertices at which datapoints are given a discrete class. An optimal binary classification tree can be obtained by solving a biobjective optimization problem that seeks to (i) maximize the number of correctly classified datapoints and (ii) minimize the number of branching vertices. In this paper, we propose four mixed integer linear optimization ($\milo$) formulations for designing optimal binary classification trees: two flow-based formulations and two cut-based formulations.

2 MIP Formulations for Partitioning a Graph into Low-diameter Clusters

Hamidreza Validi[1], Logan Smith[1], Austin Buchanan[2], Illya V. Hicks[1], [1]Rice University, Houston, TX, [2]Oklahoma State University, Stillwater, OK

In this talk, we study the problem of partitioning the vertices of a graph into s-clubs (the s-clustering problem). An s-club is a subset of vertices for which the diameter of its induced subgraph is at most s. We propose Mixed Integer Programming (MIP) formulations with length-bounded constraints and compare them with the existing ones theoretically and computationally. We also provide positive and negative approximation results for the problem. Furthermore, we develop heuristics and fixing procedures to improve the performance of our MIP formulations. Finally, we provide a logic-based Benders decomposition approach for solving the MIP models. We test our s-clustering MIP formulations on a large set of benchmark instances. Our codes and data will be available on GitHub.

3 The Influence-Coverage Optimization Problem

Majid Akhgar Farsani, Juan S. Borrero, Oklahoma State University, Stillwater, OK, Contact: majid.akhgarfarsani@okstate.edu

We introduce the Influence Coverage Optimization Problem (ICOP), in which a network's nodes get activated (i.e., influenced) either by the influence that comes from social interactions with active in-neighbors or by entering the coverage area of a physical ad or a Geo-fence. The aim is to locate a fixed number of physical ads or Geo-fences and modify the network influence rates to minimize the time that takes the entire network becomes active. Assuming a Markovian influence framework, we discuss MIP formulations under different coverage modes, modelling enhancements, heuristics, and MIP techniques that facilitate solving the ICOP.

4 On Polynomial-time Solvable Nonlinear Optimization Problems with Indicators

Shaoning Han, Andres Gomez, University of Southern California, Los Angeles, CA, Contact: shaoning@usc.edu

Optimization problems with nonlinear terms and indicator variables arise pervasively in operational and machine learning problems. Solution methods for such problems typically involve constructing a strong convex relaxation of the feasible region of the optimization problem, which are then used in enumerative algorithms such as branch-and-bound. In this talk, we study a broad class of problems which admit polynomial-time algorithms, and thus can be solved much more efficiently.

Monday, 12:30 PM–1:45 PM

MC14

CC - Room 115

Data-Driven Healthcare: From Predictions to Decisions

General Session

Session Chair

Kyra Gan, Carnegie Mellon University, Pittsburgh, PA

Session Chair

Zachary Lipton, Carnegie Mellon University

1 A Cross-modal Autoencoder Framework Learns Holistic Representations of Cardiovascular State

Adityanarayanan Radhakrishnan, MIT, Cambridge, MA

A fundamental challenge in diagnostics is integrating multiple modalities to develop a joint characterization of physiological state. Using the heart as a model system, we develop a cross-modal autoencoder framework for integrating data modalities and constructing representations of cardiovascular state. In particular, we use our framework to construct such cross-modal representations from cardiac magnetic resonance images (MRIs), containing structural information, and electrocardiograms (ECGs), containing myoelectric information. We leverage learned cross-modal representation to (1) improve phenotype prediction from a single, accessible phenotype such as ECGs; (2) enable imputation of hard-to-acquire cardiac MRIs from easy-to-acquire ECGs; and (3) develop a framework for performing genome-wide association studies in an unsupervised manner.

2 Using Casual Machine Learning for Treatment Recommendation in Acute Settings

Rom Gutman, Sheiba Shimon, Oren Caspi, Doron Aronson, Uri Shalit, Technion, Haifa, Israel.

In this talk, I'll discuss the idea of learning how to individualize patient treatments based on data such as electronic medical records, patient generated data, and clinical trial data. I will present the notion of causality and explain why "ordinary" supervised machine learning is insufficient in many cases for properly learning individualized treatments, and why learning such treatment is strictly more challenging. I will present a framework for evaluating whether a given clinical problem and dataset are amenable for learning individualized treatments, and will briefly show case study in acute heart failure care.

3 When Do Causal Questions Require Causal Answers?

Rajesh Ranganath, 1</sup

Many machine learning for healthcare projects start out with taking a target and predicting it with some input or features. This setup makes sense for perceptual problems where the target is determined by the data. However, for questions where the prediction will be used to guide a decision there can be a mismatch in how the models are trained and how models are used because of the omission of causality. In this talk, I will discuss the mismatch in different types of predictive models despite their popularity. I will follow this by a high level overview of two approaches, one to construct causal estimates in the presence of functional confounding and to construct conditional average effect estimates from a mix of observational data and a population level effect from a randomized trial.

Monday, 12:30 PM–1:45 PM

MC15

CC - Room 120
Managing Hospital Operations
General Session

Session Chair
Nan Liu, Boston College, Chestnut Hill, MA

1 An Optimization-embedded Simulation Approach for Scheduling Prenatal Care Visits

Leena Ghrayeb[1], Amy Cohn[2], Ruiwei Jiang[2], Alex Peahl[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: lghrayeb@umich.edu

Despite widespread utilization and high levels of spending on prenatal care, the U.S. has the highest maternal mortality rate amongst peer high income nations. Tailoring the frequency of prenatal care appointments to patients' medical and social needs is hypothesized to provide higher value care - however, the operational impacts of these policies are still unknown. We propose an optimization-embedded simulation model to schedule patients for their prenatal care pathway appointments, and draw conclusions abut the effects of switching from the current "one size fits all" treatment paradigm (in which all patients follow the same sequence of prenatal visits) to a more personalized "right-sized" approach.

2 Does Delay Stimulate Speedup? Evidence from Operating Rooms

Yiwen Jin[1], Yichuan Ding[2], Steven Shechter[3], Jugpal Arneja[4], [1]University of British Columbia, Vancouver, BC, Canada; [2]McGill University, Montreal, QC, Canada; [3]University of British Columbia, Vancouver, BC, Canada; [4]University of British Columbia, Vancouver, BC, Canada. Contact: yiwen.jin@sauder.ubc.ca

We study how surgical teams respond to real-time deviations from schedules and the associated impact on surgical quality using a unique administrative surgery dataset. We conduct GMM estimation based on Arellano-Bond method. We identify a negative feedback mechanism of surgical teams where they expedite by 1.5 to 2.0 minutes on average when facing ten-minute delay and vice versa. This effect is more evident among senior surgeons and among cases in the latter part of shift. We propose a novel instrument variable to identify the speedup's impact on surgical quality and we find speedup increases 7/30-day readmission rates. A further counterfactual analysis unveils how such mechanism moderates shift end times and surgical quality.

3 Resource Allocation in Chronic Patient Care

Tolga Tezcan[1], Mustafa Gokcen Goksel[2], Nicos Savva[2], [1]Rice University, Houston, TX, [2]London Business School, London, United Kingdom. Contact: mgoksel@london.edu
Chronic patients need to be seen in specialty chronic care clinics at the frequency recommended in the medical guidelines, while newly referred patients should be seen without excessive wait to prevent their condition to deteriorate. Due to the limited number of providers that the clinics have, they need to carefully plan how to schedule appointments for these two different patient types. We develop a solution methodology to determine effective appointment scheduling for these clinics by modelling them as a network of queues with time-varying arrivals and capacity; and using a scenario-based stochastic optimization approach. We present a heuristic solution algorithm and demonstrated its performance via extensive numerical experiments.

4 Advance Notice of Diagnostic Service for Hospital Inpatients

Miao Bai[1], Nan Liu[2], Zheng Zhang[3], [1]University of Connecticut, Storrs, CT, [2]Boston College, Chestnut Hill, MA, [3]Zhejiang University, Hangzhou, China. Contact: miao.bai@uconn.edu
Inpatients are often viewed as ``on-demand” for diagnostic service and they are notified only when service capacity is available. This way of arrangement causes chaos and inefficiencies in diagnostic service. Informed by a unique dataset collected at Mayo Clinic, we develop an MDP-based advance notice policy for inpatient diagnostic service.

Monday, 12:30 PM–1:45 PM

MC16

CC - Room 121

Job Talk Lightning Session

Flash Session

Session Chair

Pengyi Shi, Purdue University, West Lafayette, IN

Session Chair

Sait Tunc, Virginia Tech, Blacksburg, VA

01 Session Description

Pengyi Shi, Purdue University, West Lafayette, IN
This session will give graduate students and postdocs who are “on the job market” an opportunity to present their healthcare-related research in a flash session. This session targets those looking for academic positions with a focus on health application and/or theory.

02 Flash Paper

Sundara Natarajan Panchanatham, INSEAD, Singapore, Singapore.
Treating many blood-related diseases requires the transplantation of genetically compatible stem cells extracted from the bone marrow (BM) of live donors or umbilical cord blood (CB) cells of babies. The BM donors are a cost-effective source with strict matching requirements whereas the CB units are a flexible but cost-intensive source. For medical reasons, BM donors are always the first choice for a transplant and only the unmet demand spills over to the CB bank. With ten million unique genetic types in the U.S., alongside both demand and supply uncertainty, it is unclear what the optimal inventory policy should be for the CB banks. We derive analytical and heuristics-based cost-effective inventory policies without compromising the matching probabilities.

03 Flash Paper

Juan Senga, HP-NTU Digital Manufacturing Corporate Laboratory, Singapore, Singapore.

04 Flash Paper

Harshita Kajaria-Montag, University of Cambridge, Leamington Spa, United Kingdom.

05 Flash Paper

Jeremy Watts, University of Tennessee, Knoxville, TN

06 Flash Paper

Alba Olivares Nadal, University of Zurich, Zürich, Switzerland.

07 Flash Paper

Arielle Elissa Anderer, The Wharton School, University of Pennsylvania, Philadelphia, PA

08 Flash Paper

Kan Xu, University of Pennsylvania, Philadelphia, PA
Decision-makers often face the “many bandits” problem, where one must simultaneously learn across related but heterogeneous contextual bandit instances. We study the setting where the unknown parameter in each bandit instance can be decomposed into a global parameter plus a sparse instance-specific term. Then, we propose a novel two-stage estimator that exploits this structure efficiently by using a combination of robust statistics (to learn across

similar instances) and LASSO (to debias the results). We embed this estimator within a bandit algorithm, and prove that it improves asymptotic regret bounds in the context dimension d; this improvement is exponential for data-poor instances. We further demonstrate how our results depend on the underlying network structure of bandit instances. Finally, we illustrate the value of our approach on synthetic and real datasets.

09 Flash Paper

Veronica White, University of Wisconsin Madison, Madison, WI

10 Flash Paper

Syed Hasib Akhter Faruqui, Northwestern University, Chicago, IL

11 Flash Paper

Behnam Malmir, Virginia Tech, Charlottesville, VA

12 Flash Paper

Zhuoting Yu, Georgia Institute of Technology, Atlanta, GA

13 Flash Paper

Daniel Felipe Otero-Leon, University of Michigan, Ann Arbor, MI

14 Flash Paper

Qian Cheng, University of North Carolina at Chapel Hill, Carrboro, NC

15 Flash Paper

Jaeyoung Kim, Clemson University, Clemson, SC

16 Flash Paper

Isabelle Jueli Rao, Stanford University, Stanford, CA

17 Flash Paper

Berk Gorgulu, University of Toronto, Toronto, ON, Canada.

Monday, 12:30 PM–1:45 PM

MC17

CC - Room 122

Personalized and Genetic-based Healthcare Operations

General Session

Session Chair

Kanix Wang, University of Chicago, Chicago, IL

1 Simulation-based Sets of Similar-performing Actions in Finite Markov Decision Process Models

Wesley Marrero, Dartmouth College, Hanover, NH, Contact: Wesley.Marrero@dartmouth.edu

Markov decision process (MDP) models have been used to obtain and evaluate the performance of policies in various domains, such as treatment planning in medical decision making. However, in practice, decision makers may prefer other alternative that are not statistically different from the actions in their initial policy of interest. To allow for decision makers' expertise and provide flexibility in implementing policies, this talk introduces a framework for identifying sets of similar-performing actions in finite MDP models.

2 An Optimization Framework for Customized Targeted Mass Screening of Non-uniform Populations Under The Availability of Multiple Schemes and Tests

Jiayi Lin[1], Hrayer Aprahamian[1], George Golovko[2], [1]Texas A&M University, College Station, TX, [2]The University of Texas Medical Branch, Galveston, TX, Contact: hrayer@tamu.edu

We study the problem of designing targeted mass screening of non-uniform populations which is essential in a variety of settings, e.g., mitigating the transmission of infectious diseases. We address this problem by proposing a proactive optimization-based framework that factors in population heterogeneity, limited budget, different testing schemes, the availability of multiple assays, and imperfect assays. By analyzing the model, we establish key properties which enable us to develop an efficient globally convergent threshold-style solution scheme. We conduct a nationwide case study on targeted COVID-19 screening in the US. Our results reveal that the identified strategies substantially outperform conventional practices while providing valuable managerial insights with regards to the distribution of testing assays and resources across geographic regions.

3 Testing with Limited Capacity and Pooling

Alex Mills[1], Serhan Ziya[2], [1]Baruch College, City University of New York, New York, NY, [2]University of North Carolina, Chapel Hill, NC, Contact: alex.mills@baruch.cuny.edu

We study the question "who should be tested" for a disease like COVID-19 when patients are heterogeneous and tests are limited. Using a two-stage model, we show that the answer to this question changes when pooled testing is an option, and that a combination of pooled and individual tests may be optimal.

4 **Optimal Genetic Testing of Families**

Kanix Wang[1,2], Daniel Adelman[3], [1]University of Chicago, Chicago, IL, [2]University of Cincinnati, Cincinnati, OH, [3]University of Chicago, Booth School of Business, Chicago, IL, Contact: kanix.wang@chicagobooth.edu

Knowing an individual's genetic status informs family disease risks, but current guidelines only consider one person rather than designing an optimal family testing plan. We develop a Markov decision process framework for maximizing the net benefits of genetic testing, which integrates a Bayesian network of genetic statuses, with a functional representation of cost-effectiveness. Our model provides a contingent plan that dynamically incorporates new test results, revealed sequentially at random, to decide who next to test. We show that the optimal family stopping follows a structure with two-sided thresholds in the general case. Further, for sibling testing, the optimal sequence can be fixed a priori. Using the BRCA1/2 genes as a test case, we show that our policy simultaneously increases quality-adjusted life years while decreasing testing costs.

Monday, 12:30 PM–1:45 PM

MC18

CC - Room 123

COVID Modeling and Decision Making

Flash Session

Session Chair

Maria Mayorga, North Carolina State University

1 **Mitigating The COVID-19 Pandemic Through Data-driven Resource Sharing**

Esmaeil Keyvanshokooh[1], Mohammad Fattahi[2], Kenneth Freedberg[3], Pooyan Kazemian[4], [1]Texas A&M University, College Station, TX, [2]Newcastle Business School, Newcastle, United Kingdom; [3]Harvard Medical School, Boston, MA, [4]Case Western Reserve University, Cleveland, OH

Amid local outbreaks of COVID-19, many hospitals canceled elective procedures to preserve ventilator capacity for COVID-19 patients. The virus spreads at varying rates, causing demand for care to peak at different times across different regions. Hence, sharing scarce portable resources can help alleviate local capacity shortfalls. We develop a data-driven adaptive robust simulation optimization method for allocating and relocating ventilators among different regions of multiple states to satisfy demand with fewer total ventilators. Proof of concept is given by a case study of sharing ventilators among regions in Ohio and Michigan.

2 **Modeling The Impact of Non-pharmaceutical Interventions on Covid-19 Transmission in K-12 Schools**

Yiwei zhang[1], Maria Mayorga[1], Julie Ivy[1], Kristen Hassmiller Lich[2], Julie L. Swann[1], [1]North Carolina State University, Raleigh, NC, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC, Contact: yzhang85@ncsu.edu

In the US, children are at high risk of being exposed to COVID-19 due to low vaccination rates. Thus, non-pharmaceutical interventions (NPIs) are important for controlling the spread of COVID-19 in K-12 schools. We developed a multi-grouped SEIR model and simulated the varied and layered mitigation strategies used by school districts during the pandemic. We analyzed the impact of different NPIs on COVID-19 transmission within K-12 schools. We find that masks, reducing contacts and weekly screening can greatly reduce new infections among students. Self-quarantining symptomatic infections and school closures are effective for decreasing semester-end infections but increase absenteeism.

3 **Operational Modeling to Inform a Health System Response to COVID-19**

Brian W. Patterson[1], Joel Galang[2], Oguzhan Alagoz[3], Ajay K. Sethi[1], Nasia Safdar[4], Croix Christenson[2], Matthew Churpek[1], Frank Liao[2], [1]University of Wisconsin, Madison, WI, [2]UW Health, Madison, WI, [3]University of Wisconsin-Madison, Madison, WI, [4]UNIVERSITY OF WISCONSIN-MADISON, MADISON, WI, Contact: bpatter@medicine.wisc.edu

In the first phase of the COVID-19 pandemic, hospital systems were faced with difficult choices: a cautious response could potentially harm patients by deferring routine care, while continuing with usual operations risked not having the capacity on hand to manage surges safely. Our system convened a multidisciplinary team to provide periodic reports to leadership predicting COVID-19 activity and its impact in terms of beds needed for both our system and the surrounding region. By establishing an operational reporting timetable, and combining the results of three distinct modeling techniques, we were able to provide a timely synopsis of local predicted COVID-19 activity to guide these decisions.

4 **Understanding the Impact of COVID-19 on Student Well-Being Using Longitudinal Survey Data**

Danika Dorris, Julie Simmons Ivy, Maria Esther Mayorga, North Carolina State University, Raleigh, NC, Contact: dmdorri2@ncsu.edu

The COVID-19 pandemic has taken a toll on students' mental health. Survey responses were collected from undergraduate engineering students which captured factors related to well-being, environment, and academic performance over the course of a semester during COVID-19. Machine learning methods were used to understand how students' mental well-being fluctuates over the course of the semester and may be impacted by COVID-19.

5 Examining Inequities Induced by COVID-19 Interventions

Vysaaly Sivakumaar[1], Shakiba Enayati[2], Ekundayo Shittu[3], [1]George Washington University, Washington, D.C, DC, [2]University of Missouri - Saint Louis, St Louis, MO, [3]The George Washington University, Washington, DC, Contact: vysaaly@gwmail.gwu.edu

The goal of this project is to examine the heterogeneous impacts of stipulated interventions at the peak of the COVID-19 health crisis. With the aid of COVASIM, a simulation platform, we examine the equity implications of the prescribed interventions and report our intriguing observations and incisive recommendations for healthcare policy.

6 The Path to Herd Immunity: How past Infection and Vaccination Differentially Protect a Population

Kaiming Bi, UT Austin, Austin, TX, Contact: kaiming.bi@autsin.utexas.edu

The susceptibility of a population to Covid depends on the overall immunity level. However, the relationship between the proportion immunized and the viral transmission rate depends on a number of complexities, including the magnitude and durability of vaccine-acquired and infection-acquired immunity. Here, we use a network model to elucidate another key difference between infections and vaccinations that can shape community susceptibility. As viruses spread, they disproportionately infect individuals with higher levels of exposure, the central nodes in human contact networks. Naturally occurring outbreaks may thus leave more protective wakes of immunity than mass vaccination campaigns

Monday, 12:30 PM–1:45 PM

MC19

CC - Room 124
HAS Distinguished Lectures
General Session

Session Chair
Anahita Khojandi, University of Tennessee, Knoxville, TN

Session Chair
Timothy Chan, University of Toronto, Toronto, ON, Canada.

1 Examining Resiliency in Pharmaceutical Drug Supply

Ozlem Ergun, Northeastern University, Boston, MA, Contact: o.ergun@northeastern.edu

Between 2008 and 2014, there was a 393% increase in shortages for direct lifesaving emergency medicines. The underlying causes of some shortages include a wide variety of disruptions from manufacturing suspensions due to production challenges to the physical impact of whether hurricanes on critical manufacturing sites. We present an integrated simulation framework, which allows for instantiating, testing, and improving supply chains when accounting for human components of the system. We examine how manufacturing disruptions in a pharmaceutical supply chain impact evolving trust dynamics among the stakeholders during and after a disruption and study the implications of these dynamics for the supply chain performance.

2 Optimal Treatment Models: Past, Present and Future

Andrew J. Schaefer, Rice University, Houston, TX

Optimal disease treatment models were first proposed over 50 years ago, and continue to be an active area of research. We summarize the literature, survey the state of the art, and discuss exciting areas of future research.

Monday, 12:30 PM–1:45 PM

MC20

CC - Room 125
Technology and Decision Analysis in Healthcare
General Session

Session Chair
Yeongin Kim, Virginia Commonwealth University, Glen Allen, VA

Session Chair

Abraham Sen, Virginia Commonwealth University, Richmond, VA

1 Impact of Mobile App-based Peer Community on Patient Distress Reduction

Miyeon Jung[1], Yong Chung[2], Sae Byul Lee[2], [1]University of Nevada, Las Vegas, Las Vegas, NV, [2]University of Ulsan College of Medicine, Seoul, Korea, Republic of.

As a new way to change health behavior, mobile technology is attracting attention from many researchers. This study aimed to investigate the effect of a mobile app-based community on PA enhancement and mitigation of depression in breast cancer survivors. A randomized controlled trial was conducted with a daily step counting app and a weekly distress survey using an app-based distress thermometer (DT) questionnaire for approximately 24 weeks. A total of 202 participants were enrolled in this study. By engaging the mobile community, participants showed a significant increase in their total weekly steps and a decrease in their DT scores. The mobile app-based community is an effective and resource-intensive tool to increase PA and reduce distress in breast cancer survivors.

2 Why Democratize Health Data? The Dynamics of Balancing Contextual Norms, Control and Data Sharing Choice

Hyeyoung Hah, Florida International University, Weston, FL, Contact: hhah@fiu.edu

Data democratization in healthcare is fast reshaping the traditional ways of healthcare delivery and customization. Data owners often share their data without explicit incentives, which creates tension between privacy concerns and data sharing. To understand such tension, we conceptualize health data democratization as an act of benefiting others, and its unique contextual norms that benefit self or others disproportionately change the dynamics of health data democratization. Our results present that health data owners experience a complex decision-making process in that the mediation effects only take place when they perceive a benefit, and their decision varies by contextual norms. Practically, we show health data owners still demonstrate contradicting behavior concerning who controls the data and why democratize it.

3 Racial Disparities in The Availability of Social Determinants of Health Information in EHR Data

Junjie Luo[1], Shiping Liu[1], Guodong (Gordon) Gao[2], Agarwal Ritu[1], Nawar Shara[3], [1]University of Maryland, College Park, College Park, MD, [2]University of Maryland, College Park, College Park, MD, [3]Medstar Health Research Institute, Hyattsville, MD, Contact: jjluo@umd.edu

Disparities in data availability have been identified as a root cause of AI biases. Using EHR data of 12,216 patients with prediabetes between 2010 to 2015, we examine four diabetes-related behavioral factors: smoking status, alcohol use, diet, and exercise information. We found substantial disparities in data availability across races. Our analyses show that Black patients were less likely than White patients to have related records. After controlling for physician-related information and features, racial differences in presence of all behavioral features became insignificant in the observational period. Our analysis indicates that disparities in EHRs exist between different race groups in the first year of diagnosis of prediabetes. After controlling for physician-level fixed effects, racial disparities became insignificant for the behavioral factors.

Monday, 12:30 PM–1:45 PM

MC21

CC - Room 126

Social Forecasting

General Session

Session Chair

Ville Satopaa, INSEAD, Paris, France.

2 The Replication Markets Project: Preliminary Results, Lessons, and Opportunities

Yang Liu, UC Santa Cruz, Santa Cruz, CA

The last decade saw the emergence of systematic large-scale replication projects in the social and behavioral sciences. These projects were driven by theoretical and conceptual concerns about a high fraction of false positives in the scientific publications and a high prevalence of questionable research practices. In this talk, I will introduce our Replication Markets project (https://www.replicationmarkets.com/), as part of the DARPA SCORE program that aims to scale up the evaluation of research replications. I will discuss the challenges we encountered and present some preliminary findings from the human forecasting data we collected from both the markets and surveys. I will also share some of our lessons learned, as well as opportunities.

3 Robust Recalibration of Aggregate Probability Forecasts Using Meta-beliefs

Cem Peker[1], Tom Wilkening[2], [1]Erasmus University Rotterdam, Rotterdam, Netherlands; [2]University of

Melbourne, Melbourne, Australia. Contact: acpeker@gmail.com

Previous work suggests that aggregate probabilistic forecasts on a binary event are often conservative. Extremizing transformations that adjust the aggregate forecast away from the uninformed prior of 0.5 can improve calibration in many settings. However, such transformations may be problematic in decision problems where forecasters share a biased prior. In these problems, extremizing transformations can introduce further miscalibration. We develop a two-step algorithm where we first estimate the prior using each forecasters' belief about the average forecast of others. We then transform away from this estimated prior in each forecasting problem. Evidence from experimental prediction tasks suggest that the resulting average probability forecast is more robust to biased prior than alternative methods proposed in the literature and improves calibration.

4 Overcoming Crowd Wisdom Challenges with a Bayesian Model of Social Beliefs

John McCoy, University of Pennsylvania, Philadelphia, PA

Tapping crowd wisdom has many advantages for decision making. However, a group's average judgment is often incorrect, shared information can result in correlated errors, and weighting by confidence does not guarantee accuracy. We develop a Bayesian hierarchical model to address these challenges, which incorporates predictions about the beliefs of others. The proposed model both applies to single questions, and can estimate respondent expertise given multiple questions. Unlike existing Bayesian hierarchical models for aggregation, the model does not link the correct answer to consensus. The model extends the "surprisingly popular algorithm" (an aggregation method that uses predictions of others) to enable statistical inference, and overcomes several of its limitations. We assess model performance on empirical data.

Monday, 12:30 PM–1:45 PM

MC22

CC - Room 127

Analytics for Assessing and Improving the Integration of Immigrants and Refugees in Host Communities

General Session

Session Chair

Gina Maria Galindo Pacheco, Cheektowaga, NY

1 A Data-driven Decision Tool for The Resettlement of Venezuelan Immigrants in Colombia

Gina Galindo, Jose Navarro, Jhonattan Reales, Castro Jhoan, Daniel Hernando Romero, Sandra Rodriguez, Daniel Rivera, Universidad del Norte, Barranquilla, Colombia. Contact: ggalindo@uninorte.edu.co

This research delivers a data-driven tool to recommend resettlement locations for immigrants, to improve their socio-economic integration in the host country. The methodology adapts an algorithm developed by the Immigration Policy Lab at Stanford University for its application to the arrival of Venezuelan immigrants in Colombia, where important gaps can be found among resettlement locations in terms of job opportunities and access to social services. The methodology uses machine learning algorithms to predict the probability of socio-economic integration of immigrants. It also considers the absorptive capacity of locations in Colombia and include the health and education needs of immigrants. From the application in the Venezuelan-Colombian context, the proposed redistribution increases the probability of socio-economic integration by more than 50%.

2 Big Moves: Understanding Migration and Relocation Dynamics

Isabella Loaiza, MIT, MA

The challenge of making relocation decisions is fertile ground to pose a new direction in the quest for extended human intelligence. This paper explores the impact of social connectivity, job history, and homphily on the decision to relocate and migrate, and suggests ways in which these insights can be used to build systems to aid in relocation decisions.These systems seek to foster social learning between community members to improve the match between migrants and their potential new communities so that both can reap the benefits of the move. This approach stands in contrast to top-down approaches that use algorithms to match individuals and places, as is the case for some refugee relocation programs.

Monday, 12:30 PM–1:45 PM

MC23

CC - Room 128

Humanitarian Operations and SDGs: Progress Today II

General Session

Session Chair
Erica L. Gralla, George Washington University, Washington

Session Chair
Maria Besiou, Kuehne Logistics University Gmbh, Hamburg, Germany.

1 Keepwater Flowing The Hidden Crisis of Ensuring Rural Water Supply in Sub-saharan Africa

Chengcheng Zhai, Rodney P. Parker, Kurt M. Bretthauer, Jorge Mejia, Alfonso J. Pedraza-Martinez, Indiana University, Bloomington, IN, Contact: zhaic@iu.edu

In rural areas of developing countries, people rely on individual hand-pumps as their only safe drinking water supply. Building new water points such as hand-pumps is the main operational response to mitigate the drinking water crisis by dedicated non-governmental organizations (NGO). Such water points provide people with their first and likely only access to clean water. However, it is estimated that across SSA around one in four hand-pumps are non-functioning at any given moment, which in 2015 was roughly equivalent to 175,000 inoperative water points and 1.5-2.5 billion US dollars in capital investment. In this project, we study a circuit-rider program that is commonly implemented to increase water point functionality, using a stochastic dynamic model .

2 Modeling Market Systems in a Humanitarian Crisis

Tristan Downing[1], Jarrod D. Goentzel[1], Maria Besiou[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Kuehne Logistics University Gmbh, Hamburg, Germany.

Humanitarian organizations increasingly use cash and vouchers to provide assistance, but there is a limited ability to model market dynamics during complex emergencies. Working with the International Committee of the Red Cross (ICRC), and focusing on a complex emergency in northeast Nigeria, we create a novel market system model that holistically captures the demand for food during a crisis, and the response of supply chain actors. We find that to improve the availability and affordability of food when cash assistance is being provided to affected populations, marginal spending on credit for supply chain actors can be orders of magnitude more cost-effective than marginal spending on cash assistance. We also identify market conditions to further improve affordability and availability while reducing spending, linking humanitarian and development interventions.

3 Optimal Investment of Farming Mechanization

Ying Zhang[1], Jayashankar M. Swaminathan[2], [1]Clemson University, Clemson, SC, [2]University of North Carolina Chapel Hill, Chapel Hill, NC, Contact: ying6@clemson.edu

Adopting mechanization in farming is a fundamental and sustainable approach to increase agricultural productivity. We study the procurement of seeds and farm equipment for a single crop under budget and land constraint. We use a Cobb Douglas function to model the agriculture output. Within the monopoly model, we show that the optimal procurement policy of the seeds and farming equipment is a threshold type policy and the budget threshold is non-decreasing in the land size.

4 Analysis of Social Capital in Smallholder Supply Chains

Megan Peters, George Washington University, Washington, DC, Contact: petersml@gwu.edu

The network of partnerships between buyers and suppliers is the foundation for a market system. The partnerships themselves and the value creation mechanisms within them has not been studied much in smallholder economies. The researchers conducted open-ended interviews in Mbale, Uganda. The goal was theoretical saturation on value creation mechanisms from distinct relationships for different value chain agents. The findings are compared and contrasted across agent populations and across extant literature. This research can be beneficial for practitioners, program designers, and policy makers in international development.

Monday, 12:30 PM–1:45 PM

MC25

CC - Wabash 2

Teaching Supply Chain Analytics - From Problem Solving to Problem Discovery

Tutorial Session

Session Chair
Mabel Chou, National University of Singapore, Singapore, Singapore.

1 Teaching Supply Chain Analytics: from Problem Solving to Problem Discovery

Yao Zhao, Rutgers University, Newark, NJ

Mainstream teaching of supply chain analytics focuses on model-driven predictive and prescrip-tive analytics to solve problems. Data-driven descriptive and diagnostic analytics to define and discover problems is almost entirely missing from the curriculum. The reason, as some believe, is that the latter is easier and of a lower value. But Steve Jobs once said: "If you can define the problem correctly, you almost have the solution." Problem discovery by descriptive and diag-nostic analytics is not only highly valuable but can also be difficult - it is just difficult in a dif-ferent way from problem solving. One key challenge is data interpretation, that is, transforming data into insights - INFORMS's definition of Analytics. In this tutorial, I summarize recent de-velopment and education modules that use descriptive and diagnostic analytics to define and discover problems based on data in various supply chain domains from source, make, move, sell to integration. I showcase the value and methodology by inventory analytics, sourcing analytics and competitive intelligence.

Monday, 12:30 PM–1:45 PM

MC27

CC - Room 138

Nonprofit Operations Management

General Session

Session Chair

Telesilla Olympia Kotsi, The Ohio State University, Columbus, OH

1 Allocation of Nonprofit Funds Among Program, Fundraising, and Administration

Telesilla Olympia Kotsi[1], Arian Aflaki[2], Goker Aydin[3], Alfonso J. Pedraza-Martinez[4], [1]The Ohio State University, Columbus, OH, [2]University of Pittsburgh, Pittsburgh, PA, [3]Johns Hopkins University, Baltimore, MD, [4]Indiana University, Bloomington, IN, Contact: kotsi.1@osu.edu

US nonprofits declare annually three expenses: program spending to meet beneficiaries' needs; fundraising spending to raise donations; administration spending to build and sustain capacity. Charity watchdogs expect nonprofits to prioritize program over other expenses. We study when such expectations are counterproductive. The intertemporal tradeoffs among program, fundraising and administration shape nonprofits' operations but have received scant attention in the literature. We provide insights on how nonprofits can manage these tradeoffs to optimize budget allocation. We characterize the optimal budget allocations to the three expenses using a two-period model, which also includes the nonprofit's capacity, return on program (net program value to beneficiaries) and uncertain beneficiaries' future needs. We verify our insights with foodbank public data.

2 The Effect of Customer Concentration on Firm Operating Performance During The Covid-19 Pandemic

YoungSoo Park[1], Yun Shin Lee[1], Jaeseog Na[2], [1]KAIST Business School, Seoul, Korea, Republic of; [2]Duksung Women's University, Seoul, Korea, Republic of. Contact: jsna@duksung.ac.kr

This paper investigates the effect of customer concentration on the firm's abnormal operating performance during the COVID19 pandemic. We find that the firm's customer concentration level is negatively correlated with its operating performance during the first year of the pandemic outbreak. It implies that the firms with a diversified customer base prior to the outbreak better manage supply chain risks during the disruption periods. However, we find that the effect of customer concentration level is the opposite after the first year of the outbreak. The results indicate that the firms with a concentrated customer base can coordinate more effectively with their major customers during the recovery period.

3 Managing Volunteers and Paid Workers in a Nonprofit Operation

Gemma Berenguer[1], Lei Li[2], William Haskell[2], [1]Universidad Carlos III de Madrid, Getafe, Spain; [2]Purdue University, West Lafayette, IN, Contact: gemma.berenguer@uc3m.es

Nonprofit organizations (NPOs) can run activities with a workforce composed of a mix of volunteers, part-time, and full-time workers. We study the NPO's finite-horizon staffing problem to determine the optimal initial staff planning and per period optimal hiring and assignment decisions given uncertain supply of volunteers and part-time workers. Our main goal is to study the best staffing policy in a way that is effective and easy to implement. To this end, we demonstrate that the optimal staffing policy is computationally challenging to identify in general. However, we demonstrate that a prioritization assignment policy and a hire-up-to policy for part-time workers can be conveniently applied and are close to optimal. Based on these results, we suggest two easy-to-implement heuristics and provide analytical and computational results.

4 Carrots and Sticks: How Do Curbside Feedback Tactics Impact Households' Recycling Performance?

Erin Mckie[1], Aravind Chandrasekaran[1], Sriram Venkataraman[2], [1]The Ohio State University, Columbus, OH, [2]University of South Carolina, Columbia, SC

In this study, we examine the role of two popular feedback mechanisms - information-only and information plus penalty - in correcting households' curbside recycling behaviors. To test our hypotheses, we analyze data from a 2019 curbside

auditing effort. We find that information-only feedback mechanisms, while preferred by some stakeholders, are ineffective at reducing environmental violations. In comparison, our results indicate that households that receive punitive feedback reduce their contamination severity by 59%, and are 75% less likely to commit a violation in the future. Most importantly, we show that punitive feedback mechanisms generally do not discourage participation. Our study informs policymakers on how curbside feedback mechanisms can be more effectively leveraged to enhance opportunities for material reuse.

Monday, 12:30 PM–1:45 PM

MC28

CC - Room 139

Data Driven Social Impact Operations

General Session

Session Chair

Kamalini Ramdas, London Business School, London, United Kingdom.

Session Chair

Amrita Kundu, McDonough School of Business, Georgetown University, Washington

1 Generic Drug Effectiveness: An Empirical Study on Health Service Utilization and Clinical Outcomes

Xinyu Shirley Liang, Jun Li, Ravi Anupindi, University of Michigan, Ann Arbor, MI, Contact: xinyul@umich.edu

Close to 90% of drugs consumed in the US are generics, saving the healthcare system over 2.4 trillion dollars over the past decade. The cost-saving benefit, however, can only be realized when the drug's effectiveness is ensured. In this paper, we study the effectiveness of generic drugs. We estimate the effect of generic drug usage on health outcomes using a staggered difference-in-differences design and address the potential endogeneity using instrumental variables. We find that generic drug usage leads to significantly more hospital visits. Generic drugs also appear to be less clinically effective in reducing patients' low-density lipoprotein cholesterol levels. Overall, our paper highlights the aggregate impact of generic drug usage on healthcare utilization and differential impacts based on patient and manufacturer heterogeneity.

2 Improving Smallholder Artisans' Productivity in Rugs Manufacturing: An Empirical Analysis

bhavya singhvi[1], Divya Singhvi[2], Somya Singhvi[3], Xinyu Zhang[4], [1]Indian Institute of Management, Udaipur, Udaipur, India; [2]New York University, New York, NY, [3]USC Marshall School of Business, Los Angeles, CA, [4]New York University, Stern School of Business, New York, NY

This work is in close collaboration with a social enterprise that works with thousands of women textile artisans from low-income households in India. A majority of the women artisans complete the weaving tasks from their homes and the platform hires quality supervisors to ensure timely completion of the weaving tasks. Using detailed manufacturing data from the platform, we present empirical analysis to shed light on important factors that affect artisans' productivity. Our work highlights that regular supervision can play a critical role in ensuring timely completion and limited quality defects, eventually improving artisans' income and productivity.

3 Can Data-driven Food Subsidies Help Curb Malnutrition in Emerging Markets?

Ali Aouad, Kamalini Ramdas, Alp Sungu, London Business School, London, United Kingdom. Contact: asungu@london.edu

We investigate the impact of consumer food subsidy programs on poor consumers' nutrient purchases and data-driven pathways to improve the efficacy of such programs. We conduct an experiment in an urban settlement in Mumbai, India. First, we open a subsidy store to mimic governments' food subsidy programs. Second, we equip local grocery stores with point of sale scanner devices and start a loyalty card program to track individuals' shopping baskets. By randomly assigning households to a subsidy program, we examine how government-like subsidies affect food shopping behaviour. Next, we develop a predictive model to determine households' propensity to avail of their subsidies using a combination of transfer learning and choice modelling. Using this data-driven approach, we can devise alternative, optimized food subsidy schemes.

4 Reducing Lead Poisoning by Increasing Uptake of High Quality Batteries in Bangladesh - Assessment of a Business Model Innovation

Amrita Kundu[1], Erica Plambeck[2], Qiong Wang[3], [1]McDonough School of Business, Georgetown University, Washington, DC, [2]Stanford University, Stanford, CA, [3]University of Illinois, Urbana, IL, Contact: ak1924@georgetown.edu

We develop a business model that aligns incentives of multiple stakeholders to reduce market inefficiencies and increase the demand for high quality and long lasting batteries for electric three wheelers in Bangladesh. By extending battery life, we aim to decrease the rate of informal recycling of lead acid batteries and reduce lead poisoning. With our partnering organizations, we are delivering and testing the effectiveness of the business model and its potential to scale up through a randomized control trial.

Monday, 12:30 PM–1:45 PM

MC29

CC - Room 140

Operations Approaches to Societal Healthcare Challenges

General Session

Session Chair

Benjamin Grant, Clemson College of Business, Greenville, SC

Session Chair

Benjamin Grant, Clemson College of Business

1 **Area- and Location-based Determinants of Health: Examining Care Continuity in Pediatric Obesity**

John Lowrey[1], Benjamin Grant[2], [1]Northeastern Unversity, Boston, MA, [2]Clemson University, Clemson, SC, Contact: bngrant@clemson.edu

Care continuity between a patient and her primary care provider has been associated with lower risk of inpatient hospitalization, particularly for those diagnosed with a chronic disease. Non-clinical factors, such as a patient's area- and location-based determinants of health, may condition the effect of operational interventions like care continuity. We explore these conditional effects using an interaction model, which helps advance a more integrative understanding of healthcare systems.

2 **Coordinating Health and Social Services: Impact of Allowing Non-medical Services in Medicare Advantage Programs**

Heikki Peura[1], Jonas Oddur Jonasson[2], Woonam Hwang[3], [1]Imperial College Business School, London, United Kingdom; [2]MIT Sloan School of Management, Somerville, MA, [3]University of Utah, Salt Lake City, UT

Following the CHRONIC Care Act of 2018, CMS allowed Medicare Advantage (MA) plans to offer non-medical supplementary benefits to patients with chronic conditions from 2020. The impact the CHRONIC Care Act will have on the cost, quantity, and quality of health services offered to the Medicare population is unclear. It might also affect beneficiaries' enrollment choice between MA and MO. We ask two main questions. First, when is it in the best interest of MA providers to offer non-medical services? Second, will the increased flexibility of service offerings give MA providers additional opportunities to cream-skim? To answer these questions, we develop a model of the interaction between CMS, MAs, and Patients. We find that cream-skimming can increase as MA providers are allowed to offer a wider scope of services.

3 **One too Many: Inventory Policies for Effective Maintenance of Cord Blood Banks**

Sundara Natarajan Panchanatham[1], Sameer Hasija[2], Harry Groenevelt[3], [1]INSEAD, Singapore, Singapore; [2]Insead, Singapore, Singapore; [3]University of Rochester, Rochester, NY, Contact: sundaranatarajan.panchanatham@insead.edu

Treating many blood-related diseases requires transplantation of genetically compatible stem cells extracted from the bone marrow (BM) of live donors or umbilical cord blood (CB) cells of babies. The BM donors are a cost-effective source with strict matching requirements whereas the CB units are a flexible but cost-intensive source. For medical reasons, BM donors are always the first choice for a transplant and only the unmet demand spills over to the CB bank. With ten million unique genetic types in the U.S., alongside both demand and supply uncertainty, it is unclear what the optimal inventory policy should be for the CB banks. We derive analytical and heuristics-based cost-effective inventory policies without compromising the matching probabilities. We provide a performance guarantee for the heuristics and compare it with the current industry practice.

4 **Is Telemedicine Here to Stay? Equilibrium Analysis of An Outpatient Care Queueing Game**

Xiaole (Alyssa) Liu, Mor Armony, New York University, New York, NY, Contact: xl2500@stern.nyu.edu

Telemedicine is a practice that has become widely used in recent times. For example, the implementation of telemedicine has increased sharply from 4.1% of total primary care visits in Q1 2020 to 35.3% in Q2 2020 in the US. Recognizing the many benefits of telemedicine these trends may continue after the pandemic in part thanks to regulatory changes. As observed in some empirical studies, however, the use of telemedicine can trigger more demand for in-person visits. We develop a queueing game model to assess the impact of telemedicine in equilibrium. We also characterize the optimal resource allocation for outpatient clinics in order to rip the benefits of telemedicine without overstressing the system load.

Monday, 12:30 PM–1:45 PM

MC30

CC - Room 141

Blockchain in Supply Chain

General Session

Session Chair

Yao Cui, Cornell University, Ithaca, NY

1 The Blockchain Newsvendor: Value of Freshness Transparency and Smart Contracts

N. Bora Keskin[1], Chenghuai Li[2], Jeannette Song[2], [1]Duke University, Durham, NC, [2]Duke University, Durham, NC, Contact: chenghuai.li@duke.edu

Motivated by blockchain applications in the fresh produce industry, we consider a retailer who faces uncertain freshness-dependent consumer demand. The retailer can have more transparency on the freshness of supply by adopting blockchain. We find that the value of blockchain, measured by the retailer's expected profit growth and food waste reduction, increases in the freshness uncertainty while decreases in the demand uncertainty. We design and analyze a type of smart contracts contingent on the freshness of supply, and demonstrate that such smart contracts can add value to both retailer and supplier on the basis of blockchain. Finally, we show that the benefits of blockchain to the retailer is closely related to the degree of supplier participation in the blockchain system, the freshness-related data accuracy, and the price differentiation based on freshness of supply.

2 Operations and Capital Structure Under Inventory Monetization

Jie Ning[1], Peter Ritchken[2], [1]Case Western Reserve University, Cleveland, OH, [2]Case Western Reserve, Cleveland, OH, Contact: jie.ning@case.edu

Inventory monetization (IM) is a novel arrangement that provides financing by securitizing a firm's inventory. It relies on a transparent information environment that utilizes advanced tracking and monitoring technologies and blockchain. All inventories financed by IM are monitored, thus revealing otherwise unobservable internal operations to the IM provider. We explore operational and financial implications of this fully monitored debt under IM. We show that it can completely eliminate moral hazard and recover first-best operations. Interestingly, this can only be achieved if a firm finances its investment entirely by IM debt and leaves its internal capital unused, contrary to the classic pecking order theory. We show that IM debt does not always create value and specify types of firms that would benefit from IM debt under demand and supply risk.

3 Behavioral Simulation of Blockchain-enabled Market for Supplier Capacity Trading Among Retailers

Kai Wendt[1], Daniel Hellwig[1], Arnd H. Huchzermeier[1], Volodymyr O. Babich[2], [1]WHU - Otto Beisheim School of Management, Vallendar, Germany; [2]Georgetown University, Washington, Contact: kai.wendt@whu.edu

We study markets for trading supplier capacity among retailers facing random demands and varying goods valuations. Retailers buy claims on supplier's capacity before knowing their demand and trade them after demand realization. Two novel trading strategies emerge. Players, whom we call *spot sellers*, buy more claims than the maximum demand initially and sell excess to the market. Other players, whom we call *spot buyers*, buy few claims from the supplier, using the market instead. These strategies reinforce each other, reduce a player's demand risk, and contribute to the reduction of mismatch between supply and demand. In small markets, clearing prices are correlated with the product values and the net demand. But in large markets, clearing prices are anchored to the capacity reservation price and do not reflect either product values or the net demand.

4 Nonfungible Tokens: How to Match Supply with Demand in The Metaverse

Dmitrii Sumkin[1], Pavel Kireyev[2], Serguei Netessine[3], [1]INSEAD, Singapore, Singapore; [2]INSEAD, Paris, France; [3]The Wharton School, University of Pennsylvania, Philadelphia, PA, Contact: dmitry.sumkin@insead.edu

The sales volume of NFTs surged to $25bn USD in 2021, and currently, it is a $40bn market. The novelty of NFT is that the marketplace holder may adjust its marginal costs, and its supply is very flexible. We study the supply design in NFT markets, building a structural model to quantify the trade-off between price and liquidity given the non-linearity in the expected gain from reselling. We analyze a dataset of transactions in the Decentraland platform, a new social media environment, and a virtual real estate market. We find that only "token sales" is an effective supply policy, while token burn and airdrop are not efficient in the Decentraland setting. We show that at the optimal production rate of NFTs, the platform revenue increases by 8.3%, and optimal policy is extremely sensitive to the secondary market volume, minting cost, and the transaction fee value.

Monday, 12:30 PM–1:45 PM

MC31

CC - Room 142

Dynamic Decision-Making Algorithms with Performance Guarantees

General Session

Session Chair

Mohamad Kazem Shirani Faradonbeh, University of Georgia, Athens, GA

1 FALCON: Fourier Adaptive Learning and Control in Partially Observable Nonlinear Dynamical Systems

Ali Sahin Lale[1], Peter Renn[1], Kamyar Azizzadenesheli[2], Babak Hassibi[1], Morteza Gharib[1], Anima Anandkumar[1], [1]California Institute of Technology, Pasadena, CA, [2]Purdue University, West Lafayette, IN, Contact: alale@caltech.edu

We study model-based reinforcement learning (MBRL) in unknown partially observable nonlinear dynamical systems. We propose an MBRL framework, Fourier Adaptive Learning and Control (FALCON), that learns the underlying system dynamics with finite-time guarantees and has efficient real-world performance. FALCON uses Fourier basis for model learning and deploys model predictive control for control design. We deploy FALCON to design stabilizing policies for an airfoil under extreme turbulence. We show that FALCON quickly learns the flow dynamics, adapts to the changing conditions, and achieves better performance than the state-of-the-art methods while using an order of magnitude fewer samples. This makes FALCON the first MBRL method deployed in real-world extreme turbulent conditions. Further, we prove that FALCON attains $O(\sqrt{T})$ regret after T time steps.

2 A Game-theoretic Approach to Provably Correct and Scalable Offline RL

Tengyang Xie, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: tx10@illinois.edu

The use of pessimism, when reasoning about datasets lacking exhaustive exploration has recently gained prominence in offline RL. Despite the robustness it adds to the algorithm, overly pessimistic reasoning can be equally damaging in precluding the discovery of good policies, which is an issue for the popular bonus-based pessimism. In this paper, we introduce the notion of Bellman-consistent pessimism for general function approximation: instead of calculating a point-wise lower bound for the value function, we implement pessimism at the initial state over the set of functions consistent with the Bellman equations. Our theoretical guarantees only require Bellman closedness as standard in the exploratory setting. The variant of our proposed approach, ATAC, also consistently outperforms SOTA offline RL algorithms on a range of continuous control tasks.

3 Online Sensor Scheduling for Linear Time-varying Dynamical Systems with Performance Guarantees

Reza Vafaee, Milad Siami, Northeastern University, Boston, MA

In this work, we investigate the problem of time-varying sensor selection for linear time-varying (LTV) dynamical systems. We develop a framework to design an online sparse sensor schedule for a given large-scale LTV system with guaranteed performance bounds using randomized algorithms. In our online setting, the contribution of each sensor at each time is calculated on-the-fly, and we immediately decide to keep the corresponding sensor at each time in the sensor schedule or discard it without ever retracting these decisions.Furthermore, we provide new performance guarantees to approximate fully-sensed LTV systems up to a multiplicative approximation factor and an additive one by choosing on average a constant number of active sensors at each time.

4 Asymptotic Analysis of Multi-class Advance Patient Scheduling

Mohamad Sadegh Shirani Faradonbeh[1], Hossein Abouee Mehrizi[2], Mohamad Kazem Shirani Faradonbeh[3], [1]Stanford University, Stanford, CA, [2]University of Waterloo, waterloo, ON, Canada; [3]University of Georgia, Athens, GA, Contact: sshirani@stanford.edu

A fundamental problem that health policy-makers need to address is about strategies for scheduling patients to avoid undue costs. We consider the problem of scheduling appointments for multiple patient classes advance in time. At any time, the service provider needs to decide whether to schedule the patients waiting in line and, if so, which available appointment time slots must be assigned to them. We analyze it in an asymptotic regime and characterize the optimal scheduling policy as a state-dependent threshold structure. We propose an easy-to-implement scheduling policy that fully determines the scheduling decision.
The performance of the presented scheduling policy is examined based on the data of two hospitals in Canada,

illustrating that it effectively prioritizes the waiting patients and efficiently balances the workload across the days in the booking window.

Monday, 12:30 PM–1:45 PM

MC32

CC - Room 143
Supply Chain Analytics
General Session

Session Chair
Retsef Levi, MIT, Cambridge, MA

1 **Examining the Drivers for Lead Contamination in the Supply Chain for Consumers and Industrial Products**
Prashant Yadav, INSEAD, Fontainebleau, France.
Toxicity resulting from lead exposure has been studied by environmental health scientists due to its adverse impact on human health, in particular for young children. Lead exposure in developing countries often results from consumer and industrial products with higher than acceptable levels of lead. This talk looks at the supply chain for 3-4 consumer and industrial items with the highest risks of lead contamination/exposure using flow data. It then evaluates remedial measures to prevent such exposures.

2 **Matching Platforms for Smallholder Supply Chains**
Sergio Camelo[1], Joann de Zegher[2], Dan Andrei Iancu[1], [1]Stanford University, Stanford, CA, [2]MIT Sloan, Cambridge, MA, Contact: camelo@stanford.edu
We design a platform that matches smallholder farmers with intermediaries that provide transportation for their fruit. The platform sells the fruit and uses its revenue to pay both parties, while guaranteeing that participating in the platform is more profitable for both farmers and intermediaries than working outside of it. To model the profits that could be obtained outside of the platform we assume that intermediaries and farmers who know each other could work outside of the platform. Data on intermediary-farmer relationships is inferred from GPS trackers installed on intermediary trucks, and uncertainty in data collection is modeled through a distributionally robust approach based on the Wasserstein metric. We show that such platform can reduce transportation costs, while also easing the digitization and improving the transparency of smallholder supply chains.

3 **Digital Supply Chain Analytics to Predict Cyber Risk**
Kevin Hu, El Ghali Ahmed Zerhouni, Retsef Levi, Raphael (Rafi) Yahalom, MIT, Cambridge, MA
The presentation provides the first empirical evidence that certain supply-chain attributes are significant predictors of cyber risk for enterprises, in addition to their internal characteristics and level of cybersecurity management. It leverages outside-in cyber risk scores that represent quality of cyber security management, and augment these with supply chain features that are inspired by network science research, to develop a more comprehensive risk assessment. The main result is to develop a model that shows that supply chain network features add significant detection power relative to merely internal enterprise attributes in predicting risk of cyber data breach incidents. Additionally, the model highlights several cybersecurity risk insights related to third party data breach mechanisms that have seen significant increase over the last several years.

4 **Understanding and Preventing Zoonotic Diseases Outbreaks**
El Ghali A. Zerhouni[1], Retsef Levi[2], [1]MIT, Cambridge, MA, [2]MIT, Cambridge, MA, Contact: egaz@mit.edu
Zoonotic diseases such as avian influenza, SARS, or COVID-19 have been responsible for major pandemics in the last several decades. Meanwhile farms could be a source of such zoonotic disease, most of the outbreaks have been linked to markets selling live animals in China. This talk presents a supply chain motivated transmission, interaction, and persistence (TIP) stochastic epidemiology model that seeks to explain the mechanism of disease amplification in markets, with a case study on avian influenza. It shows how even low infection rates among animals flowing from farms to markets and staying there less than one day can lead to large outbreaks. The study identifies the environment as a critical transmission host and vector of the disease. The results also stress and quantify the importance of sanitation practices to mitigate the risk of future pandemics.

Monday, 12:30 PM–1:45 PM

MC33

CC - Room 144
MSOM Flash Session I
Flash Session

Session Chair
Han Zhang, Michigan State University, East Lansing, MI

1 A Mixture Model for Queue Inference Based on Inter-departure Time Data

Xiyuan Ge[1], Masha Shunko[1], Serguei Netessine[2], [1]University of Washington, Seattle, WA, [2]The Wharton School, Philadelphia, PA

We consider inference for M/G/1 queues solely based on departure time data. Different from past literature, we adopt a mixture model free of recursions to calculate the likelihood. Such a mixture model allows efficient parametric and nonparametric estimation for the unobserved service time distribution. We also leverage the semi-Markov property of the $M/G/1$ system and estimate the average queue size at each departure. With synthetic and real-life data, we illustrate the performance of our method and compare it with established methods previously proposed for similar problems.

2 Order Stacking in Food Delivery Platforms

James R. Scott, N. Bora Keskin, Robert Swinney, Duke University, Durham, NC, Contact: james.scott956@duke.edu

Food delivery platforms can "stack" orders together and assign them to a single driver to pick them up and deliver them sequentially. Using a theoretical model in which each entity participates only when it is rational for them to do so, we investigate the impact of order stacking on customers, drivers, and the platform.

3 Online Learning for Two-sided Sequential Matching Markets with Temporal Effects

Alberto Giudici[1], Jan van Dalen[1], Tao Lu[2], Rob A. Zuidwijk[3], [1]Rotterdam School of Management, Rotterdam, Netherlands; [2]University of Connecticut, Storrs, CT, [3]Erasmus University Rotterdam, Rotterdam, Netherlands.

Digital transport marketplaces can leverage user preferences and behavior to improve their information design decisions. Motivated by our collaboration with a digital transport marketplace, we devise a dynamic two-sided assortment optimization model that learns user preferences while maximizing the expected number of matches, considering expiring demand and intermittent user log-ins. Through simulations, we show that our multi-armed-based model can manage the sequential interaction dynamics and successfully improve the expected number of matches.

4 First or Second Dose First? Two-dose Vaccine Allocation Under Finite Capacity

Ming Hu[1], Yun Zhou[2], [1]University of Toronto, Toronto, ON, Canada; [2]McMaster University, Hamilton, ON, Canada. Contact: zhouy185@mcmaster.ca

Most Covid-19 vaccines require two doses for a recipient to be considered as fully vaccinated. However, receiving only one dose still provides some protection. We study the allocation of vaccination capacity between 1st and 2nd doses. Building on the SIR model, we formulate an optimal control model and show that the optimal policy makes an all-or-nothing-type allocation at any time instant. We then compare the "first doses first" and "second doses first" policies. We find that even if the 1-dose efficacy is slightly greater than 50% of the 2-dose efficacy, "second doses first" is still better.

5 Multi-product Dynamic Pricing with Reference Effects Under Logit Demand

Mengzi Amy Guo[1], Hansheng Jiang[1], Zuo-Jun Max Shen[2], [1]University of California, Berkeley, Berkeley, CA, [2]University of California Berkeley, Berkeley, CA, Contact: mengzi_guo@berkeley.edu

We consider an infinite-horizon multi-product dynamic pricing problem with reference effects in a monopolistic setting, where we model the reference price through exponential smoothing and the demand as the MNL model. Our analyses on the myopic pricing policy includes its solution, long-run behavior, and performance guarantee. Moreover, we show structural properties of the optimal pricing policy. When consumers are loss-neutral towards all products, the steady state admits a simple expression when it exists and can be computed by the bisection method. We further identify that the convergence behavior of the optimal pricing policy relies on the range of the admissible price, where a narrow price range facilitates the policy to converge. In contrast, if consumers are gain-seeking towards all products, we prove that the optimal pricing policy admits no steady state.

6 Flash Paper

Greg Frobes, Stanford University, CA

7 Flash Paper

Dustin Cole[1], Sriram Narayanan[2], Shawnee Vickery[2], [1]Auburn University, Auburn, AL, [2]Michigan State University, East Lansing, MI

We examine the impact of a leader with disabilities on team productivity as the number of workers in a team with disabilities increases. We find that as the number of people with disabilities in a team increases, having a leader with a disability helps improve productivity. We complement our quantitative analysis with a qualitative study.

8 Advertising Strategies for The Proprietary and Open Source Systems

Yong Zha[1], Xiangxiang Wu[2], Xiuli He[3], Yugang Yu[1],

[1]University of Science and Technology of China, Hefei, China; [2]USTC, Hefei, China; [3]UNC-Charlotte, Charlotte, NC

We investigate how manufacturers determine advertising strategies for smartphone products with homogeneous operating system quality. The manufacturer has two advertising strategies: informative advertising (IA) and persuasive advertising (PA). We consider the proprietary and open source OS development strategies. Our results show that in the proprietary system, the OS quality serves as an accelerator to expand the base market. The manufacturer prefers IA when its effectiveness is not lower than a threshold, and always prefers PA regardless of its effectiveness. In the open source system, The OEM chooses PA when the OS quality is low and chooses no-advertising when the OS quality is high. When the OS quality is moderate, the OEM's decision depends on the PA effectiveness.

9 Strategic Investment in Supplier Reliability

Lusheng Shao[1], Han Zhang[2], Srinivas Talluri[2], [1]University of Melbourne, Melbourne, Australia; [2]Michigan State University, East Lansing, MI

A buyer procures a product from a supplier to sell to the downstream market. The buyer invests in the supplier's reliability to lower the probability of a disruption, which may occur after the buyer reserves capacity at the supplier. We observe that when the capacity reservation cost is low, increasing the cost drives up investment in the supplier, as the buyer bears a larger share of the uncertainty. In some cases, the higher investment drives up capacity reservation even while the capacity cost gets higher. However, once the capacity cost is already high, any further increase discourages the buyer from investing. The buyer cuts both supplier investment and capacity reservation to limit risk exposure.

Monday, 12:30 PM–1:45 PM

MC35

CC - Sagamore 1

Distributionally Robust Learning and Optimization - I

General Session

Session Chair

Harsha Gangammanavar, Southern Methodist University, Dallas, TX

Session Chair

Hamed Rahimian, Clemson University, Clemson, SC

1 Distributionally Robust Two-Stage Convex Quadratic Programming

Nazlican Arslan, David Morton, Northwestern University, Evanston, IL, Contact: nazlicanarslan2024@u.northwestern.edu

Distributionally robust optimization is a framework to model stochastic optimization problems where the distribution of the random parameters is uncertain. The uncertain distribution is assumed to belong to a set of plausible distributions, called an ambiguity set. The goal is to compute decisions that hedge against the worst possible distribution in a given ambiguity set. We study a two-stage stochastic program with convex quadratic recourse under distributional ambiguity with uncertainty only in the right-hand side vector. We consider data-driven distributional ambiguity sets based on the Wasserstein distance and based on an optimal quadratic transport distance. For the latter, we derive a cutting-plane algorithm, and show computational results.

2 Convex Chance Constraints and Applications in Path Planning and Optimal Power Flow

Haoming Shen, Ruiwei Jiang, University of Michigan, Ann Arbor, MI

As a natural approach to modeling system safety conditions, chance constraints (CC) seek to satisfy a set of uncertain inequalities individually or jointly with high probability, but the feasible regions they produce are non-convex in general. In this talk, we discuss various sufficient conditions that allow CC with Wasserstein ambiguity and a Gaussian reference distribution to produce a convex feasible region. In particular, we derive second-order conic representations and (asymptotically tight) approximations for the CC that satisfy these sufficient conditions. We demonstrate the out-of-sample performance and scalability of our approach in robotics path planning and optimal power flow.

3 Sinkhorn Distributionally Robust Optimization

Jie Wang[1], Rui Gao[2], Yao Xie[3], [1]Georgia Institute of Technology, ATLANTA, GA, [2]University of Texas at Austin, Austin, TX, [3]ISyE Georgia Tech, Atlanta, GA, Contact: jwang3163@gatech.edu

We study distributionally robust optimization with Sinkhorn distance -- a variant of Wasserstein distance based on entropic regularization. We derive convex programming dual reformulations when the nominal distribution is an empirical distribution and a general distribution, respectively. Compared with Wasserstein DRO, it is computationally tractable for a larger class of loss functions, and its worst-case distribution is more reasonable. To solve the dual reformulation, we propose an efficient batch gradient descent with a bisection search algorithm. Finally, we provide various numerical examples using both synthetic and real data to demonstrate its competitive performance.

4 Tikhonov Regularization is Optimal Transport Robust Under Martingale Constraints

Jiajin Li, Stanford University

Distributionally robust optimization (DRO) has been shown to offer a principled way to regularize learning models. In this paper, we find that Tikhonov regularization is distributionally robust in an optimal transport sense (i.e. if an adversary chooses distributions in a suitable optimal transport neighborhood of the empirical measure), provided that suitable martingale constraints are also imposed. Further, we introduce a relaxation of the martingale constraints which not only provide a unified viewpoint to a class of existing robust methods but also lead to new regularization tools. To realize these novel tools, provably efficient computational algorithms are proposed. As a byproduct, the strong duality theorem proved in this paper can be potentially applied to other problems of independent interest.

Monday, 12:30 PM–1:45 PM

MC36

CC - Sagamore 2

Packing and Covering

General Session

Session Chair

Lingyi Zhang, NEW YORK, NY

Session Chair

Matias Villagra, [1</sup]

1 Fully Dynamic Online Vector Load Balancing

Varun Gupta[1], Ravishankar Krishnaswamy[2], Sai Sandeep[3], Janani Sundaresan[4], [1]University of Chicago Booth School of Business, Chicago, IL, [2]Microsoft Research India, Bangalore, India; [3]Carnegie Mellon University, Pittsburgh, PA, [4]Rutgers University, New Brunswick, NJ, Contact: sun.j@rutgers.edu

We study fully dynamic multi-dimensional load balancing problems with recourse against oblivious adversaries.
The adversary presents a stream of n insertions and deletions of jobs from R^d.
In the vector scheduling problem, we must maintain an assignment of active jobs to m identical machines to minimize the maximum load on any dimension on any machine. We give an algorithm with an O(1) amortized recourse, with an O(log d/log log d) competitive ratio.
In the vector bin packing problem, we must maintain an assignment of active jobs into a number of bins of unit capacity in all dimensions, to minimize the number of bins. We present an O(1)-competitive algorithm with O(log n) recourse under the so-called small jobs assumption that the size of all jobs in all the coordinates is O(1/log d).
The competitive ratios are against the optimal solution for the set of active jobs at each time step.

2 Monotone Submodular Incremental Knapsack Problem

Yuri Faenza[1], Lingyi Zhang[2], [1]Columbia University, New York, NY, [2]Columbia University, NEW YORK, NY

Incremental knapsack problems extend the classical knapsack problem to a multi-period setting. In this setting, the knapsack capacity is non-decreasing overtime, allowing for more items to be selected as capacity grows. At each time, previously inserted items must remain inserted. In the monotone submodular incremental knapsack problem, we assume the objective function is a monotone submodular function. We consider a special case of the function where the inclusion of an item in a set either earns the full profit or zero profit. Under these assumptions, we give a PTAS for the problem by showing that it can be reduced to a incremental knapsack instance where the objective function is linear.

3 Packing and Covering in Directed Graphs

Ahmad Abdi[1], Gerard P. Cornuejols[2], Michael Zlatin[3], [1]London School of Economics, London, United Kingdom; [2]Carnegie Mellon University, Pittsburgh, PA, [3]Carnegie Mellon University, pittsburgh, PA

In any directed graph, the minimum size of a dijoin is equal to the maximum number of disjoint dicuts. This is the celebrated Luccesi-Younger theorem and is even known to hold in a weighted setting. However, by interchanging the roles of dicuts and dijoins, we obtain the much more mysterious Woodall's conjecture, which asks: If the minimum size of a dicut is k, are there always k pairwise disjoint dijoins? This beautiful conjecture in combinatorial optimization has remained open for 50 years with little recent progress. In this talk, I will discuss new results towards Woodall's conjecture. In particular, we show that in any optimal fractional packing, at least one dijoin can be chosen to have value 1.

4 A Synergy of Ridesharing and Tradable Credit Scheme: A Morning Commute Problem

Mohammadhosein Pourgholamali[1], Mohammad Miralinaghi[2], Samuel Labi[1], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN

This research discusses a novel approach to relieve traffic congestion at a highway bottleneck during the morning rush hour. The approach features two travel demand management strategies: ridesharing and tradable credit scheme (TCS). Formulated as a mixed-linear complementarity problem to capture the user equilibrium and system optimal conditions, the problem is solved after introducing several cuts that exclude infeasible regions from solution spaces. The solution yields the simultaneous mode and departure-time choices and the optimal TCS. The results are suggestive of the efficacy of the proposed approach in mitigating traffic congestion impacts in terms of total system travel time (without additional road capacity) and environmental impacts.

Monday, 12:30 PM–1:45 PM

MC37

CC - Sagamore 6
Latest Developments in Optimization Software Part 1
General Session

Session Chair
Hans Mittelmann, Arizona State University, Tempe, AZ

4 Latest Developments and Improvements in MindOpt
Kuo-Ling Huang, Alibaba, Sunnyvale, CA, Contact: kuoling.huang@alibaba-inc.com
We Will Give An Overview Of The Latest Developments And Improvements In The MindOpt Optimization Solver.

1 New Performance Techniques in The Gurobi Optimizers
Zonghao Gu[1], Ed Klotz[2], [1]Gurobi Optimization, Alpharetta, GA, [2]Gurobi Optimization, Incline Village, NV
This talk will discuss various new techniques or ideas to improve the performance to solve mixed integer programs, quadratic programs, and linear programs, in particular network flow problems, then shows the computational results for these techniques.

2 The Progress of Copt
DongDong Ge, Cardinal Operations, Shanghai, China.
In this talk we will report the progress of cardinal optimizer (COPT) over the past year. In particular, we will introduce its new progress on Linear and integer program and its new components, SDP and convex QP. We will also talk about our new open source program in linear and SDP optimization: ABIP and HDSDP.

3 Some Machine Learning Techniques in The OptVerse Solver
Zirui Zhou, Huawei Technologies Canada, Burnaby, BC, Canada.
In this talk we will give an overview of the latest development of the OptVerse solver. We will also discuss some machine learning techniques for improving the performance of the optimization solver and report some computational results.

Monday, 12:30 PM–1:45 PM

MC38

CC - Sagamore 7
OPT/Optimization Under Uncertainty Flash Session I
Flash Session

Session Chair
Luyang Zhang, University of Southern California, San Jose, CA

1 Optimal Pump Control for Water Networks via Data-based Distributional Robustness
Yi Guo[1], Shen Wang[2], Ahmad Taha[3], Tyler Summers[4], [1]ETH Zurich, Zurich, Switzerland; [2]Beijing University of Posts and Telecommunications, Beijing, China; [3]Vanderbilt University, Nashville, TN, [4]University of Texas at Dallas, Richardson, TX, Contact: guo@eeh.ee.ethz.ch
In this paper, we propose a data-based methodology to solve a multi-period stochastic optimal water flow problem for water distribution networks. The objective is to determine the optimal feedback decisions of network-connected components, such as nominal pump schedules and tank head levels, which specify device reactions to forecast errors of fluctuating water demand. A distance-based ambiguity set with the Wasserstein metric is leveraged to quantify the distance between the real unknown data-generating distribution of water demand and the empirical distribution. This allows our framework to trade-off system performance and inherent sampling errors in the training dataset.

2 Multi-period Power System Risk Minimization Under WildfiRe Disruptions
Hanbin Yang, The Chinese University of Hong Kong, ShenZhen, Shenzhen, China.

Electric grid faults can cause severe wildfires; however, electric utilities often have few options to reduce wildfire risk, leading to disruptive measures such as the use of active blackout equipment, commonly known as public safety blackouts. These sudden power cuts had a significant impact on customers. This work constructs a multi-stage model to express the trade-off between serving more load and avoiding wildfire. The model plans the first-stage decisions until the first wildfire disruption. We address this problem by implementing SDDiP algorithm solving by the level-set method.

3 Distributionally Robust Resource Planning Under Binomial Demand Intakes

Ben Black[1], Christopher Kirkbride[2], Trivikram Dokka[3], Russell Ainslie[4], [1]Lancaster University, Lancaster, United Kingdom; [2]Lancaster University, Lancaster, United Kingdom; [3]Queen's University Belfast, Belfast, United Kingdom; [4]BT Technology, Ipswich, United Kingdom. Contact: b.black1@lancaster.ac.uk

In this paper, we consider a resource planning problem inspired by a service industry workforce. There is a mixture of known and unknown demand. Known jobs can be completed prior to their due date to free up capacity. Incomplete jobs incur a cost and become due the following day. Our task is to optimise completions in order to minimise the total costs. We consider a distributionally robust model, where the number of uncertain jobs on each day is a Binomial random variable with an unknown success probability. The binomial information results in a complex model, and hence we develop heuristics to solve it. We perform extensive computational experiments to establish the performance of our algorithms.

4 Neural Architecture Search for Efficient Computer Vision

Shengcao Cao, University of Illinois Urbana-Champaign, Urbana, IL

Deep neural networks have become the standard solution to various tasks from image classification to object detection in computer vision. However, the computation demand of neural networks is rapidly increasing. To mitigate this issue, neural architecture search (NAS) has been proposed to automatically design neural networks with both high accuracy and high efficiency. In this talk, I'll introduce our recent research on NAS with an optimization perspective: 1) using Bayesian optimization techniques to efficiently compress a large network, and 2) enhancing NAS optimization objective with a "flatness" consideration for better generalization.

5 Sequential Efficient and Fair Resource Allocation Under Inventory Capacity Constraint and Stochastic Demand

Qian Xie, Sean Sinclair, Chamsi Hssaine, Sid Banerjee, Cornell, Ithaca, NY

We consider warehouses with capacity constraints on the stock level (amount of stored resources). Over an infinite horizon, the principal decides per-person allocation while observing supplies and demands. The goal is to analyze the trade-off between two desired properties: (hindsight) envy-freeness and efficiency. The former is defined as the maximum difference among individuals' allocations, focusing on the individual's satisfaction with the allocations when compared with others; while the latter considers the time that the warehouses are either full or empty, guaranteeing the sufficiency of the inventory level. Our result shows that slightly relaxing the hindsight envy can significantly improve efficiency. This work can be applied to real-world settings such as mobile food-bank, healthcare stockpile allocation, and computing resource reservation system.

6 Convex Approximations of Risk Measures with Applications to Chance-constrained Programming

Ashish Chandra[1], Mohit Tawarmalani[2], [1]Illinois State University, Normal, IL, [2]Purdue University, West Lafayette, IN, Contact: achand6@ilstu.edu

We introduce a new two-stage model for integrated quantile functions. This framework leads to a bilinear optimization problem (P), a special case of which reveals a new model for the VaR minimization problem. We discuss various techniques to under- and over-estimate the optimal value of (P), in turn developing new lower and upper-estimators for VaR. We also consider chance-constraint programs (CCP). Utilizing the overestimates we construct for (P), we develop convex inner approximations for the CCP and compare their performance with CVaR approximation and ALSO-X approach proposed by Jiang, Nan, et al in 2021. We also provide computational comparisons over Network traffic engineering problems.

7 A Notion of Basic Feasible Solution for Infinite Horizon Programs

Filipe Cabral, Georgia Institute of Technology, Atlanta, GA, Contact: fcabral3@gatech.edu

Infinite horizon programs are usually the limit of multistage programs. This work analyzes the primal and dual optimal solutions of a particular infinite horizon program and how it motivated our extension of a Basic Feasible Solution for the class of row-finite linear programs. We present an algebraic procedure to certify that a feasible solution from this class is an extreme point using the notion of a Hermitian Normal Form of a row-finite matrix.

8 Robust Gradient Descent, Robust Regression and Applications

Philip Thompson, Purdue university, WEST LAFAYETTE, IN, Contact: philipthomp@gmail.com

In this talk we present a "robust" version of stochastic gradient descent which is resistant to data with heavy-tails and adversarial outliers. Our main contribution is to show improved guarantees compared to ones obtained recently in the stochastic optimization literature. Finally, we consider some applications in machine learning and present simulation results.

9 The Power of Linear Programming in Promoted Listing Allocation: A Field Study at Ebay

Luyang Zhang[1], Haihao Lu[2], [1]University of Chicago, Chicago, IL, [2]University of Chicago Booth School of Business, Chicago, IL, Contact: zhangl1@uchicago.edu

Promoted listing is one of the major revenue sources for many prominent online marketplaces. The main difficulty of this problem is the trade-off between the overall revenue and the relevance of the allocated listing. In this paper, we propose an innovative promoted listing allocation algorithm based on linear programming (LP). In theory, we show that this LP model can collect approximately 100% of the maximal revenue one can achieve for any given relevance level. In practice, we conduct an A/B test of the LP model on eBay's platform and compare it with the model that eBay currently deploys in production. Recording 73 million impressions in total, the experiment results show that the LP model dominates the current model, improving revenue by 1.80%, purchase count by 1.55%, and gross merchandise value (GMV) by 1.39%.

Monday, 12:30 PM–1:45 PM

MC39

CC - Room 201

Recent Advances in Bilevel Optimization Under Uncertainty and Applications

General Session

Session Chair

Tomás Lagos González, 1</sup

1 Distributionally Robust Multi-level Optimization Problem

Zhengsong Lu, Bo Zeng, University of Pittsburgh, Pittsburgh, PA, Contact: zs.lu@pitt.edu

We study a distributionally robust multi-level optimization problem.

2 A Bilevel Approach to Robust Congested Network Design

Azucena Orellana, University of Chile, Santiago, Chile. Contact: azu.orellana.78@gmail.com

In this work, we present a robust network design problem (RNDP) with uncertain demands. We consider selfish users satisfying a Wardrop equilibrium. This behavior is incorporated through a bilevel problem approach, where the lower decision level determines the behavior of users while a network planner decides to reduce the costs of the network at the upper-level decision problem. We provide lower and upper bounds to the optimal value of the RNDP in the case of polyhedral uncertainty and convex cost function. In our simulations we show how the RNDP is able to provide solutions that performs close the average case while reducing significantly the cost in the worst-case scenario.

3 Min-max-min Optimization with Smooth and Strongly Convex Objectives

Jourdain Lamperski, Oleg A. Prokopyev, Luca Wrabetz, University of Pittsburgh, Pittsburgh, PA, Contact: luw28@pitt.edu

We consider min-max-min optimization with smooth and strongly convex objectives. Our motivation for studying this class of problems stems from its connection to the *k*-center problem and the growing literature on min-max-min robust optimization. In particular, the considered class of problems non-trivially generalizes the Euclidean *k*-center problem in the sense that distances in this more general setting do not necessarily satisfy metric properties. We present a 9□-approximation algorithm (where □ is the maximum condition number of the functions involved) that generalizes a simple greedy 2-approximation algorithm for the classical *k*-center problem. We show that for any choice of □, there is an instance with a condition number of □ per which our algorithm yields a (4 □ + 4√□+1)$-approximation guarantee, implying that our analysis is tight when □ = 1.

4 A Bilevel Optimization Approach for Fuel Treatment Planning Under Uncertainty

Tomas Lagos, University of Pittsbugh, Pittsburgh, PA

Every year there are millions of acres burned by thousands of fires, affecting in many regions over the world. The practice of ``fuel treatment'' involves removing all or some of the vegetation (fuel) from a landscape to reduce the potential for fires and their severity. We present a two-stage bilevel optimization model, where the upper level represents the actual decision-maker (fire manager), and the lower level represents an adversarial ``nature'' seeking to maximize fire severity in the long term. The considered bilevel optimization problem is NP-hard even if the leader's decision is fixed. We exploit the problem structure to develop several solution approaches. Our computational experiments are performed in both artificial and real-life instances, exploring scalability of the proposed approaches and their value with respect to a single-level stochastic setting.

Monday, 12:30 PM–1:45 PM

MC40

CC - Room 202

Quantum Linear Algebra and Optimization

General Session

Session Chair

Mohammadhossein Mohammadisiahroudi, Lehigh University, Bethlehem, PA

1 Accurately Solving Linear Systems with Quantum Oracles

Mohammadhossein Mohammadisiahroudi[1], Brandon Augustino[2], Ramin Fakhimi[1], Tamás Terlaky[1], [1]Lehigh University, Bethlehem, PA, [2]Lehigh University, Landing, NJ, Contact: mom219@lehigh.edu

Quantum linear system algorithms (QLSA), w.r.t dimension, have the potential to solve linear systems (LS) faster than classical methods. However, to extract the classical solution, a quantum tomography algorithm (QTA) is needed which increases both error and time complexity. To accurately and efficiently solve LSs using QLSA and QTA algorithms, we propose an Iterative Refinement method (IRM) which uses limited-precision quantum oracles iteratively to improve dependence on precision to logarithmic. The IRM is broadly applicable. We discuss its application in Quantum Interior Point Methods (QIPM) and discuss how the proposed IRM accelerates QIPMs.

2 Preconditioned Quantum Linear System Solvers Using Fast Inversion

Yu Tong[1], Dong An[2], Nathan Wiebe[3], Lin Lin[1,4], [1]University of California, Berkeley, Berkeley, CA, [2]University of Maryland, College Park, MD, [3]University of Toronto, Toronto, ON, Canada; [4]Lawrence Berkeley National Laboratory, Berkeley, CA

Preconditioning is the most widely used and effective way for treating ill-conditioned linear systems in the context of classical iterative linear system solvers. We introduce a quantum primitive called fast inversion, which can be used as a preconditioner for solving quantum linear systems. We demonstrate the application of our method for computing single-particle Green's functions of quantum many-body systems, which are widely used in quantum physics, chemistry, and materials science. Besides solving linear systems, fast inversion also allows us to develop fast algorithms for computing matrix functions, such as the efficient preparation of Gibbs states.

3 Variational Quantum Linear Solver with Dynamic Ansatz

Hrushikesh Patil[1], Yulun Wang[2], Predrag Krstic[2], [1]North Carolina State Univesity, Raleigh, NC, [2]Stony Brook University, Stony Brook, NY, Contact: hpatil2@ncsu.edu

Quantum algorithms for linear systems of equations are of special interest in the scientific community. Amongst the algorithms proposed for the quantum linear systems problem, the Variational Quantum Linear Solver is promising. In our study we introduce the dynamic ansatz in the Variational Quantum Linear Solver. In this improved algorithm, the number of layers in the hardware efficient ansatz circuit is evolved by gradually increasing until convergence is reached. We demonstrate the algorithm advantage in comparison to the standard, static ansatz by utilizing fewer quantum resources and with a smaller quantum depth on average, in presence and absence of quantum noise, and in cases when the number of qubits or condition number of the system matrix are varied. We contrast the performance of our algorithm by a newly defined metric.

4 Quantum Hamiltonian Descent

Jiaqi Leng, University of Maryland, College Park, MD, Contact: jiaqil@umd.edu

Continuous optimization has been a central topic investigated for quantum speed-ups. Inspired by a recently established connection between discrete-time gradient methods and their continuous-time limits, we propose *Quantum Hamiltonian Descent* (QHD) as a truly quantum counterpart of classical gradient methods. The convergence of QHD to global optimum is established in both convex and non-convex settings. QHD is efficiently simulated on both digital and analog quantum computers. In particular, we develop an analog implementation of QHD, which allows us to empirically evaluate QHD's performance on randomly generated non-convex quadratic programming instances up to 75 dimensions. We observe that QHD significantly outperforms a selection of state-of-the-art classical solvers (e.g., IPOPT, SNOPT, Matlab) as well as the quantum adiabatic algorithm.

Monday, 12:30 PM–1:45 PM

MC41

CC - Room 203
OPT/Nonlinear Optimization Flash Session
Flash Session

Session Chair
Tommaso Giovannelli, Lehigh University, Bethlehem PA, PA

1 Algorithms for Deterministically Constrained Stochastic Optimization
Albert Solomon Berahas, University of Michigan, Ann Arbor, MI
Stochastic gradient and related methods for solving unconstrained optimization problems have been studied extensively in recent years. However, settings with general nonlinear constraints have received less attention. In this talk, we present and analyze stochastic optimization algorithms for deterministically constrained problems based on the sequential quadratic optimization methodology. We discuss the rationale behind our proposed techniques, convergence in expectation and complexity guarantees, and preliminary numerical results. Joint work with Raghu Bollapragada, Frank E. Curtis, Michael O'Neill, Daniel P. Robinson, Jiahao Shi and Baoyu Zhou.

2 ON FIRST ORDER METHODs for LARGE SCALE LINEAR PROGRAMMING
Bo Jiang[1], DongDong Ge[1], Yinyu Ye[2], [1]Shanghai University of Finance and Economics, Shanghai, China; [2]Stanford University, Stanford, CA, Contact: jiang.bo@mail.shufe.edu.cn
It is well known that first order methods can scale to very large problems but suffer from requiring more time to find very high accurate solutions. In this talk, we briefly review three first-order methods tailored for large-scale linear programming: the split conic solver (SCS), the ADMM-based interior-point (ABIP) method, and the primal-dual hybrid gradient method for linear programming (PDLP). We then present some practical algorithmic improvements of ABIP method, and compare its numerical performance with SCS and PDLP on various LP benchmark instances including the ones from the large-scale application of PageRank.

3 Lyapunov Stability of The Subgradient Method with Constant Step Size
Cedric Josz, Lexiao Lai, Columbia University, New York, NY, Contact: lexiao.lai@columbia.edu
We consider the subgradient method with constant step size for minimizing locally Lipschitz semi-algebraic functions. In order to analyze the behavior of its iterates in the vicinity of a local minimum, we introduce a notion of discrete Lyapunov stability. We propose necessary and sufficient conditions for stability, as well as sufficient conditions for instability. We hence establish that several spurious local minima arising in data science applications are unstable.

4 Depth Flattens The Optimization Landscape Around The Ground Truth in Linear Models
Jianhao Ma, Salar Fattahi, University of Michigan, Ann Arbor, MI, Contact: jianhao@umich.edu
This work characterizes the effect of depth on the optimization landscape of robust linear regression, proving that deeper linear models enjoy a flatter landscape around ground truth. On the negative side, we show that this problem \textit{does not} have a benign landscape: given any N>=1, with constant probability, there exists a solution corresponding to the ground truth that is neither local nor global minimum. However, on the positive side, we prove that a simple sub-gradient method is oblivious to such a "problematic" solution; instead, it converges to a solution that is not only close to the ground truth but also enjoys a flat local landscape, thereby eschewing the need for "early stopping".

5 On The Convergence of Stochastic Heavy Ball Method
Raghu Bollapragada[1], Rachel Ward[2], Tyler Chen[3], [1]The University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, Austin, TX, [3]University of Washington, Seattle, WA, Contact: raghu.bollapragada@utexas.edu
Stochastic momentum methods are widely used in machine learning. However, their theoretical properties are not well studied in the literature. In this talk, we show that the stochastic heavy ball method can achieve the same fast linear rate of convergence as the deterministic counterpart for quadratic optimization, provided the minibatch size is sufficiently large.

6 Byzantine-robustness in Decentralized Non-convex Stochastic Optimization
Weiyu Li[1], Qing Ling[2], [1]Harvard University, Allston, MA, [2]Sun Yat-sen University, Guangzhou, China.

We consider the non-convex stochastic optimization problem defined over a decentralized network, where some of the agents can be arbitrarily malicious and send faulty models to their neighbors. The so-called Byzantine agents may bias the optimization process, and we develop a regularized approximation of the Byzantine-free problem to cope with them. Algorithmically, we propose a stochastic first-order method to solve the regularized problem. It is shown to approach a neighborhood of the Byzantine-free optimal solution in both theoretical analysis and numerical experiments.

7 Improved Convergence Rates of First-order Methods for Linear Quadratic Regulator

Caleb Ju[1], Guanghui Lan[2], Georgios Kotsalis[2], [1]Georgia Insitute of Technology, Atlanta, GA, [2]ISyE Ga Tech, Atlanta, GA, Contact: Calebju4@gatech.edu

The infinite-horizon linear quadratic regulator problem, or LQR, is a classic problem in control theory that has recently attracted attention from the reinforcement learning community. Despite the problem being non-convex and non-smooth, first-order methods have been shown to converge to the global optimum. However, the convergence rates are far from optimal. In this talk, we substantially improve the iteration and sampling complexity for finding globally optimal solutions in LQR using first-order methods. By exploiting the structure of the problem, we improve upon the state-of-the-art for solving the policy optimization and policy evaluation problem within LQR.

8 Bilevel Stochastic Methods for Optimization and Machine Learning: Bilevel Stochastic Descent and Darts

Tommaso Giovannelli, Griffin Kent, Luis Nunes Vicente, Lehigh University, Bethlehem PA, PA, Contact: tog220@lehigh.edu

Two-level stochastic optimization formulations have become instrumental in a number of machine learning contexts. However, practical stochastic bilevel optimization problems become challenging in optimization or learning scenarios where the number of variables is high or there are constraints. The goal of this paper is twofold. First, we aim at promoting the use of bilevel optimization in large-scale learning and we introduce a practical bilevel stochastic gradient method (BSG-1), which achieves a performance better than DARTS. Second, we develop bilevel stochastic gradient descent for bilevel problems with lower level constraints.

Monday, 12:30 PM–1:45 PM

MC42

CC - Room 204

Surrogate and Global Optimization Methods with Applications

General Session

Session Chair

Xinglong Ju, The University of Oklahoma, Norman, OK

1 Gpu Accelerated Algorithms for The Generalized Set Packing Problem

Samhita Vadrevu[1], Rakesh Nagi[2], [1]UIUC, Champaign, IL, [2]U of Illinois at Urbana-Champaign, Urbana, IL, Contact: samhita3@illinois.edu

The set packing problem is an NP-Hard combinatorial problem, where the objective is to choose the optimal packing of the sets such that the total weight of the system is maximized. In this paper, we solve the weighted generalized set packing problem. We propose a novel quadratic set packing (QSP) formulation that is designed to be more efficient in terms of memory requirements in comparison with the standard generalized set packing formulation. A reduced formulation with fewer constraints and variables is obtained from a series of relaxations and pre-processing. A GPU accelerated heuristic is proposed to solve the dual of this formulation, resulting in a strong lower bound. We integrate this lower bounding scheme with a customized and a parallel branch and bound technique to obtain provably optimal solutions to the set packing formulation.

2 Surrogate Optimization Using Globally Optimal Solutions for Multivariate Adaptive Regression Splines

Srividya Sekar[1], Jay Michael Rosenberger[2], Victoria C. P. Chen[1], Hadis Anahideh[3], [1]The University of Texas at Arlington, Arlington, TX, [2]University of Texas-Arlington, Arlington, TX, [3]University of Illinois at Chicago, Chicago, IL, Contact: srividya.sekar@mavs.uta.edu

Surrogate optimization algorithms employ flexible surrogate models to represent the objective function surface and iteratively update the surrogate with data following an exploration-exploitation search. Multivariate Adaptive Regression Splines (MARS) models have been demonstrated to be appropriate surrogates when the objective is observed with uncertainty. This talk presents a surrogate optimization algorithm that uses global optimization of the MARS surrogates to conduct the exploration-exploitation search.

3 Globally Optimizing a Multivariate Adaptive Regression Splines Approximation

Jay Michael Rosenberger[1], Srividya Sekar[2], Victoria C. P. Chen[3], [1]University of Texas-Arlington, Arlington, TX, [2]University of Texas at Arlington, Arlington, TX, [3]The University of Texas at Arlington, Arlington, TX, Contact: jrosenbe@uta.edu

Multivariate Adaptive Regression Splines (MARS) is a statistical modeling method that is appropriate for building empirical models over multivariate input spaces and is commonly employed for machine learning applications. In this talk, a mixed integer quadratically constrained program (MIQCP) approach is presented to globally optimize a MARS approximation model with quintic basis functions and two-way interaction terms. This MARS model form is useful for design and analysis of computer experiments based optimization algorithms, approximate dynamic programming, and surrogate optimization.

4 Global Optimization on Non-convex Two-way Interaction Truncated Linear Multivariate Adaptive Regression Splines Using Mixed Integer Quadratic Programming

Xinglong Ju[1], Jay Michael Rosenberger[2], Victoria C. P. Chen[2], Feng Liu[3], [1]The University of Oklahoma, Norman, OK, [2]The University of Texas at Arlington, Arlington, TX, [3]Stevens Institute of Technology, Arlington, TX, Contact: xinglong.ju@ou.edu

We present an efficient and effective approach to find a global optimal value of MARS models that incorporate two-way interaction terms which are products of truncated linear univariate functions (TITL-MARS). Specifically, with a MARS model consisting of linear and quadratic structures, we can reformulate the optimization problem on TITL-MARS into a mixed-integer quadratic programming problem (TITL-MARS-OPT), which can be further solved in a more principled way. To illustrate the effectiveness of our proposed approach TITL-MARS-OPT, we come up with a genetic algorithm and a gradient descent algorithm to solve the original version of TITL-MARS, and we compared the performance of the proposed approach with the benchmark algorithms.

Monday, 12:30 PM–1:45 PM

MC43

CC - Room 205
Optimization
Contributed Session

Session Chair
Asya Atik, North Carolina State University, NULL, NC

1 A Composite Index Method for Optimization Benchmarking

Yulan Bai[1], Eli Olinick[2], [1]Southern Methodist university, Dallas, TX, [2]Southern Methodist University, Dallas, TX, Contact: yulanb@smu.edu

We propose a multi-criteria Composite Index Method (CIM) to compare the performance of alternative approaches to solving an optimization problem. The CIM is convenient in those situations when neither approach dominates the other. The CIM takes problem instance size and multiple performance criteria into consideration within a weighting scheme to produce a single number that measures the relative improvement of one alternative over the other. Different weights are given to each dimension based on their relative. We summarize the successful application of the CIM to an NP-hard combinatorial optimization problem known as the backhaul profit maximization problem (BPMP).

2 Learning-augmented Algorithms for Online Linear and Semidefinite Programming

Elena Grigorescu[1], Young-San Lin[2], Maoyuan Song[2], Sandeep Silwal[3], Samson Zhou[4], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West lafayette, IN, [3]Massachusetts Institute of Technology, Cambridge, MA, [4]Carnegie Mellon University, Pittsburgh, PA, Contact: nilnamuh@gmail.com

We study online linear and semidefinite covering programs in which the algorithm is augmented with advice from a possibly erroneous predictor. We incorporate the prediction and design learning-augmented algorithms that outperform the optimal online algorithm when the prediction is accurate while maintaining nice guarantees when the prediction is misleading.
Our framework extends both (1) the online set-cover problem augmented with machine-learning predictors, studied by Bamas, Maggiore, and Svensson (NeurIPS 2020), and (2) the online covering SDP problem, initiated by Elad, Kale, and Noar (ICALP 2016).
Our techniques are based on the primal-dual framework of Buchbinder and Naor (Mathematics of Operations Research, 34, 2009) and can be further adjusted to handle constraints where the variables lie in a bounded region, i.e., box constraints.

3 Share or Hide Emergency Department Queue-lengths to Reduce Congestion ?

Yufeng Zhang, Shrutivandana Sharma, Singapore University of Technology and Design, Singapore,

Singapore. Contact: yufeng_zhang@mymail.sutd.edu.sg
We investigate how di erent levels of queue-length information influence non-urgent patients' decision and the overall social welfare. We consider an emergency department (ED), where incoming patients are classified into urgent patients (UPs) and non-urgent patients (NUPs), UPs receive pre-emptive service priority. After a patient's classification, ED provides some level of queue-length-information: full, partial and no-information. In partial information case, ED provides an arriving UP and NUP only the queue length of UPs and NUPs, respectively. For the three systems above, we characterize equilibrium of patients' decisions and compare the resulting social welfare. Our results suggest that it is not always the best to make ED queues observable. Depending on system parameters and ED congestion, it may be better to hide the queue length of UPs from NUPs.

4 LOCATION-ALLOCATION PLANNINg of INCIDENT RESPONDENTS: AN INTEGRATED DECOMPOSITIOn and CLUSTERING TECHNIQUE

Asya Atik[1], Leila Hajibabai[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC, Contact: aatik@ncsu.edu

This study addresses incident response planning by locating respondents at optimal dispatching stations and allocating them to incident locations in a timely fashion. We have formulated a mixed-integer linear model minimizing the total response time and maximizing the total incident demand covered. The model accounts for the location, severity, and frequency of historical incidents, dispatching locations, and availability of incident respondents. We have implemented a hybrid solution technique with column generation, Lagrangian relaxation, and a density-based spatial clustering (DBSCAN) method. A Benders decomposition technique is implemented as a benchmark analysis. An empirical case study in Raleigh, North Carolina, is solved with the proposed methodology, and the preliminary results suggest that the solution algorithm can solve the problem efficiently.

Monday, 12:30 PM–1:45 PM

MC44

CC - Room 206

Large Scale Network Optimization

General Session

Session Chair

Chun Ye, Amazon.com

1 Fulfillment Planning and Execution in a First Party Network

Andrea Qualizza, Amazon.com, McLean, VA

We will discuss methods for fulfillment planning and execution. The challenge is the coordination of labor and transportation resources provisioning at all points within our network in anticipation of demand then ensuring that package-level decisions for actual demand cumulatively achieve the targeted flows. The overall goal is to strike the right balance between cost, speed, quality and sustainability objectives.

2 Batch Optimization for Joint Order and Transportation Assignment

Weihong Hu[1], Joyjit Roy[1], Alex Fedorov[1], Andrea Qualizza[2], Narayan Venkatasubramanyan[3], [1]Amazon, Seattle, WA, [2]Amazon, Tempe, AZ, [3]Amazon, San Jose, CA

We propose a framework to optimize simultaneously large batches of open customer demand that have not yet reached a point of no return. I.e. we can still re-assign warehouses, demand split patterns and shipment paths until the demand are picked/scheduled/shipped, so as to resolve inefficiency caused by the initial myopic decisions in our online fulfillment execution systems, and achieve various macro level business goals. The primary mathematical modeling tool we use is a compact graph representation of Generalized Networks. The graph construction is modularized and offers multiple levers to scale.

3 Dynamic Discretization Discovery Under Hard Node Storage Constraints

Madison Van Dyk[1], Jochen Koenemann[2,3], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada; [3]Amazon, Bellevue, WA, Contact: madison.vandyk@uwaterloo.ca

Practical network design applications are often complicated by temporal considerations such as transit times and time-varying network parameters. While these problems can be modelled with time-indexed formulations, this often results in huge time-expanded graphs. The well-known dynamic discretization discovery (DDD) framework allows us to strategically solve a series of problems on sparser networks in order find an optimal solution to our original time-indexed formulation in less time. Previously, this framework required the underlying problem to have unlimited storage at nodes. In this talk, we extend DDD to the setting with node storage capacities.

Monday, 12:30 PM–1:45 PM

MC45

CC - Room 207
AI4OPT: Sparsity and Fused Lasso in Machine Learning
General Session

Session Chair
Alper Atamturk, University of California-Berkeley, Berkeley, CA

1 **New Penalized Stochastic Gradient Methods for Large-Scale Linearly Constrained Optimization and Learning**
Meng Li, University of California-Berkeley, Berkeley, CA

2 **Screening for Sparse Logistics Regression**
Anna Deza, University of California-Berkeley, Berkeley, CA
Logistic regression with a large number of features compared to available labels presents numerous challenges for learning. We present screening rules that safely remove features from the sparse logistic regression with L0-L2 regularization before solving the problem. The screening rules are based on the Fenchel dual of strong conic relaxations of the sparse logistic regression problem. Numerical experiments with real and synthetic data suggest that a high percentage of the features can be effectively and safely removed apriori, leading to substantial speed-up in the computations.

3 **Three Fastest Algorithms for Convex Generalized 1-D Fused Lasso Problems**
Cheng Lu, Dorit Simona Hochbaum, University of California, Berkeley, Berkeley, CA
We present three algorithms for convex generalized 1-D fused lasso problems: min-cut based, primal-dual and KKT-based algorithms. While all three algorithms apply across all instances of the problem, the min-cut based algorithm achieves the best possible complexity for convex piecewise linear data fidelity/deviation functions; for general convex data fidelity functions, our primal-dual algorithm is applied with almost linear time complexity; for any convex data fidelity and regularization functions, the KKT-based algorithm runs in almost quadratic time. All the three algorithms are either faster or match the complexities of the existing best (ad-hoc) algorithms for the respective class of problems and their special cases.

4 **Functional Constrained Risk-Averse Sparse Optimization**
Yi Cheng, Guanghui Lan, Edwin Romeijn, Georgia Institute of Technology, Atlanta, GA
Recent years witness considerable attention to joint optimization of sparsity and risk aversion due to its wide applicability in real-world problems. However, algorithmic development of such optimization seems to be scarce in existing literature. In this paper, we focus on a class of convex and nonconvex functional constrained optimization problems that can be used to jointly model sparsity and risk aversion. We propose a class of efficient projection-free methods separately to tackle the convex and nonconvex problems, and demonstrate their practical efficiency by devising formulations and conducting numerical experiments on two important sparse risk averse optimization applications: cardinality-free and cardinality-constrained portfolio selection problem and a large-scale radiation therapy planning problem in the healthcare area.

Monday, 12:30 PM–1:45 PM

MC46

CC - Room 208
Shared Mobility: Models and Algorithms
General Session

Session Chair
Yu Yang, University of Florida, Gainesville, FL

1 **Dynamic Match Swapping to Enhance Shared Mobility Services**
Shiyu Shen, Yanfeng Ouyang, U of Illinois at Urbana-Champaign, Urbana, IL, Contact: sshen10@illinois.edu
This paper proposes a generic dynamic swap strategy that can enhance mobility system efficiency by reducing the expected deadheading time. The strategy can (i) mitigate the wild goose chase phenomenon when the vehicles serve only one type of customers, and (ii) reduce needed fleet size when the vehicles serve multiple types of customers. Approximate analytical formulas are derived from a series of differential equations to examine the expected system performance in the steady-state. Agent-based simulations are used to verify the formulas, and to demonstrate the effectiveness of the dynamic swap strategy. Numerical experiments and sensitivity analysis are conducted to test the effects of various parameters on the system's performance. The formulas can be applied to a broad range of scenarios, and hence can be used by service providers to optimize their service offerings.

2 **E-scooter Rebalancing with En Route Charging Capability**

Yufeng Cao[1], Yu Yang[2], Xiangyu Jin[1], [1]Shanghai Jiao Tong University, Shanghai, China; [2]University of Florida, Gainesville, FL, Contact: 2016-jinxiangyu@sjtu.edu.cn

Electric scooters (e-scooters) have emerged as a popular means of transport. However, the rapid growth of the e-scooter riding demand imposes significant operational challenges for its operators, especially the charging and rebalancing issues. It is vital for the operators to find efficient ways to accomplish the work while keeping their customers satisfied.

We consider a setting where e-scooters can be charged on the rebalancing truck en route or while the truck is waiting at each site. We formulated the joint problem as a mixed-integer linear program. Fixing the truck route and waiting times, we proved that the resulting problem is an integer program with a totally unimodular coefficient matrix. We proposed an effective algorithm to solve the problem based on Benders decomposition. Finally, we validated the proposed algorithm with extensive numerical experiments.

3 Stable Matching in Ridepooling Systems

Hoda Atef Yekta[1], Mohsen Emadikhiav[2], [1]James Madison University, Harrisonburg, VA, [2]Florida Atlantic University, Boca Raton, FL, Contact: atefyehx@jmu.edu

The primary goal of this research is to study matching problems for ride-pooling systems in which a group of two or more riders are matched together and are assigned to a car. Most of the existing research focuses on economically efficient solutions and match riders to minimize the total travel distance for all riders in the market. However, the market-wide optimal solution may not be optimal for all subsets of riders. It is possible that a subset of riders would have a shorter ride if they could ignore their assigned match and form a new group to increase their benefits. Matching solutions in which no subset of riders can benefit by leaving the market solution are called stable solutions. This research explores stability and efficiency by developing new models and algorithms for ride-pooling systems.

Monday, 12:30 PM–1:45 PM

MC47

CC - Room 209

Emerging Rail Technologies

General Session

Session Chair

Ken Kenjale, Wabtec Corp., Pittsburgh, PA

Presenter

Stefano Rieppi, Norfolk Southern Railway, Roswell, GA

Potential for applying ML to rail operations and capacity planning. The emerging dialog and brainstorming from an operator's and practitioner's perspective.

Monday, 12:30 PM–1:45 PM

MC48

CC - Room 210

Electric Vehicles

Contributed Session

Session Chair

Jesus Osorio, University of Illinois Urbana-Champaign, Urbana, IL

1 Solving The Electric Vehicle Scheduling Problem at Scale

Omer Verbas[1], Taner Cokyasar[1,2], Joshua Auld[1], [1]Argonne National Laboratory, Lemont, IL, [2]Tarsus University, Mersin, Turkey. Contact: omer@anl.gov

Vehicle scheduling problem is a difficult to solve problem at a large scale, and the complexity had been addressed in the literature. Yet, electrified vehicles bring in a further computational challenge due to the necessity of returning to a depot for a recharging event. Therefore, the decades long problem is revisited in this study. We provide a brief review of the literature, develop an optimization-supported modeling framework to tackle with the complexity, and test the framework in the Chicago metropolitan area utilizing validated simulation data.

2 An Efficient Heuristic Algorithm for An Ev Routing Problem Considering Driving Speed and Heterogeneous Non-linear Charging Stations

Jerimi Lee[1], Yonna Kang[1], Ohjae Kwon[1], Eunseo Ko[1], Chungmok Lee[2], [1]Hankuk University of Foreign Studies, Yong-in, Korea, Republic of; [2]Hankuk University of Foreign Studies, Yongin-si, Korea, Republic of. Contact: jerimilee1225@gmail.com

As electric vehicles become more common worldwide, the limited battery capacity is the most critical concern of the drivers of EVs. Current EVs have two major issues regarding the battery capacity: (1) short driving range causing range anxiety and (2) long recharging time, which is a highly non-linear function of the stage-of-charge (SoC). This talk introduces a routing problem for EVs considering the route, charging plan, and driving speed. We first present an MIP formulation for the problem, which is very challenging to solve by state-of-the-art MIP solvers. An extended network is then established by integrating the driving mode and the resulting battery consumption into the underline network of the charging station. An efficient two-phase heuristic will be presented based on an extended network, which outperforms Cplex.

3 Probabilistic Shortest Electric Vehicle Paths: Balancing Efficiency and Reliability

Ridvan Aksu[1], Mesut Yavuz[1], Leonardo Lozano[2], [1]University of Alabama, Tuscaloosa, AL, [2]University of Cincinnati, Cincinnati, OH, Contact: raksu@crimson.ua.edu

The popularity and the market share of Electric Vehicles (EVs) are rising mainly due to sustainability efforts and the recent developments in battery technologies. However, long charging times and limited infrastructure coupled with limited driving autonomy remains as obstacles for a complete adaptation of EVs, especially in commercial side. In order to overcome these issues we investigate several heuristic, math-heuristic, and stochastic methods to generate offline path planning methods and online recourse procedure to further decrease the associated costs, given the problem has a non-linear discrete multi-stage stochastic nature. Our research indicates that as opposed to a naïve shortest path approach, significant time and costs savings can be achieved.

4 Optimal Rebalancing and Charging of Shared Electric Scooters with Charging Hubs

Jesus Osorio, Yanfeng Ouyang, University of Illinois Urbana-Champaign, Urbana, IL

This paper presents a series of models for the overnight e-scooter rebalancing and charging problem in which e-scooters are allowed to charge at a set of charging hubs distributed in the service area. Operators may use the charging hubs to hold the e-scooters for charging temporarily, and then pick them up later for repositioning. A discrete formulation is first presented in which e-scooters with different states of charge range are considered as multiple commodities linked through a transition charging function. Then, a discrete-continuous hybrid model is developed for computational enhancement in which asymptotic formulas are used to approximate local operations. Numerical results are presented to test the models' and algorithms' performance, and sensitivity analyses are conducted to draw insights.

Monday, 12:30 PM–1:45 PM

MC49

CC - Room 211

Delivery Optimization for E-Commerce Fulfillment

General Session

Session Chair

Dipayan Banerjee, Georgia Institute of Technology, Atlanta, GA

1 Capacity Planning Problem in Urban Last-mile Crowdsourced Delivery

Dingtong Yang[1], Michael Hyland[2], [1]University of California Irvine, Irvine, CA, [2]University of California, Irvine, Irvine, CA

Capacity planning is a critical step for quality crowdsourced delivery service. Unlike conventional in-house logistics for delivery, crowdsourced delivery usually involves various driver types and available time slots. The study attempts to include three types of drivers for crowdsourced delivery, namely dedicated drivers, time-based drivers and trip-based drivers, for the capacity planning problem of crowdsourced delivery. This study formulates the capacity planning problem in crowdsourced delivery as a fleet size and vehicle routing problem. The analysis includes discussion on the impact of parcel types, time-based crowdsourced driver working hours and trip-based driver participation rate.

2 The Value of Crowdshipping in Urban Environments with Microhubs

Sarah Powell[1], Ann Melissa Campbell[2], Iman Dayarian[3], [1]University of Iowa, Iowa City, IA, [2]University of Iowa, Iowa City, IA, [3]The University of Alabama, Tuscaloosa, AL, Contact: sarah-powell@uiowa.edu

Crowdshipped delivery allows those who are not professional couriers to complete the last-mile delivery of goods. Many studies on crowdshipping focus on which packages to assign to crowdshippers and/or professional drivers. We examine when it is cost-effective to use crowdshipping in urban environments when traditional delivery options are available and microhubs, which serve as package pickup locations for crowdshippers, are used. We determine the relative cost levels that make crowdshipped delivery desirable for different crowdshipper compensation models and truck mileage costs. Analytical and computational results yield a valuable set of managerial insights that can help businesses make important decisions about when and to what extent to use crowdshipping vs. traditional delivery models.

3 A Lossless a Priori Splitting Rule for Split-delivery VRPs

John Gunnar Carlsson, University of Southern California, Los Angeles, CA

Resource allocation problems in which demand is splittable are usually solved using different solution methods from their unsplittable equivalents. For such problems, one strategy that has recently shown potential is the use of an "a priori splitting rule" in which each customer's demand is split into smaller pieces in advance, which enables one to simply solve the splittable problem as an instance of the unsplittable version. In this paper, we introducea splitting rule that minimizes the number of pieces, subject to the constraint that all demand splitting patterns remain feasible.

4 System Design and Management for Concurrent Same-day and Next-day E-retail Fulfillment

Dipayan Banerjee, Alan Erera, Alejandro Toriello, Georgia Institute of Technology, Atlanta, GA, Contact: dipayan.banerjee@gatech.edu

Increased competition in the e-commerce sector has led to the proliferation of same-day delivery (SDD) and next-day delivery (NDD) systems. However, prior research in optimizing and designing such systems has largely assumed that orders with SDD and NDD guarantees are served by separate vehicle fleets. In this work, we propose a continuous approximation model for analyzing the performance of e-commerce delivery systems in which SDD and NDD orders are fulfilled by the same fleet. We use this model to assess the feasibility of providing desired service levels in a given system. Then, to maximize customer satisfaction, to we seek to maximize the number of orders delivered a day early. We propose efficient optimal algorithms, and we demonstrate our model's applicability via computations on a real-world road network.

Monday, 12:30 PM–1:45 PM

MC50

CC - Room 212

Online Platform Design and User Engagement

General Session

Session Chair

Jenny Jin, [1</sup]

1 The Blessing of High Price: A Field Experiment on E-commerce Platform

Jie Song[1], Miaozhe Han[1], Siqi Pei[1], Michael Zhang[2], Feng Zhu[3], [1]Chinese University of Hong Kong, N.T., Hong Kong; [2]Chinese University of Hong Kong, Shatin, N.T., Hong Kong; [3]Harvard Business School, Boston, MA

We challenge the ubiquitous belief that price promotion leads to higher sales. We conduct a randomized field experiment on a leading e-commerce platform in China to test the hypothesis that showing consumers higher-priced items would effectively generate more sales. We find that masking lower-priced items would (1) induce consumers to purchase higher-priced items without reducing the total number of orders, and (2) induce consumers to actively search for higher-priced items that would eventually transform into actual sales. Moreover, the search efforts of consumers remain unchanged. We believe that it is a cognitive bias created by the deviation of the consumer's perception of the value of high-priced items when low-priced items are not available. Our findings have important implications for e-commerce retailers.

2 Social Interactions in a Blockchain Social Network for Witness Election

Sejun Park[1], Alain Pinsonneault[2], [1]McGill University, Montreal, QC, Canada; [2]McGill University, Montreal, QC, Canada. Contact: sejun.park@mail.mcgill.ca

The evolution of blockchain technologies is now shifting toward a new phase where blockchain technologies have progressed to provide an infrastructure for social system. Blockchain Social Network enables necessary sociability for users to further create social relationships. The emergence of 'Blockchain Social Networks' raises an important question about the governance in a blockchain system that has not been examined in past research: How does the social relationships influence the witness election? Our study provides the answer to the question and refines the knowledge on governance in this new type of blockchain system, a Blockchain Social Network.

3 How Does Popularity Information Affect Product Design

Guangrui(Kayla) Li[1], Zheng Gong[2], [1]York University, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada. Contact: kaylali@schulich.yorku.ca

Popularity information serves as quality signal for consumers. Past literature has shown that the revealing popularity information herds consumers to the popular products and leads to a superstar phenomenon. However, the previous literature takes the product design as given. In this project, we examine the impact of popularity information revealing on firms' product design strategy by using a policy change on Wechat Official Account platform. Interestingly, we found that the revealing of popularity information leads to less clicks for the top influencers. Furthermore, top influencers reduced advertising after popularity information shock, and their topic choices became more disperse.

4 Incentive Systems in Revenue-sharing Contract

Keehyung Kim, Chinese University of Hong Kong, Shatin, Hong Kong.

In revenue-sharing contract, experts often provide professional advice to help investors make informed decisions. In return, an incentive mechanism implemented allows experts to collect a small share from investors or companies. This study examines how the incentive structure (the existence and the source) affects the objectivity of experts and whether companies and investors can strategically respond by anticipating the expert's bias. We introduce an abstract model that captures key features of revenue-sharing contract with three parties and test it via an incentive-aligned experiment. Then, we develop and estimate a behavioral model that captures the expert's psychological tradeoff between being self-interested and remaining objective. Our findings provide insights to policymakers in designing an effective incentive mechanism.

Monday, 12:30 PM–1:45 PM

MC51

M - Santa Fe

Teaching Analytics

Contributed Session

Session Chair

Amy B. David, Purdue University, West Lafayette, IN

1 Teaching Decision Analysis and Utility Theory in Business Analytics Ii

Michael Morelli, University of Cincinnati, Cincinnati, OH, Contact: mikeshan89@aol.com

The textbook Business Analytics by Camm, et al. does an excellent job of explaining the concepts of expected utility and expected value and the relationship between them. These are concepts that are normally difficult for students. We will look at some of the examples from the above textbook and from other sources that will help students with these ideas.

2 Critical Thinking and Visualizations for Accounting

Marsha Jance, Shari Fowler, Indiana University East, Richmond, IN

The updated CPA (Certified Public Accounting) exam will have a greater focus on data analytics. As a result, accounting faculty are looking at ways to better incorporate analytics into accounting programs in order to prepare students for the new CPA exam.

This presentation involves a case scenario paper developed by an analytics faculty member and an accounting faculty member. The paper focuses on critical thinking and visualizations which are key components for the new CPA exam. The paper can be used in an accounting and/or analytics course to increase critical thinking skills and understanding of visualizations.

3 Management Students Create Visual Art: A Novel Approach to Introducing Supply Chain Ethics

Amy B. David, Purdue University, West Lafayette, IN, Contact: david11@purdue.edu

A visual arts assignment given to management students in an introductory supply chain management course proved to be a novel and effective technique for introducing students to ethical issues in supply chain management. Students were asked to choose a supply chain ethics issue and create a work of visual art and an artist's statement that explored that issue. The majority of students turned in art work that was creative, relevant, and well-executed, and a very broad range of topics and media were used. Further, students were in agreement that the assignment was more enjoyable than a comparable written assignment. In addition, their understanding of ethical issues in supply chain management increased through both the creation of their own art and interactions with the art of their peers.

Monday, 12:30 PM–1:45 PM

MC52

M - Lincoln

Scheduling I

General Session

Session Chair

Yumei Huo, City University of New York, College of Staten Island & The Graduate Center, Staten Island, NY

1 Streaming Approximation Scheme for Minimizing Total Completion Time on

Parallel Machines Subject to Varying Processing Capacity

Hairong Zhao, Purdue University Northwest, Hammond, IN

We study the problem of minimizing total completion time on parallel machines subject to varying processing capacity. We develop an approximation scheme under the data stream model. The algorithm can compute the approximate value in one pass and output the schedule with the approximate value in two passes.

2 Energy-efficient Unrelated Parallel Machine Scheduling with General Position-based Deterioration

Yusheng Wang, Ada Che, Northwestern Polytechnical University, Xi'an 710072, China. Contact: wang.yusheng@mail.nwpu.edu.cn

We investigate an energy-efficient scheduling problem on unrelated parallel machines considering general position-based deterioration. The objective is to minimise the total energy consumption with a bounded makespan. A mixed-integer linear programming (MILP) model is first proposed and then enhanced from the perspectives of constraints and variables. We also develop an iterative heuristic embedded with a variable neighbourhood search procedure (IHVNS). Computational results demonstrate that the improved model is up to 230 times faster than the original one. Moreover, the proposed heuristic yields excellent solutions with average gaps of less than 0.73% for large-scale instances.

3 Multiprocessor Job Scheduling Problem Under a Grade of Service Provision

Tao Sun, Jun-Qiang Wang, Shuang Yan, PacPos, Xi'an, Shaanxi, China. Contact: pacpos.tsun@gmail.com

We study a multiprocessor job scheduling problem under a grade of service (*GoS*) provision. The objective is to minimize the makespan. A multiprocessor job is the job that needs a fixed number of machines for collaborative processing at the same time. Jobs and machines are labeled with *GoS* levels. If the *GoS* level of a machine is less than or equal to that of a job, the machine can participate in the processing of the job. For the problem on identical parallel machines with two *GoS* levels, we propose largest size-lowest grade-longest processing time (*LS-LG-LPT*) algorithm. For the problem on three uniform machines, we design lowest grade-longest processing time (*LG-LPT*) algorithm. We analyze the worst-case performance ratio of these two algorithms.

Monday, 12:30 PM–1:45 PM

MC53

M - Denver
Finance Flash Session
Flash Session

Session Chair

Agathe Sadeghi, Stevens Institute of Technology, Jersey City, NJ

1 A Rational Theory for Disposition Effects

Yipeng Jiang[1], Min Dai[1], Hong Liu[2], Jing Xu[3], [1]National University of Singapore, Singapore, Singapore; [2]Washington University at St. Louis, St. Louis, MO, [3]Renmin University of China, Beijing, China. Contact: yipeng.jiang@u.nus.edu

Extant theories on the disposition effect are largely silent on most of the disposition-effect related trading patterns, including the V-shaped probabilities of buying and selling against unrealized profit. On the other hand, portfolio rebalancing and learning have been shown to be important, even for retail investors. We show that rational rebalancing with transaction costs and unknown expected returns can generate many disposition-effect-related trading patterns, including the V-shape results. Our paper complements the extant theories by suggesting that portfolio rebalancing may also constitute a significant driving force behind the disposition effect and the related patterns.

2 Reinforcement Learning for Mean Field Games

Alan Raydan, University of California, Santa Barbara, CA

Mean field games (MFG) are an extension of the stochastic differential game paradigm when the number of players approaches infinity. Numerical methods for solving such games have traditionally been focused on solving a coupled PDE system or an FBSDE of McKean-Vlasov type; however, both approaches are model-based in that they rely on an accurate representation of the underlying dynamics and reward function. Here we present a model-free continuous-time reinforcement learning (RL) approach to MFG in which an RL agent mimics a representative player attempting to maximize her cumulative reward through repeated interactions with the mean field dynamics.

3 On The Entrance of New Members in a Risk-sharing Product

Seongyoon Kim, University of Illinois at Urbana-Champaign, Champaign, IL

This paper studies the conditions under which the entrance of a new agent is accepted by the existed members or the organizer of a risk-sharing scheme. Imposing entropic risk measures and normally distributed risks, we show that the pricing of shared risks determined by the fair premium principle leads to a consensus among current agents. We then establish an equilibrium concept where the organizer of the sharing scheme aims to maximize the number of participants. The necessary conditions are provided, which determine the nature of the equilibrium and develop an optimization algorithm that results in the optimal order of entrance of new members.

4 An Approach to Solve Stochastic Consumption Utility Models in Incomplete Markets

Univa Song[1], Daniel Bauer[2], [1]UW Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI, Contact: univa.song@wisc.edu

We study optimal savings and consumption choices under the assumption of uncertain lifetime and stochastic health risk. An extensive literature considers individuals' decisions over their life-cycle in the context of an uncertain lifetime following Yaari's seminal work. Previous research has primarily studied settings with deterministic health conditions. We extend the life-cycle framework to allow for stochastic health and mortality in a continuous-time setting with survival-contingent income. Explicit solutions for optimal consumption paths are solved for individuals with constant relative risk aversion.

5 Delta Hedging and Volatility-Price Elasticity: A Two-Step Approach

Peng Zhu[1], Kun Xia[2], Xuewei Yang[1], [1]Nanjing University, Nanjing, China; [2]Hong Kong University of Science and Technology, Hong Kong, Hong Kong. Contact: pengzhu@smail.nju.edu.cn

Black-Scholes delta is to be optimized since it neglects the relationship between volatility and underlying price. Existing works have seized the relationship and improved the hedging performance. Stepping further, we find that the dependency of minimum variance (MV) delta on volatility-price elasticity is stable and that the elasticity exhibits mean-reverting property. Therefore we first estimate a model which fit the dependency of hedging ratio on elasticity, and then substitute predictions of elasticity into the pre-fixed model to obtain the MV delta. The empirical tests show that our approach improves hedging performance over related methods that appeared in recent works.

6 Optimal Investment with Private Information, Price Impact, and Risk Aversion

Nikolaos Vingos, Boston University, Boston, MA

We revisit the setting of Rochet and Vila (as well as Kramkov and Xu) where an insider obtains private information about the terminal asset payoff, and wishes to optimally invest, accounting for her impact on prices. Our goal is to allow for risk averse market maker. Using results from Kramkov and Xu, we identify the equilibrium pricing function with a second order elliptic partial differential equation. Results are valid when the market maker has exponential preferences, and for general terminal payoff distributions (admitting a density function). Time permitting, we will discuss how to extend results to arbitrary market maker preferences. This is joint work with Scott Robertson, Boston University.

7 E-backtesting Risk Measures

Qiuqi Wang[1], Ruodu Wang[2], Johanna Ziegel[3], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada; [3]University of Bern, Bern, Switzerland. Contact: q428wang@uwaterloo.ca

Expected Shortfall (ES) is the most important risk measure in finance and insurance. One of the most challenging tasks in risk modeling practice is to backtest ES forecasts provided by financial institutions, based only on daily realized portfolio losses without imposing specific models. Recently, the notion of e-values has gained attention as potential alternatives to p-values as measures of uncertainty, significance and evidence. For our work, we use e-values and e-processes to construct a model-free backtest of ES using the notion of universal e-statistics, which can be naturally generalized to many other risk measures and statistical quantities.

8 Factor Model of Mixtures

Cheng Peng[1], Stan URYASEV[2], [1]Stony Brook University, Stony Brook, NY, [2]Stony Brook University, Stony Brook, NY, Contact: cheng.peng.1@stonybrook.edu

We propose a novel framework to model nonlinear dependence structure between factors and a univariate random variable. The framework characterizes the distribution conditioned on some factors with a mixture (linear combination) of characterizing functions. Depending on the user's preference, the characterizing functions can be quantiles, CVaRs and expectiles. The conditional distribution is flexible in both tail and body, since we can include arbitrary valid characterizing functions in the mixture. Furthermore, it has a closed-form expression. The model calibration is formulated as a linear-regression problem. It can be efficiently solved by convex optimization and in some cases reduced to linear programming. Various types of constraints, such as cardinality of the number of functions in the mixture, and penalties can be included in the optimization problem.

9 Learning The Implied Contagion Risk from The Credit Default Swap Market

Agathe Sadeghi, Zachary Feinstein, Dragos Bozdog, Stevens Institute of Technology, Hoboken, NJ, Contact: asadeghi@stevens.edu
One of the financial instruments that embodies the default risk of an institution is Credit Default Swap (CDS) spreads. In this paper, we build correlation and Granger causality networks and look into the risk contagion. We introduce three absolute centrality measures for the firms and the system which, unlike existing measures, are easily interpretable. These measures reflect the instability and interrelation of the network. We exhibit two case studies, one having ten different sectors and another including only financials and consumer services. This approach enables us to compare the network in various time windows and shows that different sectors mitigated the vulnerability of the system.

Monday, 12:30 PM–1:45 PM

MC54

M - Marriott 1
Online Decision Making Algorithms
General Session

Session Chair
Mika Sumida, University of Southern California

Session Chair
Jinglong Zhao, Boston University, Boston, MA

1 Feature-Based Dynamic Matching
Yilun Chen, Yash Kanoria, Akshit Kumar, Columbia University, New York, NY
Motivated by the real operational challenges faced by P2P platforms such as Uber/Lyft, Airbnb, TaskRabbit etc., we study a dynamic two-sided matching problem where sequentially arriving demand units are to be matched to a pool of supply units. Both demand and supply units are characterized by feature vectors, the dot products of which give the matching utility. Under the natural setup that feature vectors are i.i.d. drawn from two distinct demand and supply distributions, we propose an algorithm dubbed *Symmetrized Online Fair Allocate* (SoFA) that achieves the best offline regret scaling (up to polylog factors) when the market size scales up. Such a result indicates that in a thick market, the cost of not knowing future demand vanishes as the cost of (offline) matching dominates. The optimality of our algorithm is based on two novel ideas: *symmetrization and fair allocation*, where we note applying existing techniques developed for relevant problems incur polynomially worse regret scaling. As a corollary of our techniques, we also resolve an open problem posed in Kanoria (2021).

2 Bypassing The Monster: A Faster and Simpler Optimal Algorithm for Contextual Bandits Under Realizability
Yunzong Xu, David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA
We consider the general (stochastic) contextual bandit problem under the realizability assumption, i.e., the expected reward, as a function of contexts and actions, belongs to a general function class. We design a fast and simple algorithm that achieves the statistically optimal regret with only O(log T) calls to an offline regression oracle across all T rounds. Our results provide the first universal and optimal reduction from contextual bandits to offline regression, solving an important open problem in the contextual bandit literature. Based on these results, we discuss a broader research agenda on bridging online and offline learning towards improved data-driven decision-making, and illustrate the applications of our results in recommendation systems, dynamic pricing, and personalized medicine.

3 Optimizing Personalized Assortment Decisions in The Presence of Platform Disengagement
Mika Sumida, Angela Zhou, University of Southern California, Los Angeles, CA, Contact: mikasumi@usc.edu
We consider a problem where customers repeatedly interact with a platform. During each interaction with the platform, the customer is shown an assortment of products and selects among these products according to a MNL choice model. The probability that a customer interacts with the platform in the next period depends on the customer's cumulative number of past purchases. The goal of the platform is to maximize the total revenue obtained from each customer over a finite time horizon. We first study a non-learning version of the problem where consumer preferences are completely known, and prove structural properties of the optimal policy. Next, we study the learning problem where parameters governing consumer preferences and return probabilities are unknown and learned over multiple episodes. We present an online reinforcement learning algorithm for this contextual MDP.

Monday, 12:30 PM–1:45 PM

MC55

M - Marriott 2

Efficient Learning via Adaptive Experimentation

General Session

Session Chair

Daniel Russo, Columbia University, New York, NY

1 Statistical Inference After Adaptive Sampling for Longitudinal Data

Kelly Zhang, 1</sup

There is a great desire to use adaptive sampling methods, such as reinforcement learning and bandit algorithms, for the optimization of digital interventions in areas like mobile health and education. A major obstacle preventing more widespread use of such algorithms in practice is the lack of assurance that the resulting adaptively collected data can be used to reliably answer inferential questions, including questions about time-varying causal effects. In this work, we introduce the adaptive sandwich estimator to quantify uncertainty for Z-estimators on data collected by a large class of adaptive algorithms that learn to select actions by pooling the data of multiple users. Our approach is applicable to longitudinal data settings and in simpler settings, our results generalize those in the adaptive clinical trial literature.

2 Optimal Best Arm Identification Algorithms

Junpei Komiyama, NYU Stern, New York, NY

In this talk, I discuss the best arm identification problem. This problem involves K arms (treatments) and the goal is to find the best arm that has the largest expected reward. The goal of the problem is to maximize the probability of finding the best arm given a fixed number of samples by using an efficient sampling algorithm. Several different measures of the performance of algorithms, such as the frequentist convergence rate (Audibert and Bubeck 2010), posterior convergence rate (Russo 2020), and Bayesian simple regret (Komiyama et al. 2021) are discussed. We show the way to design a good algorithm for each of these measures, focusing on the difference among them.

3 A Closer Look at The Worst-case Behavior of Multi-armed Bandit Algorithms

Anand Kalvit, Assaf Zeevi, Columbia University, New York, NY, Contact: akalvit22@gsb.columbia.edu

This work provides new results on the arm-sampling behavior of two classical multi-armed bandit algorithms; the canonical UCB (Upper Confidence Bound) and Thompson Sampling (TS) policies. Our work culminates in a fascinating discovery that arm-sampling rates under UCB are asymptotically deterministic in probability, regardless of the hardness of the problem instance. This leads to the first "complete" characterization of the worst-case regret of UCB, as well as a diffusion limit characterization of the problem, the first under UCB-type algorithms. We also identify and elucidate an instability result for TS that explains some long-standing empirical observations. Among other things, our analysis reveals profound distinctions between the behavior of UCB and TS, which have complex implications for fairness, off-policy inference and more general learning problems.

4 Recent Progress in Adaptive Experimental Design

Lalit Jain, Foster School of Business, University of Washington, Seattle, WA

Scientific discovery is driven by the researcher's ability to collect high-quality data relevant to either verifying or disproving a hypothesis as quickly as possible. In recent years, a paradigm addressing this problem known as adaptive experimental design (AED) has been gaining traction. AED uses past measurements to inform the researcher what future measurements they should collect in a closed loop. In this talk, we explain the main ideas behind AED in the linear bandit setting. We will discuss how, somewhat surprisingly, Active Classification can be seen as an instance of the linear bandit. This perspective has recently led to instance-optimal and computationally efficient algorithms for Active Classification. Time permitting, we will discuss extensions to fair classification and FDR control as well.

Monday, 12:30 PM–1:45 PM

MC56

M - Marriott 3

Online Platforms/The Digital Economy

General Session

Session Chair

Zhen Lian, Cornell University, NEW YORK, NY

1 Redesigning VolunteerMatch's Search Algorithm: Toward More Equitable Access to Volunteers

Vahideh Manshadi[1], Scott Rodilitz[2], Daniela Saban[3], Akshaya Suresh[1], [1]Yale University, New Haven, CT, [2]UCLA, Redondo Beach, CA, [3]Stanford University, Aachen, CA

Using online platform-based technology, VolunteerMatch (VM) helps connect volunteers to opportunities. VM strives to help all opportunities find connections and has facilitated over 10 million connections; however, many opportunities still get no connections and others get too many to accommodate. We propose a new algorithm, SmartSort, that improves VM's current search ranking practice by incorporating a feedback loop to prioritize opportunities without connections. This paper reports the results of a field-experiment designed to measure the impact of SmartSort, using a difference-in-difference design. Our results suggest that SmartSort can increase the number of opportunities with connections and decrease the percentage of excess connections, without significantly impacting the total number of connections.

2 Do Predictive Scheduling Laws Work?

Wee Kiat Lee[1], Yao Cui[1], Karan Girotra[2], [1]Cornell University, Ithaca, NY, [2]Cornell Tech/Johnson Cornell University, New York, NY, Contact: wl639@cornell.edu

Workers in the service industry tend to have varying work schedules from week to week. Such unpredictable work schedules can be detrimental to their welfare. The advent of the predictive scheduling law in some areas serves to protect these workers from unpredictable work schedules. This law requires the firms to schedule the work in advance or they will be required to compensate the workers. Opponents of the law have argued that such an intervention may be harmful to both the firms and workers. We build a theory model to analyze the effect of this law. We find that while the firm's hiring level may increase with the regulation, the contracted shift hours and social welfare can potentially decrease. We also find empirical evidence for the predictions from our model using data from the state-wide implementation of a predictive scheduling law in Oregon.

3 Centralized Versus Decentralized Pricing Controls for Dynamic Matching Platforms

Ömer Saritac[1], Ali Aouad[2], Chiwei Yan[3], [1]London Business School, London, United Kingdom; [2]London Business School, London, United Kingdom; [3]University of Washington Seattle, Bellevue, WA, Contact: osaritac@london.edu

We develop a stylized model to study the impact of centralization versus decentralization of pricing decisions in dynamic matching markets. This issue is motivated by new regulation and public scrutiny on the level of operational control exercised by platforms in the gig economy. Analytically, we provide a comprehensive, easy-to-compute characterization of the unique market equilibrium in several settings. By leveraging these theoretical analyses, we conduct extensive simulations to analyze the social welfare attained by different levels of centralization.

4 Early or Late Warnings: A Dynamic Information Design Approach

Feng Tian[1], Shouqiang Wang[2], Feifan Zhang[3], [1]Hong Kong University, Hong Kong, Hong Kong; [2]The University of Texas at Dallas, Richardson, TX, [3]Duke Kunshan University, Durham, NC, Contact: fengtian@hku.hk

We study how public agencies disseminate early warnings when facing a looming disaster such as an epidemic outbreak. We look at how they trade off the incentives to trigger timely yet costly preemptive actions with the benefits of collecting more accurate information. We characterize the optimal warning policy, which may induce governments to distort their proprietary information.

Monday, 12:30 PM–1:45 PM

MC57

M - Marriott 4

QSR Best Case Study Paper Competition

Award Session

Session Chair

Arman Sabbaghi, Purdue University, West Lafayette, IN

1 Award Presenter

Tong Wu[1], Yudong Wang[1], Zhisheng Ye[1], Nan Chen[1], Zhijian Chen[2], [1]National University of Singapore, Singapore, Singapore; [2]China Tower Corporation Heilongjiang Branch, Harbin, China.

Statistical inference of recurrent failures in telecommunication systems is challenging because of the large number of base stations and the spatial correlation of their failure processes. We propose a customized NHPP model and demonstrate its performance using the Harbin telecommunication system example with 7,725 base stations and 4,615 failure records.

2 Award Presenter

Mengfei Chen[1], Richard Furness[2], Rajesh Gupta[2], Saumuy Puchala[3], Weihong (Grace) Guo[4], [1]Rutgers, the State University of New Jersey, Piscataway, NJ, [2]Ford Motor Company, Dearborn, MI, [3]Ford Motor Company, Dearborn, MI, [4]Rutgers, The State University of New Jersey, Piscataway, NJ

Throughput analysis plays an important role in the operations and management of automotive manufacturing systems. Accurately predicting the system throughput and identifying the associations for low throughput can facilitate downtime prevention and maintenance decision-making. Traditionally, throughput prediction is done by using analytical or simulation models that rely heavily on the modeling parameters. Today's advanced manufacturing systems are equipped with smart sensors that record process variables and machine status across the plant floor, which raises opportunities for more accurately predicting the system throughput and diagnosing the system. To take advantage of the sensing data, in this paper we propose a hierarchical Recurrent Neural Network (RNN)-based framework that is composed of clustering, feature selection, and RNN for throughput prediction and association mining. The proposed framework is applied to an automotive manufacturing system, and its effectiveness is demonstrated by comparison with conventional methods.

3 Award Presenter

Maede Maftouni[1], Bo Shen[2], Andrew Law[3], Niloofar Ayoobi Yazdi[4], Fahimeh Hadavand[5], Fereshteh Ghiasvand[6], Zhenyu James Kong[3], [1]VIRGINIA POLYTECHNIC INSTITUTE, Blacksburg, VA, [2]New Jersey Institute of Technology, Newark, NJ, [3]Virginia Tech, Blacksburg, VA, [4]Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran, Islamic Republic of; [5]Infectious Diseases and Tropical Medicine Research Center, Shahid Beheshti University of Medical Science, Tehran, Iran, Islamic Republic of; [6]Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Tehran, Iran, Islamic Republic of.

The global extent of COVID-19 mutations and the consequent depletion of hospital resources highlighted the necessity of effective computer-assisted medical diagnosis. COVID-19 detection mediated by deep learning models can help diagnose this highly contagious disease and lower infectivity and mortality rates. Computed tomography (CT) is the preferred imaging modality for building automatic COVID-19 screening and diagnosis models. It is well-known that the training set size significantly impacts the performance and generalization of deep learning models. However, accessing a large dataset of CT scan images from an emerging disease like COVID-19 is challenging. Therefore, data efficiency becomes a significant factor in choosing a learning model. To this end, we present a multi-task learning approach, namely, a mask-guided attention (MGA) classifier, to improve the generalization and data efficiency of COVID-19 classification on lung CT scan images.The novelty of this method is compensating for the scarcity of data by employing more supervision with lesion masks, increasing the sensitivity of the model to COVID-19 manifestations, and helping both generalization and classification performance. Our proposed model achieves better overall performance than the single-task (without MGA module) baseline and state-of-the-art models, as measured by various popular metrics. In our experiment with different percentages of data from our curated dataset, the classification performance gain from this multi-task learning approach is more significant for the smaller training sizes. Furthermore, experimental results demonstrate that our method enhances the focus on the lesions, as witnessed by both attention and attribution maps, resulting in a more interpretable model.

Monday, 12:30 PM–1:45 PM

MC58

M - Marriott 5

Big Data Analytics and Data-driven Decision-making

General Session

Session Chair

Xin Zan, University of Florida, Gainesville, FL

Session Chair

Xiaochen Xian, University of Florida, GAINESVILLE, FL

1 Transparent Sequential Learning for Statistical Process Control

Peihua Qiu[1], Xiulin Xie[2], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL, Contact: pqiu@ufl.edu

Machine learning methods have been widely used in statistical process control (SPC) problems. But, many machine learning methods work like black boxes, and it is difficult to interpret their learning mechanisms and the resulting decision rules. In this talk, we present a recent machine learning approach for SPC, in which process characteristics to learn are well specified in advance and process learning is sequential in the sense that the learned process characteristics keep being updated during process monitoring. This method is nonparametric and allows the process to be dynamic with serially correlated observations.

2 A Novel Active Anomaly Discovery Method and Its Applications in Additive Manufacturing

Bo Shen, Zhenyu James Kong, Virginia Tech, Blacksburg, VA, Contact: boshen@vt.edu

Anomaly detection aims to identify the true anomalies from a given set of data instances. However, labeling is often costly. Therefore, the way to balance detection accuracy and labeling cost is essential. Along this line, this paper proposes a novel active anomaly discovery (AAD) method to achieve the goal. Our approach is based on the state-of-the-art unsupervised anomaly detection algorithm, namely, Isolation Forest, to extract features. Thereafter, the sparsity of the extracted features is utilized to improve its anomaly detection performance. To enforce the sparsity of the features and subsequent improvement of the detection analysis, a new algorithm based on online gradient descent, namely, Sparse Approximated Linear Anomaly Discovery (SALAD), is proposed with its theoretical Regret analysis.

3 Anomaly Detection on Spatial Temporal Data with Tensor Autoregression

Man Li, HKUST, Hong Kong, Hong Kong. Contact: mlicn@connect.ust.hk

Traffic data often exhibit strong spatial correlations and temporal periodicity along with many features like flow, speed and etc.. Anomaly detection is one of the critical task in urban analysis to help emergency-response decision making. This work proposes a tensor autoregressive framework to model spatiotemporal traffic data for anomaly detection and diagnosis. We extend the vector autoregression to tensor in order to characterize the variation dynamically. The coefficient is assumed a low-rank structure and streaming tensor CP decomposition scheme is adapted to capture the principle components. Anomaly scores are then computed based on the temporal factor matrix to detect unusual events. Extensive experimental results on both synthetic dataset and real-work dataset demonstrate the effectiveness of our approach.

4 Real-time Sleep Apnea Monitoring Based on Weakly Supervised Deep Learning Using Coarse-grained Labels

Xin Zan, Xiaochen Xian, University of Florida, GAINESVILLE, FL, Contact: xin.zan@ufl.edu

Sleep apnea is a common sleep disorder suffered by a large population. Current automatic machine learning-based sleep apnea detection methods relying on supervised learning require massive well-labeled training data, which is yet usually inaccessible because the labeling process is labor-intensive and time-consuming. Subject to limited well-labeled data, we incorporate domain knowledge with machine learning techniques from various signals to establish a weakly supervised deep learning method using only coarse-grained labels that automatically scores the severity of apnea in real time. Through the robust short-range scoring mechanism, the proposed method enables quick and accurate apnea detection with significantly reduced labeling costs, extending the reach of real-time sleep apnea monitoring to larger population both in lab and at home.

Monday, 12:30 PM–1:45 PM

MC59

M - Marriott 6

Fabrication-Aware Machine Learning for Additive Manufacturing

General Session

Session Chair

Weizhi Lin, Los Angeles, CA

Session Chair

Qiang Huang, University of Southern California, Los Angeles, CA

1 Functional Shape Deviation Characterization and Prediction Through Partitioning Complex Manifolds for Additive Manufacturing

Weizhi Lin[1], Qiang Huang[2], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, Contact: weizhili@usc.edu

Product qualification for freeform shapes has become a critical issue for additive manufacturing. Challenges occur in geometric dimensioning for shapes with complex geometric structures and small training datasets for prediction. To address the difficulties, we propose a patch-based functional approach to characterize and predict the deviation. We first partition complex freeform surfaces into patches with homogeneous geometries to obtain sufficient samples. The deviation is then represented as the non-rigid transformation between corresponding patches on the design and printed profiles. A multivariate functional mixed effect model is proposed to predict the deviation on geometrically similar patches with location and size effects.

2 Physics-informed Explainable Ai for Quality Prediction in Powder Bed Fusion Processes

Vidita Gawade[1], Yuebin Guo[2], Weihong Guo[3], [1]Rutgers, The State University of New Jersey, Piscataway, NJ, [2]Rutgers, The State University of New Jersey, Piscataway, NJ, [3]Rutgers, The State University of New Jersey, Piscataway, NJ, Contact: vag65@soe.rutgers.edu

Laser-based powder bed fusion (L-PBF) is a process in which complicated thermal behavior of rapid heating, solidifying, and melt-back of powder particles evolve into additively manufactured objects. The dynamic behavior results in a volatile behavior contributing to quality issues. Explainable Artificial Intelligence (XAI) is proposed to better understand the convoluted links of non-sequential process physics, online time series sensing data, and part quality. Hybrid Deep Learning models which leverage tabular and time series will be developed to predict part quality issues such as potential overheating and surface roughness. Local Interpretable Model-Agnostic Explanations (LIME) and

Shapley Additive Explanations (SHAP) will be methodologies explored to interpret attributes' impact on each instance of models' predictions.

3 Machine-learning-enabled geometric compliance improvement in two-photon lithography

Sixian Jia, University of Illinois, Urbana-Champaign, IL

Two-photon lithography (TPL) has emerged as a practical and promising micro-and nano-scale additive manufacturing technology with a wide range of applications. Yet, the geometric variability of TPL-fabricated 3D structures has not been well understood. This talk will present a general machine-learning-based framework to improve the geometric compliance in TPL. The framework first quantifies the geometric variability of fabricated 3D structures, and then prescribes a compensation strategy to improve the geometric compliance. Experimental case studies demonstrate that the proposed framework can effectively improve the geometric compliance without introducing any modifications to the hardware, thus facilitating more widespread adoption.

4 Process Modeling with Multi-level Categorical Inputs Via Variable Selection and Level Aggregation

Andi Wang, Arizona State University, Mesa, AZ

IoT-enabled manufacturing system often involves multiple categorical variables, denoting the process configurations and product customizations. It leads to flexible relationship between process input and output and causes significant challenges for modeling and analysis. This paper proposes a data-driven additive model to address the effects of different categorical variables. The estimation algorithm automatically identifies the inputs with significant effects on the product quality, aggregates the levels of each categorical variable based on a priori knowledge of level similarity, and provides an accurate model that describes the relationship between the process inputs and outputs. The method is validated with a hot rolling process.

Monday, 12:30 PM–1:45 PM

MC60

M - Marriott 7

Quality, Reliability, and Statistics I

Contributed Session

Session Chair

Xiaotong Sun, University of Arkansas, Springdale, AR

1 Asset Investment Optimization Based on Failure Risk

Dzung Phan[1], Pavankumar Murali[1], Nianjun Zhou[1], Lam M. Nguyen[2], [1]IBM Research, Yorktown Heights, NY, [2]IBM Research, Ossining, NY, Contact: pavanm@us.ibm.com

We introduce a general framework for asset investment optimization for a group of geographically distributed assets over a time horizon. This enables a systematic evaluation of asset condition (i.e., failure risk) and replacement strategies to optimize capital allocation and operational expenses while maintaining system reliability. Our conditioned-based preventive replacement using predictive analytics and optimization provides better availability, utilization, and performance for assets.

2 Output Space-filling Design

Shangkun Wang, Roshan V. Joseph, ISyE Georgia Tech, Atlanta, GA, Contact: sk_wang@gatech.edu

Space-filling designs are commonly used in computer experiments to fill the space of inputs so that the input-output relationship can be accurately estimated. However, when the relationship is highly nonlinear, a good space-filling design on the input space may produce large gaps in the output space and thereby, deteriorating the prediction performance. In this article, we propose a new experimental design method that tends to fill the space of the outputs. The method is adaptive and model-free, and therefore is expected to be robust to different kinds of modeling choices and input-output relationships. Several examples are given to show the advantages of the proposed method over the traditional space-filling designs.

3 A New Shift-left Framework to Early Screen of Infant Failures by Analyzing The Correlation of Wafer and Package Test Results

Bumsuk Chung, Ji-Ho Ghil, Bokyoung Kang, Inkap Chang, Sungbo Shim, Sang hyun Ahn, Minho Jeong, Taeha Jun, Hyung-Seok Kang, Jonghoon Kim, Sangwoo Pae, Samsung Electronics, Hwaseong-si, Korea, Republic of. Contact: philip.chung@samsung.com

Predicting the results of package test by using the wafer test results to control the chip quality before packaging stage is important in terms of production time and cost reduction. To address this problem, we develop a group division based correlation analysis method and apply statistical hypothesis test to reveal the latent relationship between wafer and package test results. In order to optimize statistical quality control limit, we adopt S (Screen-ability)-chart which visualizes and quantifies the performance of pre-screen ability for package infant failures. Experimental results on test data of NAND Flash product show that the pre-screen ability of proposed approach outperforms traditional methods.

4 Significance Level Effects on Variable Selection and Information Criteria

Xiaotong Sun, Justin Chimka, University of Arkansas, Fayetteville, AR, Contact: xs018@uark.edu

We will present results of how the choice of significance level affects variable selection and information criteria across inferential tools including stepwise regression and a tree-based model designed to address interaction without requiring polynomials. In backward stepwise regression the significance level is for removal from the model. In our tree-based model the significance level serves as a standard for not only variable selection but also dividing datasets into subsets that address interaction among regressors. In either case significance levels and the resulting models can be fairly judged with Bayesian Information Criteria.

Monday, 12:30 PM–1:45 PM

MC61

M - Marriott 8

PERFORM: New Paradigms for Power System Operations I

General Session

Session Chair

Richard Paul O'Neill, ARPA-E, Silver Spring, MD

Session Chair

Daniel Bienstock, Columbia University, New York, NY

1 Managing Imbalance Risk with Reserves and Flexibility Options

Evangelia Spyrou[1], Robin Broder Hytowitz[2], Benjamin Field Hobbs[3], Siddharth Tyagi[4], Ibrahim Krad[5], Mengmeng Cai[1], [1]National Renewable Energy Laboratory, Golden, CO, [2]Electric Power Research Institute, Redwood City, CA, [3]Johns Hopkins University, Baltimore, MD, [4]Johns Hopkins University, baltimore, MD, [5]Electric Power Research Institute, Palo Alto, CA

As the electricity generated by variable resources grows, system operators and variable resources have to manage challenging imbalances between forward and real-time markets. This presentation will discuss the design of two products that could facilitate imbalance risk management: a reserve type of product similar to CAISO's proposed imbalance reserves and an option type of product that is being demanded in day-ahead by participants with uncertain real-time output. The presentation will also examine how the introduction of either product could affect system reliability and production costs, along with participant gross margins and prices.

2 Presenter

Dalia Patino-Echeverri, Duke University, Durham, NC

GRACE: A Grid that is Risk Aware for Clean ElectricityWe will discuss progress on three components of the GRACE approach: 1) the methods for uncertainty characterization of PV production, load, and generators' performance, 2) progress on the development of the risk-adjusted stochastic unit commitment, and 3) progress on the algorithms to search the solution's libraries.

3 Abscores, Managing Risk and Uncertainty in Electricity Systems

Alberto J. Lamadrid, Lehigh University, Bethlehem, PA

We build a rigorous, innovative and implementable end-to-end risk management framework that spans relevant information gathering and novel quantification of risk, addresses operational integration, and investigates market innovations that close loopholes due to information asymmetry. The resulting framework for asset and system risk management can be incorporated into current electricity system operations to improve economic efficiency and establishes an Electric Assets Risk Bureau.

4 Risk Analysis for Energy Markets

Daniel Bienstock, Columbia University, New York, NY

Monday, 12:30 PM–1:45 PM

MC64

M - Indiana A

Optimizing Matchmaking in Platforms

General Session

Session Chair

Thanh Nguyen, Purdue University, West Lafayette, IN

1 (near) Substitute Preferences and Equilibria with Indivisibilities

Thanh Nguyen, Purdue University, West Lafayette, IN

An obstacle to using market mechanisms to allocate indivisible goods is the non-existence of competitive equilibria (CE). To surmount this Arrow and Hahn proposedthe notion of social-approximate equilibria: a price vector and corresponding excessdemands that are 'small'. We identify social approximate equilibria where the excessdemand, good-by-good, is bounded by a parameter that depends on preferences onlyand not the size of the economy. This parameter measures the degree of departure fromsubstitute preferences. As a special case, we identify a class called geometric substitutesthat guarantees the existence of competitive equilibria in non-quasi-linear settings. Itstrictly generalizes prior conditions such as single improvement, no complementarities,gross substitutes and net substitutes.

2 Presenter

Changhwa Lee, 1</sup

3 Interviewing and Matching in Random Markets

Maxwell Allman, Stanford, CA

Many matching markets involve an interviewing process before the final match is determined, such as the NRMP where hospitals first interview doctors before a final match is made by a centralized clearinghouse. Several interventions have been proposed to better coordinate and reduce the cost of such interviewing processes, such as capping the maximum number of interviews, adding a signalling system, or creating an interview match. We study theoretical properties of a range of these proposals for random markets, allowing for heterogeneous agents and a rich class of preference distributions.

4 The Cost of Impatience in Dynamic Matching

Angela Kohlenberg, Northwestern University, Evanston, IL, Contact: angela.kohlenberg@kellogg.northwestern.edu

We study how to optimally match heterogenous agents with finite patience. Agents of each type arrive over time to a dedicated queue and wait to be matched. Agents have finite patience and abandon if not matched by the time their patience expires. Each match corresponds to two different agents and yields a fixed reward. A matching policy specifies which matches to perform at any point in time, based on the number of agents in each queue. We characterize explicitly, in terms of the network parameters, the loss relative to the no-abandonment case and propose a policy that achieves the optimal loss.

5 Optimizing Free-to-play Multiplayer Games with Premium Subscription

Yunke Mai[1], Bin Hu[2], [1]University of Kentucky, Lexington, KY, [2]University of Texas at Dallas, Richardson, TX, Contact: yunke.mai@uky.edu

We consider the optimal operating policies of a free-to-play online multiplayer game with premium subscription to maximize its lifetime operating profit. Accounting for social-comparison effects between free and premium players, we model the game attracting or losing players with a hybrid of the Bass diffusion model and the replicator equation in evolutionary game theory. Leveraging optimal control theory, we characterize optimal dynamic pricing and advertising policies and show that the developer should prioritize initial growth by aggressively advertising while postponing the introduction of premium subscription, and surprisingly the subscription price may start high and gradually decrease.

Monday, 12:30 PM–1:45 PM

MC65

M - Indiana B

Information Design in Markets

General Session

Session Chair

Eray Turkel, 1</sup

Session Chair

Yunus Can Aybas, Stanford University, CA

1 Private Private Information

Kevin He[1], Fedor Sandomirskiy[2], Omer Tamuz[2], [1]University of Pennsylvania, Philadelphia, PA, [2]Caltech, Pasadena, CA, Contact: fsandomi@caltech.edu

In a private private information structure, agents' signals contain no information about the signals of their peers. We study how informative such structures can be, and characterize those that are on the Pareto frontier, in the sense that it is impossible to give more information to any agent without violating privacy. In our main application, we show how to optimally disclose information about an unknown state under the constraint of not revealing anything about a correlated variable that contains sensitive information.

2 Perfect Bayesian Persuasion

Elliot Lipnowski[1], Doron Ravid[2], Denis Shishkin[3], [1]Columbia University, New York City, NY, [2]University of Chicago, Chicago, IL, [3]UC San Diego, La Jolla, CA

A sender commits to an experiment to persuade a receiver. We study attainable sender payoffs, accounting for sender incentives for experiment choice, and not presupposing a receiver tie-breaking rule when indifferent. We characterize when the sender's equilibrium payoff is unique and so coincides with her value in Kamenica and Gentzkow (2011). A sufficient condition is that every action which is receiver-optimal at some belief over a set of states is a uniquely optimal at some other such belief—a generic property for finite models. In an extension, this uniqueness generates robustness to imperfect sender commitment.

3 Organizing Data Analytics

Odilon Camara[1], Ricardo Alonso[2], [1]University of Southern California, Los Angeles, CA, [2]London School of Economics and CEPR, London, United Kingdom.

We develop a theory of credible skepticism in organizations to explain the main trade-offs in organizing data generation, analysis and reporting. In our designer-agent- principal game, the designer selects the information privately observed by the agent who can misreport it at a cost, while the principal can audit the report. We study three organizational levers: tampering prevention, tampering detection and the allocation of the experimental-design task. We show that motivating informative experimentation while discouraging misreporting are often conflicting organizational goals. To incentivize experimentation, the principal foregoes a flawless tampering detection/prevention system and separates the tasks of experimental design and implementation.

4 Communicating with Anecdotes

Nika Haghtalab[1], Nicole Immorlica[2], Brendan Lucier[2], Markus Mobius[2], Divyarthi Mohan[3], [1]University of California, Berkeley, CA, [2]Microsoft Research New England, Cambridge, MA, [3]Tel Aviv University, Tel Aviv - Yafo, Israel. Contact: divyarthim@tau.ac.il

We study a communication game between a sender and receiver. The sender has access to a set of informative signals about a state of the world ▯; she chooses one of her signals and communicates it to the receiver. We call this an *anecdote*. The receiver takes an action, yielding a utility for both players. The players both care about the state ▯ but also have their own personal preference so their ideal actions may differ. We characterize perfect Bayesian equilibria when the sender cannot commit to a communication scheme. Here the sender faces *persuasion temptation*: she is tempted to send a more biased anecdote to influence the receiver's action, which comes at the cost of precision. Hence the receiver prefers to listen to like-minded senders because they provide higher-precision signals. However under commitment differences in personal preferences no longer affect communication.

Monday, 12:30 PM–1:45 PM

MC66

M - Indiana C

Learning and Optimization Methods in Renewable Power Systems

General Session

Session Chair

Iesia Mitridati, [1]</sup

Session Chair

Antoine lesage-Landry, Polytechnique Montréal, QC, Canada.

1 Tightening QC Relaxations for The ACOTS Problem

Cheng Guo[1], Harsha Nagarajan[2], Merve Bodur[3], [1]Clemson University, Clemson, SC, [2]Los Alamos National Laboratory, Los Alamos, NM, [3]University of Toronto, Toronto, ON, Canada. Contact: cguo2@clemson.edu

The Alternating Current Optimal Transmission Switching (ACOTS) problem incorporates line switching decisions into the fundamental AC optimal power flow (ACOPF) problem. The advantages of ACOTS include reducing the operational cost and improving system reliability. ACOTS optimization models contain discrete variables and nonlinear structures. We derive strengthened quadratic convex (QC) relaxations for ACOTS by combining several methodologies, including the use of strong linearization with extreme-point representation, and adding several types of valid inequalities. In particular, we derive a novel kind of on/off cycle-based polynomial constraints. Our experiments show that our strengthening techniques are able to improve the bounds for ACOTS relaxations on PGLib instances, with some of those improvements substantial.

2 State-of-charge Segment Production Cost and Bidding Model for Energy Storage

Ningkun Zheng[1], Xin Qin[2], Gabe Murtaugh[3], Bolun Xu[4], [1]Columbia University, New York, NY, [2]University of Cambridge, Cambridge, United Kingdom; [3]California ISO, Folsom, CA, [4]Columbia University, New York, NY, Contact: nz2343@columbia.edu

This talk will introduce a new production cost model to incorporate energy storage into real-time power system economic dispatch. In this model, all storage bids and parameters are associated with a state-of-charge segment, including discharge and charge bids, efficiency, and power rating. We will demonstrate the equivalency between the proposed model and a multi-period ideal dispatch setting under optimal bid design. This model could model both linear and nonlinear/nonconvex storage resources without compromising the computation speed. In the end, we provide simulation results to demonstrate how the proposed model improves the profitability and utilization of energy storage resources with linear storage models and nonlinear/non-convex storage models.

3 Tight and Compact Sample Average Approximation for Joint Chance Constrained Optimal Power Flow

Álvaro Porras, Concepción Domínguez, Juan Miguel Morales, Salvador Pineda, University of Málaga, Málaga, Spain. Contact: alvaroporras19@gmail.com

In this work, we tackle the resolution of a probabilistically constrained version of the DC Optimal Power Flow problem with uncertain net demand. We use Sample Average Approximation to produce a deterministic reformulation, which takes the form of a large-scale mixed-integer program cursed with Big-Ms. We then introduce an exact resolution method for the MIP that combines the addition of a set of valid inequalities to tighten the linear relaxation bound with coefficient strengthening and constraint screening algorithms to improve its Big-Ms and considerably reduce its size. The proposed valid inequalities are based on the notion of k-envelopes, can be computed offline using polynomial-time algorithms, and added to the MIP program all at once. In a series of numerical experiments which involve five power systems, we show the efficiency of the proposed methodology.

4 Leveraging Power Grid Topology in Machine Learning Assisted Optimal Power Flow

Thomas Falconer, DTU, Copenhagen, Denmark.

Machine learning assisted optimal power flow (OPF) aims to reduce the computational complexity of these non-linear and non-convex constrained optimization problems by consigning expensive (online) optimization to offline training. The majority of work in this area typically employs fully connected neural networks (FCNN). However, recently convolutional (CNN) and graph (GNN) neural networks have also been investigated, in effort to exploit topological information within the power grid. Although promising results have been obtained, there lacks a systematic comparison between these architectures throughout literature. Accordingly, we introduce a concise framework for generalizing methods for machine learning assisted OPF and assess the performance of a variety of FCNN, CNN and GNN models for two fundamental approaches in this domain: regression (predicting optimal generator set-points) and classification (predicting the active set of constraints). For several synthetic power grids with interconnected utilities, we show that locality properties between feature and target variables are scarce and subsequently demonstrate marginal utility of applying CNN and GNN architectures compared to FCNN for a fixed grid topology. However, with variable topology (for instance, modelling transmission line contingency), GNN models are able to straightforwardly take the change of topological information into account and outperform both FCNN and CNN models.

Monday, 12:30 PM–1:45 PM

MC67

M - Indiana D

Innovations in Pricing and Sales Promotion Strategies

General Session

Session Chair

Shima Nassiri, Amazon, San Francisco, CA

1 Amazon Retail Pricing Science

Tara Mardan, Amazon, Seattle, WA

Amazon is known for having a vast selection, low prices and fast delivery. With millions of products available on Amazon.com, our Retail Pricing Systems is using technology to compute and publish prices for every item in Amazon's retail catalog, delivering competitive prices across our full range of products and automating decision-making. In this presentation we talk about Amazon retail pricing and the models that we use to deliver value to our customers.

2 Estimating Product-specific Price Elasticities with a Bayesian Hierarchical Model at Scale

Pau Pereira, Amazon, Seattle, WA

Price elasticities measure the causal effect of a price change on units sold. As such, they are central to many optimization problems where we need the counterfactual expected sales at different price levels. In this talk we show how we use Bayesian hierarchical modeling together with modern Bayesian approximate inference techniques to "easily" estimate individual product-level elasticities in what is likely to be the largest product selection in the world.

3 Estimating The Typical Price of a Product and Its Distibution

David Cui, Amazon, Seattle, WA

Amazon earns Customer trust by offering competitive, low prices on across all products on the store. A key challenge is to estimate the typical price of a product at scale and determine ranges that fall within typical and atypical ranges. In this presentation, we describe a pricing aggregator (based on research in truth discovery) that estimates a product's price distribution based on available pricing signals and product attributes. We then propose a machine learning approach to predict the future distribution of this pricing aggregator, which can be used as an input for various pricing applications.

4 Trustworthy Experiments in The Presence of Interference

Shima Nassiri, Amazon, San Francisco, CA, Contact: shmnas@amazon.com

Any A/B experiment consists of treatment and control groups. The treatment group is exposed to a new policy while the control group is expected to be unaffected by the treatment. The difference in the outcome of interest between these groups can identify the treatment effect. In the presence of substitutable or complementary products in a pricing setting, the treatment can affect (spill to) the controlled observations and bias the estimated treatment effect. This issue is known in the literature and practice as spillover or interference. In this study, we aim to characterize such bias using an exposure mapping technique and reduce the bias using cluster randomization.

Monday, 12:30 PM–1:45 PM

MC68

M - Indiana E

Modern Algorithmic Paradigms in Operation

General Session

Session Chair

Yiding Feng, 1</sup

Session Chair

Rad Niazadeh, Chicago Booth School of Business, Stanford, CA

1 Optimal Multi-stage Configuration Allocation with Applications to Video Advertising

Yiding Feng[1], Rad Niazadeh[2], [1]Microsoft Corporation, Cambridge, MA, [2]Chicago Booth School of Business, Stanford, CA, Contact: yidingfeng@microsoft.com

Motivated by real-time resource allocation (e.g., video streaming ads), we study designing optimal competitive multi-stage configuration allocation algorithms (with preemption) in an adversarial setting, where users arrive in batches in a stage-wise fashion. This problem generalizes bipartite matching, b-matching, and Adwords problem. We propose a novel convex-programming based multi-stage configuration allocation algorithm. We further show an intimate connection between the convex programs used in each stage and a recursive functional equation. Using this connection, we develop a recursive primal-dual analysis for our algorithm and show it attains the optimal competitive ratio $1-(1-1/K)^K$ competitive, where K is the number of stages.

2 Online Matching with Reusable Network Resources and Decaying Rewards: A Unified Framework

Feng Zhu[1], Zeyu Zheng[2], David Simchi-Levi[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]University of California, Berkeley, Berkeley, CA, Contact: fengzhu@mit.edu

We build a new unified modeling and analysis framework that encompasses a number of classical online matching problems and accommodates three practical features: reusable resources, network resources and decaying rewards. For the unified framework, we provide a unified performance analysis for the greedy policy and greedy-like policies, measured by competitive ratios under the adversarial environment. We prove that greedy-like policies can achieve near-optimal performances under the unified framework. We then dig deeper into several representative special classes of online matching problems, which impose additional realistic structural assumptions on top of the unified framework. We show that slight modifications to greedy-like policies can successfully utilize additional structural information to further enhance policy performances.

3 Sequential Search with Acquisition Uncertainty

David Brown, Cagin Uru, Duke University, Durham, NC, Contact: cagin.uru@duke.edu

We study a variation of the classical Pandora's problem in which a decision-maker (DM) sequentially explores alternatives from a given set and learns their values while trying to acquire the best alternative. In this variation, alternatives randomly become unavailable during exploration and the DM's ability to acquire a remaining alternative is uncertain and depends on a chosen offer price. We develop and study a class of "take-it-or-leave-it" threshold policies. We show that these threshold policies are asymptotically optimal as the number of alternatives grows large with a convergence rate that we characterize and that in general, these policies obtain at least $1-1/e \approx 63.2\%$ of the optimal value.

4 Online Resource Allocation with Time-flexible Customers

Negin Golrezaei[1], Evan Yao[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Canton, MA, Contact: golrezae@mit.edu

In classic online resource allocation problems, we need to make immediate and irrevocable choices regarding arriving demand (agents). However, in many settings such as hospitals, services, and ride-sharing, some agents may be willing to wait a short amount of time for the resource. Motivated by that, we study the online resource allocation problem in the presence of time-flexible agents under an adversarial online arrival model. We present a setting with flexible and inflexible agents who seek a resource or service that replenishes periodically. Our work presents a class of POLYtope-based Resource Allocation (POLYRA) algorithms that achieve optimal or near-optimal competitive ratios. Such POLYRA algorithms work by consulting a particular polytope and only making decisions that guarantee the algorithm's state remains feasible in this polytope.

Monday, 12:30 PM–1:45 PM

MC69

M - Indiana F

RMP Flash Session I

Flash Session

Session Chair

Max R. Biggs, University of Virginia, Charlottesville, VA

1 Project 412Connect: Bridging Students and Communities

Alex DiChristofano[1], Michael L. Hamilton[2], Sera Linardi[2], Mara F. McCloud[2], [1]Washington University in St. Louis, St. Louis, MO, [2]University of Pittsburgh, Pittsburgh, PA, Contact: a.dichristofano@wustl.edu

In this work, we investigate some of the challenges Black-owned businesses face. Taking into account dynamics specific to the Pittsburgh region, we determine that university students represent an under-utilized market for these businesses. We investigate the root causes for this inefficiency and design and implement a platform, 412Connect, to increase support for Pittsburgh Black-owned businesses from students in the university community. The platform operates by coordinating interactions between student users and participating businesses. Our platform design choices are aided by two simple, novel models for badge design and equity-orientated recommendation that may be of independent interest.

2 Fair Division of Gains in Outcome-driven Dynamic Refugee Matching

Yonatan Gur[1], Elisabeth Paulson[2], [1]Stanford University, Stanford, CA, [2]HBS, Cambridge, MA

Recent work has proposed new methods for assigning refugees and asylum seekers to localities within a host country, with the goal of maximizing total employment. Under these optimization-driven approaches, large gains are found compared to status quo procedures. However, the gains are not always evenly distributed across the localities, which is undesirable for policymakers, local agencies, and the local community. This study develops a new algorithm whose goal is to maximize the average overall employment rate, while ensuring that a super-proportional division is achieved amongst the localities. The performance of the algorithm is demonstrated on real refugee resettlement data from the US.

3 Understanding Opaque Selling from An Inventory-control Perspective

Yuan Qu[1], Jian Yang[2], [1]Rutgers Business School, Newark & New Brunswick, NJ, [2]Rutgers University, New York, NY, Contact: yuan.qu@rutgers.edu

We take an inventory angle to understand opaque selling. With two closely-related products, the seller can use price discounts and guaranteed availabilities to urge buyers to accept probabilistic deliveries. Our study first takes aggregate buyer behaviors as given. The seller's preference for a balanced inventory would lead to a balance-inducing rationing policy and the seller's welcome of more opaque selling. Different from existing works, we allow lost sales. It can extract operational efficiencies in absolute terms and rationalize opaque selling. Also considered is a more realistic but more complex case where the choices of buyers with heterogeneous valuations and the fulfillment of the seller are reached as equilibrium. The seller's decisions on the price and replenishment policy are discussed. Further managerial insights are gained from our numerical analyses.

4 Probabilistic Approximations for Network Revenue Management

Saied Samiedaluie[1], Dan Zhang[2], Rui Zhang[3], [1]University of Alberta, Edmonton, AB, Canada; [2]University of Colorado, Boulder, CO, [3]Leeds School of Business University of Colorado Boulder, Boulder, CO, Contact: samiedal@ualberta.ca

Approximate linear programs for network revenue management based on affine and separable piecewise linear (SPL) approximations are shown to have intuitive probabilistic interpretations in the literature: While the affine approximation tracks the expected resource levels and acceptance rates over time, the SPL approximation tracks their marginal distributions. However, neither approximation captures the interactions among resources and acceptance decisions explicitly. Motivated by this observation, we propose probabilistic approximations to alleviate this limitation. The probabilistic approximations are stronger than SPL approximation in the sense that they lead to tighter upper bounds. Our numerical results also suggest that the probabilistic approximations lead to better control policies than the SPL approximation.

5 The Refined Assortment Optimization Problem

Gerardo Berbeglia[1], Alvaro Flores[2], Guillermo Gallego[3], [1]Melbourne Business School, newport, Australia; [2]Sportsbet, Melbourne, Australia; [3]Hong Kong University of Science and Technology, Hong Kong, Hong Kong. Contact: g.berbeglia@mbs.edu

We introduce the refined assortment optimization problem where a firm may finitely reduce the utility of some products instead of making them unavailable. As an example, imposing longer delivery times on low-revenue products may steer demand towards high-revenue products. We show that for the latent-class MNL model, refined assortment optimization can make up to $\min(n,m)$ times more than a firm that offers traditional assortments. We also show that for the random consideration set model the ratio is at most 2, and that this bound is tight. Surprisingly, the revenue-ordered heuristic has the same performance guarantee relative to {\em personalized} refined assortment optimization as it does relative to known tight bounds for the traditional {\em non-personalized} assortment optimization problem.

6 Convex Surrogate Loss Functions for Contextual Pricing with Observational Posted-price Data

Max Biggs, University of Virginia, Charlottesville, VA, Contact: maxbiggs91@gmail.com

We study an off-policy contextual pricing problem where a seller has access to historical prices offered and whether individual customers purchased. This contrasts with the well-studied setting in which samples of the customer's valuation (willingness to pay) are observed. We propose convex loss functions, in particular a generalization of the hinge and quantile loss functions adapted to the pricing setting, that provide expected revenue guarantees when optimized. We avoid estimating an intermediate demand function, which aside from being indirect, may lead to a challenging non-linear revenue optimization problem if complex machine learning models are used. In contrast, when linear pricing policies are desired, our proposed loss functions result in a tractable convex revenue optimization problem

Monday, 12:30 PM–1:45 PM

MC70

M - Indiana G

Computing Society Flash Session

Flash Session

Session Chair

Stephany Coffman-Wolph, Ohio Northern University, Ada, OH

1 Machine Learning, a Wiser Way to Make Branching Decisions with Column Generation Involved

Zhengzhong You, University of Florida, Gainesville, FL

The recently presented idea to learn strong branching without column generation involved is promising. The choice of feature is always the key part of a desired learned model. However, when the whole variable set is not fixed, the same feature could lead to a bad performance if applied to strong branching with column generation involved (SBCG). To make this idea still powerful to SBCG, we need to find another set of features. We propose a set of features that utilize the information contained in the graph defined by the specific problem and the solution of the root node. An extensive computational study using instances generated from the benchmark of Solomon and Homberger shows promising results.

2 Robustness to Fraudulent Behavior and Incentivizing Truthfulness in Predictive Decision-making

Saba Ahmadi[1], Hedyeh Beyhaghi[2], Avrim Blum[1], Keziah Naggita[1], [1]Toyota Technological Institute at Chicago, Chicago, IL, [2]Carnegie Mellon University, Pittsburgh, PA

Predictive ML algorithms that inform life-changing decisions incentivize agents to change themselves strategically to get desirable outcomes. We present Strategic Perceptron, a modified online perceptron-style algorithm making a bounded number of mistakes given fraudulent strategic agents. The algorithm works with known l1 and l2 manipulation costs and generalizes to unknown l2 manipulation costs and heterogeneous agents whose utility functions differ slightly. We extend our work to scenarios where an agent's strategic behavior can be truthful and fraudulent. Because it's in the best interest of the decision-maker to not only separate true positives from false positives but also incentivize improvement/truthfulness, we formulate mechanisms to maximize the number of true positives subject to no false positives.

3 EXPERT-GUIDED POLICY OPTIMIZATION VIA METRIC-AWARE TRUST REGION:REINFORCEMENT LEARNING APPROACh for WHOLE-BUILDING HVAC CONTROL

Jun Song, University of Washington, Seattle, WA, Contact: juns113@uw.edu

We propose a reinforcement learning (RL) approach, namely expert-guided Wasserstein policy optimization (EG-WPO), for the efficient control of the heating, ventilation and air conditioning (HVAC) system in buildings. Trust-region methods based on Kullback-Leibler divergence are pervasively used to stabilize policy optimization in RL. In this paper, we exploit more flexible metrics and examine a natural extension of policy optimization with Wasserstein trust regions. Instead of restricting the policy to a parametric distribution class, we directly optimize the policy distribution and derive close-form policy updates based on the Lagrangian duality. A practical WPO algorithm is proposed based on the closed-form policy updates and expert guardian in the loop. Experiments on HVAC control demonstrate the performance improvement of WPO over state-of-art RL.

4 Strategic Campaigning Vs Fairness Metrics in Political Redistricting

Sanyukta Deshpande[1], Ian Griffith Ludden[2], Sheldon H. Jacobson[3], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois at Urbana-Champaign, Urbana, IL, [3]University of Illinois, Urbana, IL, Contact: spd4@illinois.edu

Despite multiple streams of dedicated research, gerrymandering remains very much a problem. Every redistricting cycle, many congressional and legislative maps are drawn with political incentives. In parallel, political parties invest huge campaign budgets to maximize their numbers of seats. In our work, we connect the two, studying the impact of strategic campaigning on the redistricting process. In particular, we examine the role of fairness metrics in alleviating or aggravating gerrymandering and the implications for social choice.

5 The Effect of Contextual Ambidexterity on Open Source Project Success

Orcun Temizkan[1], Ram Kumar[2], [1]Ozyegin University, Istanbul, Turkey; [2]University of North Carolina, Charlotte, NC, Contact: orcun.temizkan@ozyegin.edu.tr

Although open source development is an increasingly important type of software development, there is scope for improved understanding of its success. This research analyzes open source projects at the level of individual artifacts and projects at multiple levels in an open source development context. Hence, we formalize decisions made by open source project developers about which part of a project to work on using the concept of contextual ambidexterity. Moreover, we empirically illustrate the impact of contextual ambidexterity achieved at multiple levels on open source project success using data collected from SourceForge. Research and managerial implications will also be discussed.

6 Let'S Talk to Our Rubber Ducks: Tackling Computational Thinking and Analyzing Code Using a Scavenger Hunt

Stephany Coffman-Wolph, Ohio Northern University, Ada, OH, Contact: s-coffman-wolph@onu.edu

A skilled coder must develop essential skills, including debugging, computational thinking, and code analysis. So how do we instill these concepts into first-year programming students? Instructors are adding active learning and fun to appeal to modern students - enter the code-based scavenger hunt! The activity gets students out from behind computers, introduces them to industry practices, and opens the door to future assignments on debugging techniques. The "old school" practice of paper questions away from the compiler forces students to work on understanding the specifics of the material. The final clue leads the students to the professor's office for each student to select a debugging duck that "quacks" to them. The duck acts as a sounding board for programmers to work through tricky concepts because speaking code logic aloud is hugely beneficial when stuck.

7 Benchmarking the Operation of Quantum Heuristics and Ising Machines: Scoring Parameter Setting Strategies on Real World Optimization Applications

David Bernal Neira, NASA Ames Research Center, Pittsburgh, PA

We present guidelines for the performance evaluation of parameterized stochastic solvers of optimization problems, interested mainly on unconventional computing, such as Quantum Annealing, Coherent Ising Machines, or quantum gate-based algorithms, e.g., QAOA. Our benchmarking procedure uses statistical analysis of a performance metric expected outcome considering resources related to real-world deployment. We identify evaluation principles of parameter setting strategies. In particular, we present the method and software implementation details by scoring an illustrative baseline family of parameter setting strategies that feature an exploration-exploitation tradeoff.

8 Quantum Computing for Operations Research

Luis Fernando Perez Armas, Stefan Creemers, IESEG, Lille, France.

In quantum computing, information is stored in so-called ”qubits”. Qubits are the quantum counterpart of a classical bit, however, in contrast to a classical bit, a qubit can either be 0 a 1, or it can be in a superposition of both states. Most quantum algorithms try to exploit this property, by performing operations on qubits in a superposition state, resulting in potential computational gains. The outcome of a quantum algorithm is inherently probabilistic. The goal of a quantum algorithm then is to maximize the probability that the correct outcome is identified. We present a quantum algorithm that allows to solve a knapsack problem, using the IBM's Qiskit platform to evaluate its performance.

Monday, 12:30 PM–1:45 PM

MC71

M - Arizona

New Algorithmic Techniques for Hard Optimization Problems

General Session

Session Chair

Christopher Hojny, 1</sup

1 The Monomial Pattern Approach for Global Polynomial Optimization

Daria Shaydurova, Otto von Guericke Universität Magdeburg, Madgeburg, Germany.

Convex relaxations of polynomial optimization problems (POP) allow to compute bounds on the optimal objective function value. A nowadays established convexification technique is the moment-sum of squares hierarchy by Lasserre, which provides tight relaxations, but has a well-known scalability limitation. To overcome this limitation one can, e.g., use alternative decompositions of nonnegative polynomials, which can be computed via linear programming. These approaches are comparatively cheap in evaluation, but typically do not provide tight relaxations with respect to bounds for the original problem. The monomial pattern approach is based on exploiting sparsity of the problem and allows to trade off the quality of the bounds against computational expenses. We explain the new approach and illustrate its potential with numerical results.

2 Orthogonality-based Cut Selection

Christoph Graczyk, Zuse Institute Berlin, Berlin, Germany. Contact: graczyk@zib.de

Cutting planes are an important element in reducing the solving time of mixed-integer programs. Because of the many available generators for these cutting planes, we need good selection policies to avoid increasingly bloating the original problem throughout the solving process while minimizing the impact of discarding cuts. In this talk I present new cut selection methods that employ a dynamic orthogonality criterion to greedily select cuts with a minimum increase of the efficacy for any pair of cutting planes in the set. We present detailed computational results for an implementation in SCIP 8 on the MIPLIB2017 benchmark testset.

3 Mixed-Integer Programming Techniques for The Minimum Sum-of-squares Clustering Problem

Christopher Hojny, Eindhoven University of Technology, Eindhoven, Netherlands.

The minimum sum-of-squares clustering problem is a very important problem in data mining and machine learning with very many applications in, e.g., medicine or social sciences. However, it is known to be NP-hard in all relevant cases and to be notoriously hard to be solved to global optimality in practice. In this presentation, we discuss novel tailored mixed-integer programming techniques to improve the performance of state-of-the-art MINLP solvers when applied to the problem - among them are propagation techniques, branching rules, or primal heuristics. Our extensive numerical study shows that our techniques significantly improve the performance of the open-source MINLP solver SCIP. We now solve many instances that are not solvable without our techniques and we obtain much smaller gaps for those instances that can still not be solved to global optimality.

4 Price&Cut for The Graph Coloring Problem

Alexandre Dupont-Bouillard, Pierre Fouilhoux, Roland Grappe, Mathieu Lacroix, Université Sorbonne Paris Nord - LIPN CNRS UMR 7030, Villetaneuse, France. Contact: pierre.fouilhoux@lipn.fr

Adding strenghtening inequalities, like Chvátal-Gomory Inequalities (CGI), is the key ingredient to improve the value of the linear relaxation of integer programs. However, such a reinforcement is often hard to perform on formulations with an exponential number of variables as the pricing phase depends on the dual values of the added strenghtening inequalities. This is the case for the stable set based formulation of the graph coloring problem. We propose a Price&Cut algorithm using CGI for this formulation. We investigate and compare several strategies for alternating the pricing and cutting phases and exhibit a strategy in which both the number of generated columns and the value of the relaxation are improved. We also consider dual optimal inequalities (DOI) which stabilize the column generation by cutting the dual space without removing any optimal dual solution.

Monday, 12:30 PM–1:45 PM

MC72

M - California

Strategic Value of Social Media Analytics

General Session

Session Chair

Zhilei George Qiao, The University of Alabama at Birmingham, Birmingham, AL

1 The Relative Effects of Online Reviews on Hotel Demand: The Role of Competition

Sanghoon Cho[1], Pelin Pekgun[2], Ram Janakiraman[2], Jian Wang[3], [1]University of South Carolina, Northport, AL, [2]University of South Carolina, Columbia, SC, [3]RealPage, Alpharetta, GA, Contact: pelin.pekgun@moore.sc.edu

We examine the effects of a firm's online reviews, relative to its competitors, on actual demand of the focal firm within the hotel industry. We leverage a unique data set of actual bookings of six hotel properties in the United States, supplemented with online reviews garnered from TripAdvisor. Our findings indicate that the review sentiment of a hotel, in absolute terms as well as relative to competition, has a significant effect on a hotel's bookings and that the relative negative sentiment has a higher influence on bookings than relative positive sentiment. We also find that prices amplify the effect of relative negative sentiment even more than relative positive sentiment. Our research can help hoteliers in evaluating review scores in conjunction with prices and serve as a valuable input to incorporate relative effects of reviews into pricing strategies and solutions.

2 Digital Platforms in The News Industry: How Social Media Platforms Impact Traditional Media News Viewership

Jie Ren[1], Hang Dong[2], Gaurav Sabnis[3], Jeffrey V. Nickerson[3], Ales Popovic[4], [1]Fordham University, New York, NY, [2]IE University, Madrid, Spain; [3]Stevens Institute of Technology, Hoboken, NJ, [4]NEOMA Business School, Paris, France. Contact: jren11@fordham.edu

We examine how social media plays the role of an attention driver for traditional media. Social media attracts and channels attention to a topic. This attention triggers people to seek further information that is reported professionally in traditional media. Analyzing stock-related news articles and stock-related social media posts from Sina Finance and Sina Weibo, we find that the social media post volume of a stock at time t-1 is associated with the traditional media viewership of the same stock at time t. This effect is amplified when social media sentiment about the stock is more intense or positive, and with an increase in the volume of verified social media posts about the stock. Our results provide evidence that social media platforms act as attention drivers, which differ from the information channel functions discussed in prior literature.

3 The Effects of Betrothal Gifts Discussion on Marriage Trust: Evidence from a Chinese Social Media Platform

Li Lin, Qianzhou Du, Hong Zhu, Nanjing University Business School, Nanjing, China. Contact: mf1932111@smail.nju.edu.cn

Users can freely share information and express opinions on various topics on social media. Through analyzing the user-generated content, prior researchers have investigated many research topics, such as stock price prediction, economy index estimation, influencer identification, information diffusion, etc. However, little research intends to study how user emotion can be propagated through online discussions and the hidden mechanism. To fill this gap, we collected the posts associated with betrothal gifts from a Chinese social media platform, Weibo. Then, we used PSM to match the appropriate control group and adopted econometric model to explore the effects of the betrothal gifts discussion on marriage trust. Finally, the results show some interesting findings.

4 The Impact of Marketing Differentiation Strategies on Mobile App Performance: An Empirical Study

Zhilei George Qiao[1], Wenqi Shen[2], Alan Gang Wang[2], Weiguo (Patrick) Fan[3], [1]The University of Alabama at Birmingham, Birmingham, AL, [2]Virginia Tech, Blacksburg, VA, [3]University of Iowa, Iowa City, IA, Contact: qiaozl@uab.edu

Although the impact of product differentiation strategies in traditional market has been well studied, much less is known about firm's dynamic differential strategies in the competitive mobile app market. The paper mainly focuses on whether and how the product differentiation strategies influence product performance in the mobile apps industry. Specifically, I employ a panel model to examine the impacts of two strategies on product performance. Our findings on the product differentiation strategies imply the need to study the impact of operational environment on product performance together with market power and prices in one integrated framework. The suggested findings have important practical and theoretical implications.

Monday, 12:30 PM–1:45 PM

MC74

M - Florida

Dynamics of Agents and Particles on Large Graphs

General Session

Session Chair

Ruimeng Hu, University of California, Santa Barbara, Santa Barbara, CA

1 **Solving N-player Dynamic Routing Games with Congestion: A Mean Field Approach**

Mathieu Lauriere, NYU Shanghai, Shanghai, China.

The recent emergence of navigational tools has changed traffic patterns and has now enabled new types of congestion-aware routing control like dynamic road pricing. This talk introduces a new N-player dynamic routing game with explicit congestion dynamics. The model is well-posed and can reproduce heterogeneous departure times and congestion spill back phenomena. However, solving the game becomes intractable for large but realistic numbers of vehicles. Therefore, the corresponding mean field game is also introduced. Experiments are performed on several classical benchmark networks of the traffic community: the Pigou, Braess, and Sioux Falls networks with heterogeneous origin, destination and departure time tuples.

2 **Propagation of Chaos of Forward-backward Stochastic Differential Equations with Graphon Interactions**

Erhan Bayraktar[1], Ruoyu Wu[2], Xin Zhang[3], [1]University of Michigan, Ann Arbor, MI, [2]Iowa State University, Ames, IA, [3]University of Vienna, Vienna, Austria.

We study graphon mean field games using a system of forward-backward stochastic differential equations. We establish the existence and uniqueness of solutions under two different assumptions and prove the stability with respect to the interacting graphons which are necessary to show propagation of chaos results. As an application of propagation of chaos, we prove the convergence of n-player game Nash equilibrium for a general model, which is new in the theory of graphon mean field games.

3 **Optimal Investment in a Large Population of Competitive and Heterogeneous Agents**

Ludovic Tangpi, Princeton University, Princeton, NJ

We consider a large crowd of exponential utility maximizers acting competitively in the sense that each agent is concerned with the relative performance of their peers. In contrast to the growing literature on the question, we allow agents to weigh the performance of each agent differently. This leads to a game among heterogeneous agents set on a graph. We show that if the underlying graph stems from a step graphon, then the finite population game converges to a so-called graphon game whose well-posedness is studied. This is a game played by a continuum of interacting players generalizing the mean field game (which corresponds to the constant graphon case). The analysis is based on purely probabilistic arguments and allow for trading constraints.

4 **Mean-Field Multi-Agent Reinforcement Learning: A Decentralized Network Approach**

Haotian Gu, University of California, Berkeley, Berkeley, CA, Contact: haotian_gu@berkeley.edu

One of the challenges for multi-agent reinforcement learning (MARL) is designing efficient learning algorithms when each agent has only limited information of the entire system. In particular, little is known theoretically for decentralized MARL with network of states. This work proposes a framework of localized training and decentralized execution to study such MARL systems.

Theoretical analysis consists of three components: the first is to reformulate the MARL system as a networked Markov decision process with teams of agents; the second is to develop the Bellman equation on the measure space; and the third is to analyze the exponential decay property of the Q-function. The analysis leads to a neural network algorithm LTDE-Neural-AC. Convergence and sample complexity of the algorithm are established and shown to be scalable with respect to the size of agents and states.

Monday, 12:30 PM–1:45 PM

MC75

M - Illinois
Introduction to Journal of Blockchain Research
General Session

Session Chair
Zhan Pang, Purdue University, West Lafayette, IN

Session Chair
Hong Wan, NC State University, Raleigh, NC

1 **Presenter**
Hong Wan, NC State University, Raleigh, NC

2 **To Mine or Not to Mine: A Fluid Mean-field Equilibrium of The Bitcoin Blockchain System**
Kejun Li[1], Ping Cao[2], Yunan Liu[3], Hong Wan[4], [1]North Carolina State University, Raleigh, NC, [2]U of Science and Technology of China, Hefei, China; [3]North Carolina State University, Raleigh, NC, [4]NC State University, Raleigh, NC, Contact: kli15@ncsu.edu
Bitcoin, the first and the most famous cryptocurrency leveraging the novel blockchain technology, has caught much attention from academia and industry in recent years. This work mainly investigates the dynamics of repeated mining games in the Bitcoin blockchain network. A mining policy is computed for each individual miner in the system. With constrained monetary budget and mining power capacity, we consider dynamic interactions among different types of miners and explore Nash equilibrium for the Bitcoin network. For tractability, we introduce two essential approximations: a fluid-level formulation to approximate a large number of mining games; and a mean-field approximation of many-player mining games. Under these two approximations, we solve for the fluid mean-field equilibrium (FMFE) and obtain the consequential FMFE-based mining strategy.

3 **Blockchain: A Trust Machine for Supply Chain?**
Zhan Pang, Purdue University, West Lafayette, IN, Contact: zpang@purdue.edu
Blockchain is seen as a trust machine due to its immutability and cryptographic nature. Can blockchain technology bring trust to a supply chain where the participants have limited trust for each other? How much value can it add to the supply chain? We use a stylized model to illustrate the role and value of blockchain in supply chain.

Monday, 12:30 PM–1:45 PM

MC76

M - Michigan
Supply Chain Operations Under Uncertainty
General Session

Session Chair
Ozden Engin Cakici, American University, Washington

1 **Procurement for Assembly Systems Under Disruption Risks: An Optimal Mechanism**
Like Bu, Milind Dawande, Ganesh Janakiraman, The University of Texas at Dallas, Richardson, TX, Contact: Like.Bu@UTDallas.edu
Motivated by the recent surge in supply chain disruptions, we study a mechanism design problem faced by a firm assembling a product from multiple components. For each component, the firm has access to an unreliable supplier whose production cost information is private and whose production could be disrupted with some publicly known probability. In addition, for each component, the firm has access to a more expensive but reliable supply source upon whom it can fall back in the event of a disruption. The goal is to design a procurement mechanism that maximizes the firm's expected profit. Our main result is a practically appealing optimal mechanism for this problem.

2 **B2B Transactions and Trade Agent's Bidding Decisions**
Itir Karaesmen[1], Ozden Engin Cakici[2], [1]American University, Washington, DC, [2]American University, Washington
We study the procurement decisions of a trade agent who matches the suppliers with buyers in an industrial market. The agent makes bids, i.e. submits the unit cost to pay to procure goods to sellers. If the seller accepts the bid, goods are procured and need to be shipped to the buyer. We analyze the agent's optimal bidding decisions and the effect of uncertainty and economic parameters on the optimal bids. We also provide the conditions for monotonicity of the optimal bids. Finally, we investigate when it is optimal of the agent to diversify and bid at multiple suppliers.

3 **Have Supply Networks Become More Fragmented over Time?**
Nikolay Osadchiy[1], Vishal Gaur[2], Maximiliano Udenio[3], [1]Emory University, Atlanta, GA, [2]Cornell University, Ithaca, NY, [3]KU Leuven, Leuven, Belgium.
We study how firms' sourcing and customer acquisition decisions shape the structure of production network. We propose a measure of fragmentation that is based on a

notion of communities in the production network. Using history of buyer-supplier relationships between firms, we find that while firms in the networks become more connected with time, the network becomes more fragmented. We explore a plausible mechanism that reconciles the increased connectivity with fragmentation and identify firms that link communities in the production network. Our results can guide efforts towards improving visibility into supplier and customer networks.

Monday, 12:30 PM–1:45 PM

MC77

M - Texas
Behavioral Operations Management
Contributed Session

Session Chair
Richard C. Staats, ZE, LLC, Mclean, VA

1 A Quantitative Approach to Stratify and Measure Performance of Multi-Team Systems

Megan Chan[1], Niloufar Izadinia[1], Leslie DeChurch[2], Andreas Waechter[1], Noshir Contractor[3], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, [3]Northwestern University, Evanston, IL, Contact: megan.chan@u.northwestern.edu

We propose a unique multi-objective optimization approach to stratify and measure performance of individuals, teams, and groups of teams (multi-team systems) with competing local objectives and a shared global objective. Novel measures were empirically tested on a timed cooperative activity and validated against traditional performance measures. Additionally, to assess the external validity of these metrics, structural network features of the multi-team systems were more correlated with our new measures of performance than traditional performance measures.

2 The Impact of Remote Work on Service Quality: Insights from Quality Management System Inspections

Ashley Palmarozzo[1], Michael Toffel[2], [1]Harvard Business School, Boston, MA, [2]Harvard Business School, Boston, MA, Contact: apalmarozzo@hbs.edu

Firms increasingly use remote work formats to conduct work, a trend accelerated by COVID-19 pandemic restrictions. While remote work may provide operational flexibility to firms and productivity benefits to workers, questions remain about the relative effectiveness of remote work compared to conventional in-person work. This study investigates this question in the service context of management system certification audits. Specifically, we analyze the outputs of almost 40,000 global audits from 2019-2021 from one service provider. We find evidence that fully remote audits are less effective than in-person audits, which we theorize is due to an increase in the cost of obtaining information in remote audits. We also explore how audit-level attributes (such as complexity) and auditor-level attributes (such as auditing qualifications) moderate this effect.

3 Logistics Digitization and the 3PL Worker Performance: The Moderating Role of Preventive, Promotive and Paradoxical Mindset

Muhammad Hasan Ashraf, Anis Triki, Mehmet Gokhan Yalcin, University of Rhode Island, Kingston, RI, Contact: mashraf@uri.edu

21st century shopping and shipping mania has made it unavoidable for the Third-Party-Logistics (3PL) firms to invest in Industry 4.0 technologies that guarantee customer satisfaction and ensure a competitive advantage in the industry. Using vignettes, we aim to examine how a 3PL supervisor's regulatory focus interacts with frontline employees' paradoxical mindset in their willingness to adopt digitization in 3PL hub operations. By employing Paradox theory in conjunction with RFT, this study answers the call for more theory-driven research explaining the relation between 3PLs and Industry 4.0 technologies. Moreover, this research also introduces a Package Sorting Game that can be used by future researchers to operationalize performance. The findings of this research will have implications for future behavioral research on adoption of Industry 4.0 technologies.

4 Simple Rules for Successful Organizations

Richard C. Staats, ZE, LLC, Mclean, VA, Contact: staats@alum.mit.edu

Dr. Staats has led organizations ranging from tens of thousands in combat to the commercial world to small groups advising the senior most people in the US Federal Government. Though the size, operating environments, and missions of these organizations could not have been more different, Dr. Staats used a remarkably consistent set of organizational principles to lead these disparate bodies to success. Spend fifteen minutes to learn the Stafford, Perrin, and Petersen principles and how to apply them in your own, challenging environment.

Monday, 12:30 PM–1:45 PM

MC78

M - Utah
Information Systems Award Session
Award Session

Session Chair
Yan Huang, Tepper School of Business, Carnegie Mellon University, Pittsburgh, PA

1 **Inaugural INFORMS ISS Cluster Best Paper Award**
Olivia R Liu Sheng, University of Utah, Salt Lake City, UT
We will announce and recognize the winner(s) of the ISS Cluster Best Paper Award.

2 **Inaugural INFORMS ISS Cluster Best Session Chair Award**
Jason Chan, University of Minnesota, Minneapolis, MN
We will announce and recognize the winner(s) of the ISS Cluster Best Session Chair Award.

Monday, 12:30 PM–1:45 PM

MC79

JWM - Room 201
TIMES Best Working Paper Award
Award Session

Session Chair
Tian Chan, Emory University's Goizueta Business School, Atlanta, GA

Session Chair
Onesun Steve Yoo, University College London, London, United Kingdom.

1 **Design of Off-Grid Lighting Business Models to Serve the Poor: Field Experiments and Structural Analysis**
Bhavani Shanker Uppari[1], Serguei Netessine[2], Ioana Popescu[3], Rowan P. Clarke[4], [1]Singapore Management University, Singapore, Singapore; [2]The Wharton School, [3]INSEAD, Singapore, Singapore; [4]Harvard Business School, Boston, MA
A significant proportion of world's population does not have access to electricity. Solar-based solutions are usually unaffordable due to consumers' poverty. There are alternative business models relying on rechargeable light bulbs that are sold at a subsidized price and require regular payments for recharges. We investigate the viability of these recharge-based models under poverty. In collaboration with a firm in Rwanda, we collected the bulb usage data from randomized experiments wherein the price and the bulb capacity were varied. We also build a structural model that incorporates the light consumption dynamics, and use it to evaluate theoretically-preferred changes to the existing model.

2 **Dueling contests and platform's coordinating role**
Konstantinos Stouras, University College Dublin, Athens, Greece.

3 **Government Support and Cross-Border Innovation: How does China's Innovative City Policy affect Chinese Firms' Patenting in the U.S.?**
Kedong Chen[1], Xiaojin Liu[2], Yuhong Li[1], Kevin Linderman[3], [1]Old Dominion University, Norfolk, VA, [2]Virginia Commonwealth University, Richmond, VA, [3]Penn State University, University Park, PA
Governments want firms to innovate new processes and products not only within their countries, but also across national boundaries. Cross-border innovation refers to a firm's innovation processes and outputs across national boundaries. Many countries have initiated policies to support cross-border innovation, but how does government support influence cross-border innovation? Through the lens of Porter's Diamond Model, this study conceptualizes government support as slack resources and investigates how it affects a firm's inventive activities in an uncertain, competitive global market. This study examines Chinese firms' patent filing in the U.S. under the enactment of the "innovative city" policy. We apply matching and generalized difference-in-differences (DiD) techniques to this staggered quasi-experimental setting and find that government support stimulates firms' cross-border innovation. We further show that firms with higher R&D capacity take better advantage of government support. In addition, we show that government support leads to a rebalance between exploratory and exploitative innovation. In other words, a firm that has conducted more exploration will perform more exploitation and vice versa. Taken together, this study extends our understanding of slack from internal resources to government support in the context of global operations. Findings of the study suggest that government actions that improve the ecosystem of innovation in one country also strengthen firms' innovation and competitiveness overseas.

4 Help and Haggle: Boosting Social Reach Through Randomized, Adaptive, All-or-Nothing Discounts

Luyi Yang[1], Chen Jin[2], [1]University of California, Berkeley, Berkeley, CA, [2]National University of Singapore, Singapore, Singapore.

This paper studies a novel social e-commerce practice known as "help-and-haggle," whereby an online consumer can ask friends to help her "haggle" over the price of a product. Each time a friend agrees to help, the price is cut by a random amount, and if the consumer cuts the product price down to zero within a time limit, she will get the product for free; otherwise, the product reverts to the original price. Help-and-haggle enables the firm to promote its product and boost its social reach as consumers effectively refer their friends to the firm. We model the consumer's dynamic referral behavior in help-and-haggle and provide prescriptive guidance on how the firm should randomize price cuts.

5 Tele-Follow-Up and Outpatient Care

Meng Li, University of Houston, Houston, TX

Monday, 12:30 PM–1:45 PM

MC81

JWM - Room 203

OR / MS Applications in Enterprise Sustainability

General Session

Session Chair

Kedar Kulkarni, 1</sup

1 A Trade-off Analysis of a Multi-objective Order Fulfillment Optimizer with Financial and Emissions Savings

Isaac Wambugu[1], Kedar Kulkarni[2], Ivan Kayongo[3], [1]IBM Research, Nairobi, Kenya; [2]IBM Research, India, Bangalore, India; [3]IBM Research, Kenya, Nairobi, Kenya. Contact: isaacw@ke.ibm.com

For the vast majority of retailers with web-based stores, lowering shipping costs is the ultimate cost-cutting goal. However, for merchants operating omnichannel storefronts that support both walk-in and online sales, a number of competing business objectives emerge, such as load-balancing costs, stockout costs, and markdown costs. We offer a multi-objective optimization agent that aims to keep business costs low while also reducing carbon emissions. The findings of a simulated trade-off analysis for a major sports retailer are also presented.

2 Server Energy Efficiency Models and Framework for Greener Data Centers

Kalyan Dasgupta[1], Umamaheshwari Devi[2], [1]IBM India, Bangalore, India; [2]IBM India, Bangaluru, India.

With the increasing thrust on sustainability and climate change mitigation by policy makers and regulators, enterprises have been mandated to lower carbon emissions from their operations. For cloud operators, this necessitates reducing the energy consumed in their data centers. One predominant way of achieving this is by increasing the average server utilization, which is still low, to absorb occasional peaks and avoid interference from co-located workloads. For this purpose, we propose novel energy-efficiency and compute performance models of servers using normalized metrics across workloads and servers, accounting for both CPU and memory usage. These models can be used to formulate problems that can optimize energy efficiency and performance and design a higher-level framework for determining the right amount of extra provisioning necessary to ensure a desired performance and thereby reduce under-utilization, when multiple workloads share a common platform.

3 A Supply Chain Optimization Framework for Plastic Waste Upcycling

Jiaze Ma, Philip Tominac, Victor Zavala, University of Wisconsin-Madison, MADISON, WI, Contact: jma258@wisc.edu

We present a comprehensive supply chain optimization framework to study the economic potential of pathways for plastic waste upcycling using thermochemical technologies. The framework solves an optimization problem that aims to determine technology selection, sizing, placement, and transportation logistics simultaneously. Our preliminary results indicate that the proposed supply chain infrastructure is economically viable. We use our models to determine the importance of changing social behavior (e.g., proper sorting and cleaning of plastic waste by consumers) and the importance of government policies. Our framework is also used to reveal the inherent market value of plastic waste and of its derived products through dual pricing properties and provides insights into how revenue flows to different stakeholders involved in the supply chain.

4 Seasonal Scale Climate Encodings for Spatio-temporal Demand Forecasting

Jitendra Singh[1], Smit Marvaniya[2], Nicolas Galichet[3],

Fred Otieno[4], Reginald Bryant[4], Geeth de Mel[3], Kommy Weldemariam[4], Brian Quanz[5], [1]IBM Research, Gurugram, India; [2]IBM Research, Bangalore, India; [3]IBM Research, Warrington, United Kingdom; [4]IBM Research, Nairobi, Kenya; [5]IBM Research, Yorktown Heights, NY, Contact: jitens@in.ibm.com

Incorporating seasonal climate insights in time series forecasting problems, such as demand predictions, can help inform planning and optimizing operations. Current time series forecasting approaches incorporate deterministic short-term weather attributes as exogenous inputs. However, encoding the relationship between seasonal climate and demand is challenging due to the uncertain nature of seasonal predictions and their associated spatio-temporal variability and predictive skills. Recently, time series research has introduced a deep learning-based temporal fusion transformer (TFT) model using self-attention for modelling different types of time series. In this work, we incorporate seasonal climate predictions in TFT and experimentally observe that forecast errors can be reduced by 5-17% on real-world dataset while forecasting up to few months ahead.

Monday, 12:30 PM–1:45 PM

MC82

JWM - Room 204

Self-care Strategies

Panel Session

Session Chair

Tugce Isik, Clemson University, Clemson, SC

1 **Moderator**

Tugce Isik, Clemson University, Clemson, SC

Self-care is critical to maintain one's physical and mental well-being but it can be difficult to integrate into the busy lives of graduate students, early career faculty, or established OR/MS professionals. The panel will be discussing issues of stress and isolation, how to build a support network as a professional in OR/MS, and self-care strategies in general.

2 **Panelist**

Amy Cohn, University of Michigan, Ann Arbor, MI

3 **Panelist**

Sibel Alumur Alev, University of Waterloo, Waterloo, ON, Canada.

4 **Panelist**

Jacqueline Griffin, Northeastern University, Boston, MA

5 **Panelist**

Samaneh Shiri, UPS, Timonium, MD

Monday, 12:30 PM–1:45 PM

MC83

JWM - Room 205

spORts V

General Session

Session Chair

Thomas Robbins, East Carolina University, Greenville, NC

1 **Decision Making for Basketball Clutch Shots: A Data Driven Approach**

Yuval Eppel, Mor Kaspi, Amichai Painsky, Tel Aviv University, Tel Aviv, Israel. Contact: ep.yuval@gmail.com

Decision-making is a crucial aspect for winning a Basketball game. In particular, choosing the players who will take game-decisive shots ('clutch shots'). While some coaches prefer the teams' stars, others may prefer players who seemingly excel during clutch time ('clutch players') or are shooting well during a specific game ('hot players'). In this study, we propose a generalized decision framework that models these phenomena using a variety of player pre-game and in-game properties. We define various player-selection policies, rank them, and create a hierarchy of policies that serves as a decision guide. Using data from 25 NBA seasons, we show that by implementing our recommendations, the shot success rate increases by up to 10%.

2 **Are All Wins Created Equal? Evaluating Results from The Canadian Football League**

Keith A. Willoughby, University of Saskatchewan, Saskatoon, SK, Canada. Contact: willoughby@edwards.usask.ca

We have developed an analytical model to predict the outcomes of games in the Canadian Football League (CFL). Results from this model are regularly featured on the league's website and social media channels. One of the principal inputs to our model is the margin of victory in games already played during a season. Recognizing that margin of victory may not capture the entire flow of a football contest, we evaluate other approaches to determine relative team performance in a game.

3 **The Efficiency of Sports Betting Markets**

Thomas Robbins, East Carolina University, Greenville, NC
Betting on sports is increasingly popular, and legal in the United States. Ever since the United States Supreme Court removed the PASPA ban on sports betting in 2018 many states have moved to legalize sports betting both in-person and on-line. Sports wagering is a multi-billion-dollar market. In this paper we evaluate the sports betting market and assess its efficiency in the financial sense. Using a large dataset of betting odds and outcomes we evaluate the weak-form efficiency of the sports betting market. We find that major inefficiencies exist in the form of systematic biases in the odds.

4 DEA Model Framework to Investigate Snubbing in All-NBA Team Selections

Ben Grannan, Queens University of Charlotte, Greenville, SC
Inclusion on an All-NBA team indicates that the athlete was one of the top professional players during the most recent season. The current method to identify members on the 1st, 2nd, and 3rd All-NBA teams is a vote by 100 sportswriters and broadcasters. With release of the All-NBA results each season discussion follows on snubbed players as well as questionable inclusions. Fans and sports media rely on individual statistics, team performance, playoff seeding, and overall results to make a case for or against a given player's place among the sport's elite. This project aims to use a quantitative modeling approach to identify the best performers of the season and give evidence to identify snubbed players.

Monday, 12:30 PM–1:45 PM

MC84

JWM - Room 206
Simulation and Optimization
Contributed Session

Session Chair
Shuhan Kou, University of Maryland, College Park, College Park, MD

1 Incorporating Variability into Equipment Modeling with Trace Clustering and Simulation Techniques

Jinyoun Lee, Daeyeon Lee, Jinhong Lim, Kihong Kim, Seungho Lee, Euiseok Kum, Samsung Electronics, Hwaseong-si, Gyeonggi-do, Korea, Republic of. Contact: jinyoun0.lee@samsung.com
A novel equipment performance model that utilizes trace clustering and simulation techniques is proposed. Trace clustering is applied to identify wafer processing patterns inside a chamber of equipment, both the process state and non-process state are considered in the model to fully capture the operational variability. The simulation is used to predict productivity by selecting the correct pattern for each incoming wafer, and the result of simulation is examined to support decision making process. The accuracy of the proposed model is measured with MAPE, and the case study results revealed that the proposed model that considers patterns outperforms the model that does not incorporate patterns.

2 Node Aggregation and Parallelization in Stochastic Dual Dynamic Programming

Renata Pedrini[1], Felipe Beltrán[2], Erlon Cristian Finardi[1], [1]Federal University of Santa Catarina, Florianópolis, Brazil; [2]Norus, Florianópolis, Brazil. Contact: renata.pedrini@posgrad.ufsc.br
SDDP was first proposed to find the optimal operation of the Brazilian power system. The algorithm decomposes the optimization problem into successive one-stage linear subproblems, which are independent of each other. To improve this method, this work proposes the node aggregation and division of the scenario tree into connected subtrees solved as the algorithm proceeds. The size of each subproblem depends on the tradeoff between the computational burden to solve a bigger problem and the solution quality. The performance of the SDDP with node aggregation is tested with data from the Brazilian power system. Although the computational burden per subproblem increases, the results reveal that tighter cuts are obtained when using node aggregation, with a confidence interval for the optimality gap up to 26% smaller with the same execution time.

3 Constrained Multiobjective Optimization of Process Design Parameters in Settings with Scarce Data: An Application to Adhesive Bonding

Sebastian Rojas Gonzalez[1,2], Alejandro Morales Hernandez[1], Inneke Van Nieuwenhuyse[1], [1]Hasselt University, Hasselt, Belgium; [2]Gent University, Gent, Belgium.
Adhesive joints are increasingly used in industry for a variety of applications due to their favorable engineering design characteristics. Finding the optimal process parameters for an adhesive bonding process is inherently stochastic and multiobjective (maximize break strength while minimizing cost) and constrained (prevent damage to the materials).

Physical experiments are expensive to perform; traditional simulation optimization approaches are then ill-suited to solve the problem, due to the prohibitive amount of experiments required for evaluation. In this research we apply specific machine learning techniques to emulate the objective and constraint functions based on a limited amount of experimental data. The techniques are embedded in a Bayesian optimization algorithm, which succeeds in detecting Pareto-optimal designs in a highly efficient way.

4 ROBUST SIMULATION OPTIMIZATIOn with STRATIFIED SAMPLING

Pranav Jain[1], Sara Shashaani[1], Eunshin Byon[2], [1]North Carolina State University, Raleigh, NC, [2]University of Michigan, Ann Arbor, MI, Contact: pjain23@ncsu.edu

Stratified sampling has been widely used as a variance reduction technique when estimating a simulation output. This study shows that in an optimization routine a stratified sampling-based estimator can improve the robustness of the search. We analyze the robustness both in terms of bias and variance of the outcomes if the algorithm was to be run several times and show that while stratified sampling improves the algorithm's performance, its robustness depends on the stratification structure. We have analytically demonstrated that in the limiting case the variance of the output of the stratified sampling estimator is less than the corresponding variance of the crude Monte-Carlo estimator. From our analysis, we can see that as the number of strata increases the performance of the stratified sampling-based algorithms becomes more sensitive to various algorithm inputs.

5 Optimal TSP Tour Length Estimation Using Standard Deviation as a Predictor

Shuhan Kou[1], Bruce L. Golden[2], Stefan Poikonen[3], [1]University of Maryland-College Park, College Park, MD, [2]University of Maryland-College Park, Columbia, MD, [3]University of Colorado Denver, Denver, CO, Contact: shkou@umd.edu

For a given set of traveling salesman problem (TSP) instances, the optimal tour lengths of these instances can be predicted reasonably well using the standard deviation of random tour lengths. This surprising result was first demonstrated in a paper by Basel and Willemain (2001). In our paper, we first update and extend these earlier authors' computational experiments. Next, we seek to answer the question: Why does such a simple predictor work. In response, we reveal the relationship between the standard deviation predictor and the well-known $\sqrt{NA}$ predictor for Euclidean instances. We also empirically show that the standard deviation predictor is valid for both Euclidean and non-Euclidean instances by applying it to the TSPLIB, randomly generated instances, and real-world instances.

Monday, 12:30 PM–1:45 PM

MC85

JWM - Room 207
NSF Grant Information
Panel Session

1 NSF Grant Information

Georgia-Ann Klutke, National Science Foundation, Arlington, VA

This session will describe the NSF proposal submission, review, and post-award processes and provide helpful information for preparing competitive proposals. Junior faculty and first-time proposers are especially encouraged to attend.

2 Panelist

Reha Uzsoy, North Carolina State University, Raleigh, NC

Monday, 12:30 PM–1:45 PM

MC86

JWM - Room 208
Advances in Airline Planning and Optimization
General Session

Session Chair

Alessandro Bombelli, Delft University of Technology, Delft, Netherlands.

1 Airline Tail Assignment Optimization at Vueling Airlines

Luis Cadarso[1], Manuel Fuentes[2], Vikrant Vaze[3], Cynthia Barnhart[4], [1]Rey Juan Carlos University, Fuenlabrada, Spain; [2]Cisneria Engineering, Alcala de Henares, Spain; [3]Dartmouth College, Hanover, NH, [4]Massachusetts Institute of Technology, Cambridge, MA

To schedule aircraft, assignments of fleet types to flights and of aircraft to routes must be determined. The former is known as fleet assignment while the latter is known as aircraft routing. These problems are often solved months before operations, when there is limited available information regarding each aircraft's operational condition. The tail assignment problem, which is solved when additional information is revealed, determines aircrafts' routes for the day of operations accounting for the planned aircraft routes and crew schedules. We propose a mathematical programming approach based on sequencing and develop and apply a new solution approach based on rolling horizon methods. Computational experiments are based on realistic cases drawn from a Spanish airline. As a result, a decision support tool has been designed and provided to the airline.

2 A Math-heuristic Approach for The Sustainable Air Cargo Routing Problem

Alessandro Bombelli[1], Sebastian Birolini[2], Mattia Cattaneo[3], [1]Delft University of Technology, Delft, Netherlands; [2]University of Bergamo, Dalmine (BG), Italy; [3]University of Bergamo, Dalmine, Italy. Contact: a.bombelli@tudelft.nl

We present a math-heuristic approach to solve an integrated fleet assignment and cargo routing problem for a full-cargo airline. Our objective is to minimize fuel burns deriving from the routing while simultaneously avoiding missed deliveries of cargo. We endogenize the payload when defining the functional form of the fuel burn, which is then linearized so that a mixed integer linear programming formulation can be used. We present an arc-based formulation and a path-based formulation based on a spatio-temporal decomposition, based on geometric considerations and previous solutions, for large instances. With a vast computational campaign, we show the effectiveness of our approach, identify trade-offs between reductions in fuel burn and in profit, and highlight the necessity to include payload in the definition of fuel burns to increase the accuracy of the results.

3 Airline Dynamic Offer Creation Using a Markov Chain Choice Model

Kevin Wang, MIT, Cambridge, MA

We present a novel approach to the pricing and assortment optimization of airline ancillary offers using the Markov chain choice model (MCCM). A potential breakthrough in bundle price optimization, the MCCM decomposes the complex problem into a finite number of univariate optimization problems. We show how MCCM-based pricing adapts to the customer context, either increasing revenue by incentivizing customer buy-up to bundle offers or recommending a la carte pricing, when the customer cannot afford bundles or only finds few products relevant. We quantify the revenue benefit of dynamic offer creation by comparing MCCM bundle pricing and offer set selection against an a la carte baseline, both with and without targeted offer sets and prices.

4 Continuous Pricing with Competitor Adjustment: Incorporating Competitor Fare Quotes into Airline RM

Bazyli Szymanski, Massachusetts Institute of Technology, Cambridge, MA, Contact: bazyli@mit.edu

Most existing RM systems do not explicitly account for competitor RM tactics, and academic work that models competition tends to seek game-theoretic equilibria given strong assumptions. In contrast, we propose a competitor adjustment, where airline's willingness-to-pay (WTP) estimates used for fare quotation are altered exclusively based on current competitor fare information.
The adjustment is tested in the emerging context of continuous pricing, where airlines are not restricted to a discrete set of price points. We quantify the competitive impacts of the adjustment through simulations and discuss whether it could help pave the way to new WTP-based optimizers for continuous pricing.

Monday, 12:30 PM–1:45 PM

MC87

JWM - Room 209
Applied Probability
Contributed Session

Session Chair
Nanshan Chen, Columbus, OH

1 The Dutch Draw: Constructing a Universal Baseline for Binary Prediction Models

Etienne Pieter van de Bijl, Centrum Wiskunde & Informatica, Amsterdam, Netherlands. Contact: evdb@cwi.nl

Prediction methods should always be compared to a baseline to know how well they perform. What does it mean when a model achieves an F1 of 0.8 on a test set? A proper baseline is needed to evaluate the `goodness' of a performance score. We present a universal baseline method for all binary classification models, named the Dutch Draw (DD). This approach weighs simple classifiers and determines the best classifier to use as a baseline. We theoretically derive the DD baseline for many commonly used evaluation measures and show that in most situations it reduces to (almost) always predicting either zero or one. Summarizing, the DD baseline is: (1) general, as it is applicable to all binary classification problems; (2) simple, as it is quickly determined without training or parameter-tuning; (3) informative, as insightful conclusions can be drawn from the results.

2 Causal Impact of Customer Service Experience

Andres Cepeda[1], Farzad Daneshgar[2], [1]Amazon Corporate LLC, Bogota, Colombia; [2]Amazon Corporate LLC, Fort Worth, TX

A statistical framework is proposed to evaluate the causal impact of customer service aspects of a phone call on the customer's engagement with the company. The methodology uses Causal Inference techniques such as Targeted Maximum Likelihood Estimation to evaluate the effect. The research provides the results for a case study based on the customer's waiting time before a call. A significant impact is found across different waiting time intervals by applying the model to a customer service sample data. The results can be used in conjunction with a queueing theory model for headcount planning. This approach can be generalized for different features of the customer service experience besides the waiting time.

3 Matrix Geometric Solutions with Quantum Speed-up for Ev Battery Swapping Systems

Nanshan Chen[1], Mark S. Squillante[2], Cathy H. Xia[1], [1]The Ohio State University, Columbus, OH, [2]IBM Research, Yorktown Heights, NY, Contact: chen.8853@buckeyemail.osu.edu

Electric vehicle (EV) charging and battery swapping system is the future of urban transportation. Such a system can be modeled as a quasi-birth-and-death process and its stationary distribution could be numerically obtained from the classical cyclic reduction (CR) algorithm. We consider utilizing quantum algorithms to accelerate the computation in solving a system of linear equations and derive the exact solution of matrix-geometric form. We further analyze the steady-state behavior of the system and present useful insights for future EV infrastructure planning.

Monday, 12:30 PM–1:45 PM

MC99

CC - Exhibit Hall D

Monday Poster Session

Poster Session

Session Chair

Jun Zhuang, University at Buffalo, Buffalo, NY

Session Chair

Changhyun Kwon, University of South Florida, Tampa, FL

101 Corn Planting and Harvest Scheduling Under Storage Capacity and Growing Degree Units Uncertainty

Zahra Khalilzadeh, Lizhi Wang, Iowa State University, Ames, IA, Contact: zahrakh@iastate.edu

The research problem includes determining the planting and harvest scheduling of corn hybrids under two storage capacity cases: (1) given the maximum storage capacity, and (2) without maximum storage capacity to determine the lowest possible capacity for each site. To help improve corn planting and harvest scheduling, we propose 2 mixed-integer linear programming models and a heuristic algorithm to solve this problem considering deterministic GDU scenario and uncertainties in historical GDU scenarios for both storage capacity cases. Scheduling results demonstrate the effectiveness of our proposed models in providing consistent weekly harvest quantities that are below the maximum capacity.

102 A Transformer-based Approach for Soybean Yield Prediction Using Time-series Images

Luning Bi, Guiping Hu, Daren Mueller, Yuba Kandel, Iowa State University, Ames, IA

Crop yield prediction which provides critical information for management decision-making is of significant importance in precision agriculture. For yield prediction using high-resolution images, existing methods, e.g., convolutional neural network, are hard to model long range multi-level dependencies across image regions. This paper proposes a transformer-based approach for yield prediction using early-stage images and seed information. A case study has been conducted using a dataset that was collected during the 2020 soybean-growing seasons in Canada fields. Compared with other baseline models, the proposed method can reduce the prediction error by over 40%.

103 Drone Scheduling for Agriculture and Health Care

G N Srinivasa Prasanna, IIIT-Bangalore, Bengaluru, India. Contact: gnsprasanna@iiitb.ac.in

We present algorithms for scheduling drones for agriculture, health care, and general logistics. Drone transport is well suited to connect remote rural areas to the national backbone, and is proposed for agriculture (surveying, spraying, agritech supplychains), vaccine delivery, etc in India, and worldwide.

We describe methods for airway scheduling, and payload/range tradeoff considerations. We examine the scalability of the algorithms to 1000's of densely packed drones, and robustness to weather related uncertainty affecting the available routes, speed and travel time. Comparisons with alternatives like land vehicles are presented. Results from real world trials may also be presented.

104 Data-driven Planning for Agricultural and Food Systems Under Disruptions

Marie Pelagie Elimbi Moudio, Cristobal Pais, Zuo-Jun (Max) Shen, University of California, Berkeley, Berkeley, CA, Contact: pelagy_elimbimoudio@berkeley.edu

Rising complexities of agricultural networks resulting from increased dependencies between countries have made them extremely vulnerable. Understanding the impact of country level disruptions is essential in the analysis of the global allocation of agricultural products. We model a stochastic resource allocation problem with non-linear connectivity costs to capture trade dynamics between countries. We compare both model recommendations to historical coffee trade flow data, unveiling the value of centralized planning under potential disruption scenarios against the current practices.

105 Aligning Utility and Cost for Private Data Sharing and Acquisition

Hasan Kartal, University of Illinois Springfield, Springfield, IL, Contact: hkart2@uis.edu

Privacy mechanisms are designed to protect customer data while allowing access to the anonymized or noisy aggregate versions of the data to analysts. However, the trade-off between the utility of data and privacy remains a key challenge. While strictly anonymized data has restricted the utility, acquired customer data with privacy consent comes with self-selection bias and high acquisition costs. To overcome these limitations, this study proposes a new mechanism of anonymizing and acquiring personal data with customized privacy protection by aligning the privacy expectations of customers with the utility needs of organizations for business analytics and data mining applications.

106 Assessing Association of Dissimilarity of Business Categories in a Commercial Area with Merchants' Revenue

Mohsen Bahrami[1], Jisung Yoon[2], Burcin Bozkaya[3], Selim Balcisoy[4], Woo-Sung Jung[5], Alex Pentland[1], Yong-Yeol Ahn[6], [1]Massachusetts Institute of Technology-Media Lab, Cambridge, MA, [2]Department of Industrial and Management Engineering, Pohang University of Science and Technology, Pohang 37673, Republic of Korea., Pohang, Korea, Republic of; [3]New College of Florida, Sarasota, FL, [4]Sabanci university, Istanbul, Turkey; [5]Department of Physics, Pohang University of Science and Technology, Pohang 37673, Republic of Korea, Pohang, Korea, Republic of; [6]Indiana University, Bloomington, IN, Contact: bahrami@mit.edu

In this study, we assess the diversity of commercial districts with representation learning approaches leveraging large-scale geo-tagged credit card transactions data.We show that the homogeneity of a commercial district and the merchants' revenue have an inverted U-shape (concave) relationship. Our study results suggest that if the merchants in a commercial district are too similar or too different, the revenue is likely to decrease, but there exists an optimal point as a result of a concave relationship. Additionally, we show that if the structure is more concise (measured by the standard deviation of pairwise similarity), then the revenue is likely to increase.

107 Buy Right Now or Later? The Decision of Co-purchasers

YONG JUN KWON, JaeHong Park, Kyunghee University, Seoul, Korea, Republic of. Contact: yjun209@khu.ac.kr

Social e-commerce platforms have now adopted a new form of social-buying strategy - social-buying with just two people. Here, consumers can be either initiators or co-purchasers. This study explores how the remaining time of the deal would influence co-purchasers' decisions. For example, assume that two deals are very similar to each other in terms of price, product attributes, and brands with the one-day limit. Assume that deal A remains 7 hours with the 50% discount rate while deal B remains 22 hours with the 36% discount rate. So, we try to answer whether a co-purchaser joins either a deal A or a deal B given the different remaining time and discount rates. We thus give a guideline regarding the deal design.

108 Content Promotion for Online Content Platforms with The Diffusion Effect

yunduan lin[1], Mengxin Wang[2], Max Max Shen[3], Heng Zhang[4], Renyu (Philip) Zhang[5], [1]UC Berkeley, Berkeley, CA, [2]University of California-Berkeley, Albany, CA, [3]University of California Berkeley, Berkeley, CA, [4]Arizona State University, Tempe, AZ, [5]The Chinese University of Hong Kong, Hong Kong, China. Contact: yunduan_lin@berkeley.edu

Content promotion policies are playing an important role in improving content consumption for online content platforms. However, a frequently used promotion policy generally neglects employing the diffusion effect within users. We study the candidate generation and promotion optimization problem for online content through incorporating the diffusion effect. We also investigate ways to use the adoption data to estimate the diffusion effect. We not only highlight the differences of diffusion between online content and physical goods but also provide actionable insights for platforms to improve the effectiveness of content promotion policy by leveraging our diffusion model.

109 Sensor Variables Analysis Based on Pump Fault Classification Modeling

Seung Hwan Park[1], Jihoon Kang[2], Hyo Beom Heo[1], [1]Chungnam National University, Daejeon, Korea, Republic of; [2]Tech university of Korea, Siheung-si, Korea, Republic of. Contact: sh.park@cnu.ac.kr

This paper proposes a modeling procedure to analyze the factors affecting the defects of centrifugal pumps. Since most production facility is equipped with various centrifugal pumps, malfunction of pumps can cause problems in an entire system. Therefore, the diagnosis of pump failure is essential, and many studies have proposed data-driven modeling method for a pump fault diagnosis. In this study, fault classification was performed using various sensor signals such as pressure, flow, and motor current indicating the performance of the pump system as well as vibration signals. Also, this study presents variables that significantly affect the improvement of pump fault classification accuracy.

110 A Forensic Investigation of MBTA Repair Inventory Demand

Jingran Xu, Boston University, Boston, MA, Contact: xujr21@bu.edu

Forecasting demand is necessary to determine inventory policy for the Massachusetts Bay Transportation Authority (MBTA) repair parts warehouse, which stores parts used by all MBTA repair garages. The poster uses K-Means to categorize the 12517 spare parts using the L-Method to optimize the number of clusters based on the elbow chart. A major challenge was to disaggregate the parts usage data, which was aggregated by year. The distribution of weekly demand was identified for each of the five clusters by comparing the Gamma and Poisson distributions that were consistent with the disaggregated cluster parameters. The results show that a Poisson forecasting model is appropriate for most repair parts.

111 The Effect of Differentiated Monetary Incentives on Review Quality

SEO SEYEON, Hyunguen Kim, Jaehong Park, Kyunghee University, Seoul, Korea, Republic of.

E-commerce firms have now differentiated monetary incentives to customers' review. For example, reviewer can just receive $1 with plain text, but with photos receive $2. We noticed that previous studies couldn't answer what kind of review consumers would choose to write if such monetary incentives are differentiated. This study examines the effect of differentiated monetary incentives on the quality of the review. Our paper is unique in analyzing how differentiated monetary rewards influence the quality of the review which haven't been studied before. We also suggest e-commerce platforms a guide on how to differentiate monetary incentives in efficient way.

112 Validating Causal Inference Methods

Harsh Parikh, Duke University, Durham, NC, Contact: harsh.parikh@duke.edu

Many statistical methods have emerged for causal inference including nonparametric and doubly robust approaches. Unfortunately, there is no `one-size-fits-all' causal method that performs optimal universally. For applied researchers, it is critical to understand a method's performance for the data at hand. We introduce a framework to validate causal methods. Its novelty stems from its ability to generate synthetic data anchored at the empirical distribution for the observed sample. We demonstrate it's ability to assess the relative performance of causal techniques via two real-world data applications from Lalonde and Project STAR studies.

113 Using The or Mindset to Design a Data Program Methodology

Zohar Maia-Aliya Strinka, Analytics Strategies LLC, Thornton, CO, Contact: zstrinka@gmail.com

In the broader Analytics community, there are consistent challenges in data programs. Some of these challenges are unavoidable, but many can be solved using the Operations Research mindset to problem solving. We seek to present a methodology for identifying which data programs are worth pursuing and understanding the most effective and realistic paths that will allow you to achieve your organizational goals.

114 Shrinkage Bootstrap: A New Method of Bootstrap for Random Dot Product Graph

Jiantong Wang[1], Yichen Qin[2], [1]University of Cincinnati, Cincinnati, OH, [2]University of Cincinnati, Cincinnati, OH, Contact: WANG5JT@MAIL.UC.EDU

The study of network data has attracted more and more interest in recent years. Many statisticians work on developing analogues of classical statistics on network data. To make inference of network parameters through sampling is one of the key aspects. To exploit the information from a sample of network data, bootstrap can be used to study the sampling distribution of network statistics.There are some methods trying to conduct bootstrap on network, such as vertex bootstrap. Here we proposed a new method of bootstrapping under the framework of random dot product graph (RDPG) models, Shrinkage Bootstrap. We also did simulation to show that the new model yields a better inference of network parameters.

115 Optimal Off-policy Estimation of Linear Functionals: A Non-asymptotic Theory of Semi-parametric Efficiency

Wenlong Mou, Martin Wainwright, UC Berkeley, Berkeley, CA, Contact: wmou@eecs.berkeley.edu

We study non-asymptotic guarantees for estimating linear functionals in contextual bandits using offline data. First, we propose a two-stage estimator by estimating the outcome function under a weighted norm, and show non-asymptotic upper bounds on its estimation error. We then show non-asymptotic local minimax lower bounds on the estimation error, establishing their instance-dependent optimality. In particular, when the sample size is sufficient for estimating the best approximation of the outcome function in a small class but insufficient to estimate the remainder in a larger class, a finite-sample efficiency loss depending on the approximation error appears in the optimal risk.

116 Reliability Inference of Radioisotope Thermoelectric Generators

Marc Eskew[1], Victoria Li[1], Ashten Prechtel[1], Donovan Tokuyama[1], M. Elisabeth Pate-Cornell[2], [1]Stanford University, Stanford, CA, [2]Stanford University, Stanford, CA, Contact: esq601@gmail.com

The objective of this work is to model the reliability of a critical component in spacecraft power systems with no direct observations of the individual component performance. Based on data from NASA/JPL missions, Markov Chain Monte Carlo modeling is used to infer probability distributions of reliability parameters of interest. Using these estimates, this model provides credible intervals of reliability and probability of failure of power systems for future missions and allows updating from continued missions or testing.

117 Where Optimization Meets Prediction: Novel Use-cases from Gurobi Optimization for Data Scientists

Rahul Swamy[1,2], [1]Gurobi Optimization, New York City, NY, [2]University of Illinois at Urbana-Champaign, Urbana, IL

Can optimization co-exist with prediction? This poster spotlights two novel use-cases - in a music recommendation system and in avocado supply-chain optimization - to highlight how predictive and prescriptive analytics can synergize to create wholesome technologies.

118 Narrative Transitions Using Neural Networks

Khizar Qureshi[1], Tauhid Zaman[2], [1]MIT, SAN FRANCISCO, CA, [2]Yale University SOM, New Haven, CT, Contact: kqureshi@mit.edu

Given two narratives, we generate a sequence of messages that connect the initial narrative to the final narrative in a logical and coherent manner. These messages can be used to persuade individuals who support one narrative to support another narrative. We construct these messages using two steps. First, we train two Word2Vec models on sentiment specific social media posts supporting the initial and final narratives. Then we use these models to find a logical path of narratives between the initial and final narrative. Finally, we use the GPT-3 transformer to generate messages that transition between the narratives on this path.

119 A Science Mapping Analysis of Artificial Intelligence Research in The Field of Management and Organization

Yuan Cheng[1], Guangjian Liu[2], [1]Renmin University of China, Beijing, China; [2]Shandong University, Jinan, China.

A large and growing body of research has investigated the antecedents and consequences of artificial intelligence application in the workplace. Using science mapping analyses, we quantitatively visualize the intellectual structure of this emerging field, demonstrate how the intellectual structure has evolved over time, and detect new research frontiers as well as emerging trends. With this understanding, we propose promising theoretical and methodological opportunities for future research. In sum, we conduct a state-of-the-art review that provides an integrated and holistic view of the landscape and evolution of this field and offers a roadmap to move this field forward.

120 Finrl Framework for Financial Reinforcement Learning

Shuaiyu Chen, Purdue University, West Lafayette, IN

The FinRL project is a unified framework that includes various markets, state-of-the-art algorithms, financial tasks (portfolio allocation, cryptocurrency trading, high-frequency trading), and live trading. We demonstrate the application of deep reinforcement learning in finance and provide educational materials for newcomers.

121 Application of Artificial Intelligence on Radar Gait Signature for Walking Abnormality Detection

Abhidnya Patharkar[1], Fulin Cai[1], Harry Chen[2], Teresa Wu[1], Fleming Lure[2], Kewei Chen[3], Victor Chen[4], [1]Arizona State University, Tempe, AZ, [2]MS Technologies Corp, Rockville, MD, [3]Banner Alzheimer's Institute, Phoenix, AZ, [4]POC Technologies Group, Fairfax, VA, Contact: apathark@asu.

edu

Patients with Alzheimer's disease walk more irregularly than healthy elderly people. These gait characteristics can be used for early detection & intervention. As an initial proof-of-concept, we simulated three different types of walking patterns namely normal, moderate abnormal, and severe abnormal based on global human walk model to validate and verify the radar-based system for gait analysis. We then analyzed the gait signatures with machine learning on Doppler frequency signals & deep learning on Doppler spectrograms. It can be noticed from the results that both the techniques work well for abnormality detection on radar gait features demonstrating potential for probable clinical use.

122 Adaptive Data Debiasing Through Bounded Exploration and Fairness

Yifan Yang[1], Yang Liu[2], Parinaz Naghizadeh[3], [1]The Ohio State University, Columbus, OH, [2]UC Santa Cruz, Santa Cruz, CA, [3]Ohio State University, Columbus, OH, Contact: yang.5483@osu.edu

Biases in existing datasets used to train algorithmic decision rules can raise ethical, societal, and economic concerns due to the resulting disparate treatment of different groups. We propose an algorithm for sequentially debiasing such datasets through adaptive and bounded exploration. Our proposed algorithm can be used to balance between the ultimate goal of removing data biases, which will in turn lead to more accurate and fair decisions, and the incurred exploration risks. We show both analytically and numerically how such exploration can help debias data in certain distributions. We further investigate how fairness measures can work in conjunction with such data debiasing efforts.

123 Integrated Multimodal Artificial Intelligence Framework for Healthcare Applications

Yu Ma[1], Luis Soenksen[1], Cynthia Zeng[2], Leonard Boussioux[3], Kimberly Villalobos Carballo[1], Liangyuan Na[4], Holly Mika Wiberg[5], Michael L. Li[1], Ignacio Fuentes[1], Dimitris Bertsimas[2], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT, Operations Research Center, Cambridge, MA, [4]Massachusetts Institute of Technolgy-Operations Research Ctr, Cambridge, MA, [5]MIT, Somerville, MA, Contact: midsumer@mit.edu

Healthcare operations lack unified frameworks to apply multimodality in a streamlined, consolidated fashion. We develop Holistic Artificial Intelligence in Medicine (HAIM), a generalizable data processing and machine learning pipeline that can receive standard patient information and outperform state-of-the-art models on multiple healthcare-related tasks. This work could offer a promising pathway for future multimodal predictive systems in clinical and operational healthcare settings.

124 Artificial Intelligence Adoption in Healthcare: Do Communication Strategies Matter?

Glorin Sebastian[1], George Jackson[2], Amrita George[3], [1]Georgia Tech, Atlanta, GA, [2]Capella University, Minneapolis, MN, [3]Georgia State University, Atlanta, GA

Prior studies point out that lack of trust in AI, degrees of customer innovativeness and perceived novelty value influences AI adoption. With AI-enabled systems being marketed to consumers, the influence of communication strategies in such campaigns on AI adoption has received scant attention. This research examines if different communication strategies have better success in overcoming factors that hinder stakeholders from adopting AI. We find that certain communications strategies positively impact user's trust, customer innovativeness, and perceived novelty value, leading to improved AI adoption.

125 Artificial Intelligence in Supply Management: From a Case Study of Total Cost of Ownership, to a Literature Review and a Digital Twin Model

Jan Martin Spreitzenbarth[1,2], [1]University of Mannheim, Mannheim, Germany; [2]CARIAD SE, Stuttgart, Germany.

Artificial intelligence is a key technology for procurement and its usage is still in its infancy. For instance, the Volkswagen “Procurement Strategy 2030” stresses its potential to optimize processes and structures - and this applies to the automotive industry and other organizations worldwide. Yet, only a few have successfully integrated AI methods into their operations and across their supply chains, but these technologies are recently starting to emerge. This constitutes a research opportunity on how artificial intelligence increases its performance. Thus, the research goal is to examine and exploit ideas on how methods of artificial intelligence can be utilized in supply management.

126 Integrating Machine Learning in Agent-based Simulation of The Urban Food-energy-water Nexus

Marwen Elkamel[1], Luis Rabelo[1], Morgan C. Wang[2], [1]University of Central Florida, Orlando, FL, [2]University of Central Florida, Orlando, FL, Contact: melkamel@knights.ucf.edu

An agent-based model (ABM) is presented for the food-energy-water (FEW) nexus in support of sustainable development of integrated sectors. The focus is to increase food availability for the local community, decarbonization through renewable electrification, reduce water footprints, as well as efficiently manage energy, water, and food resources. Renewable energy (e.g. solar, biomass, and wind) data are integrated within the ABM through the development of machine learning models to better predict their availability. A smart irrigation system that gives predictions of crop yields and the optimal irrigation amount is also integrated within the ABM.

127 Stochastic Response Analysis for Multivariate Statistical Process Control

Sangki Kim[1], Seoung Bum Kim[2], Seung Hwan Park[3], Jihoon Kang[4], [1]Tech university of Korea, Siheung-si, Korea, Republic of; [2]Korea University, Seoul, Korea, Republic of; [3]Chungnam National University, Daejeon, Korea, Republic of; [4]Tech university of Korea, Siheung-si, Korea, Republic of. Contact: pon03111@tukorea.ac.kr

In manufacturing field, acquisition of complex data patterns such as intermittent, zero-inflated, multi-modal and time varying is increasing. As those data patterns degrade reliability of the model, analysis of data patterns should be preceded. In this research, we propose moving-window based stochastic transformation of data to enhance reliability. By applying the proposed methodology to actual bearing vibration data, reduction of false alarm rate and high-accuracy of predicting remaining useful life are demonstrated

128 Impacts of Effectual and Visual Attributes in Professional Vs Customer Video Reviews

Gaurav Jetley[1], Shivendu Shivendu[2], [1]Colorado State University, Fort Collins, CO, [2]University of South Florida, Tampa, FL, Contact: gaurav.jetley@colostate.edu

Extensive research has shown that textual reviews influence choice but the amount of information they contain is limited to text. Recently, large retailers are presenting professional and consumer reviews in video formats which can convey information in multiple modalities which makes videos an inherently richer and more expressive medium. We study the impacts of customer and professional video reviews on product sales by analyzing 52 hours of video reviews from 800 products in a panel format. We find that negativity bias and reviewer identity disclosure in customer video reviews significantly impacts sales. We also find that customer identity disclosure moderates the impact of negativity bias.

129 EE-SMOTE: An Oversampling Method in Conjunction with Information Entropy for Imbalanced Learning

Jiajing Huang[1], Teresa Wu[1], Kasim Selcuk Candan[1], Ojas Pradhan[2], Jin Wen[2], Zheng O'Neill[3], [1]Arizona State University, Tempe, AZ, [2]Drexel University, Philadelphia, PA, [3]Texas A&M University, College Station, TX, Contact: jhuan177@asu.edu

Imbalanced learning attracts great attention in various research fields. Existing literature-reported methodologies in imbalanced learning have shown drawbacks including over-generation or noises. This paper presents EE-SMOTE, an oversampling technique based on information entropy, to support the imbalance classifications. Specifically, a metric, Eigen-Entropy (EE), is proposed to identify homogenous samples from minority classes for oversampling technique, and SMOTE to reach data balances for classification. Experiments on public dataset and real-world datasets demonstrate the efficacy and effectiveness of the proposed EE-SMOTE in imbalanced learning.

130 A Heterogeneous Recurrence Network Based Deep Learning Method for Wind Turbine Fault Detection and Diagnosis

Bo Peng[1], Cheng-Bang Chen[2], [1]University of Miami, South Miami, FL, [2]University of Miami, Miami, FL, Contact: bxp547@miami.edu

The Recurrence Analysis (RA) and Recurrence Network (RN) are two promising concepts in complex system research. Based on the concept of RN, we proposed a novel Heterogeneous Recurrence Network (HRN) by exploiting the heterogeneity in system recurrences. By doing so, the topological information of the network is enriched, which in turn, delineate complex system dynamics and transitions in a much more precise way. We later applied our method in a real wind turbine system SCADA data for faults detection and diagnosis tasks. Through connecting the HRN measures with a deep learning CNN model, this framework has been proved to perform better than traditional methods.

131 Automatic Table Structure Identification and Content Interpretation

Minhao Yan[1], Bing Zhang[2], Pawan Chowdhary[3], Taiga Nakamura[2], [1]Cornell University, Ithaca, NY, [2]IBM, San Jose, CA, [3]IBM Research, San Jose, CA, Contact: my497@cornell.edu

Tables are a widely-used structure for data presentation and summarization in documents. However, most of the tables are designed for human readers and their layout and logical structure are not well defined for machine processing. This work focuses on designing table structure decoding systems and table content interpretation algorithms through analyzing various features within a complex table (e.g., layout, cell content, missing data, massy tables). The proposed method builds an offering to extract payment and rebate information from contract tables, and transfer it into AI/machine actionable data to identify performance gaps and cost savings opportunities.

132 A Spatio-temporal Track Association Algorithm Based on Marine Vessel Automatic Identification System Data

Md Asif Bin Syed, Imtiaz Ahmed, West Virginia University, Morgantown, WV, Contact: ms00110@mix.wvu.edu

Tracking multiple moving objects in real-time in a dynamic threat environment is important in national security and surveillance. In this work, we develop a spatio-temporal approach for tracking maritime vessels as the vessel's location and motion observations are collected by an Automatic Identification System. When our proposed track association algorithm is applied to the five test sets, the algorithm scores a very competitive performance. As the model is taking consideration of only the previous node, the Recurrent Neural Network is used for the further improvement of the performance.

133 Mapping The Modern Agora: Harnessing Data Analytics to Explore Nonprofit Sectors

Yeawon Yoo, Milan De Vries, Hahrie Han, Johns Hopkins University, Ellicott City, MD, Contact: yyoo9@jh.edu

In ancient Greek society, there was a central space in the life of the city called an Agora. It became central to making democracy work in ancient society, and now it is a representative example of democracy. In modern America, however, there does not exist an agora-like place. Specifically, these days, although few civic organizations still have an offline presence, most organizations exist online, leaving digital traces. Therefore, our proposed research will use such digital traces to create a comprehensive map of both online and offline landscapes of our civic life, called a modern agora, which depicts a set of nonprofits and their interests using natural language processing and clustering.

134 A Data-driven Prediction Model for Energy Consumption and Availability of Micro Electric Vehicle Based on Real-world Driving Data

Ingyu Choi, Seongjoon Kim, Jongho Shin, Chosun University, Gwangju, Korea, Republic of. Contact: 20161978@chosun.kr

A micro electric vehicle (EV) is a small version of a standard EV that is used for first- and last-mile solutions, and has been receiving attention for transport and delivery services. Since it takes several hours to recharge the battery, energy consumption is a major concern to drivers as well as mobility companies. In this study, large-scale MEV driving data collected in South Korea are used to build a prediction model and availability. First, feature extraction is performed for machine learning and driving profiles. Second, the prediction framework is proposed based on the machine learning model and driving profiles. Last, application examples are presented to demonstrate the proposed model.

135 Non-stationary Spatio-temporal Point Process Modeling for High-resolution Covid-19 Data

Zheng Dong[1], Shixiang Zhu[1], Yao Xie[1], Jorge Mateu[2], Francisco J. Rodríguez-Cortés[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]Universitat Jaume I, Valencia, Spain; [3]Universidad Nacional de Colombia, Medellín, Colombia. Contact: zdong76@gatech.edu

We develop a non-stationary spatio-temporal point process with a neural kernel to model fine details of COVID-19 spread, motivated by an individual-level COVID-19 dataset in Cali, Colombia. We incorporate exogenous influences of city landmarks. The numerical results demonstrate good predictive performances of our method as well as its interpretable findings.

136 The Benefits of Text Content Analysis Vs. Bert to Best Capture Product Quality in Online Reviews

Ayan Basak[1], Matthew A. Lanham[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, Lafayette, IN, Contact: basak0@purdue.edu

Text content analysis has been successful in many studies to identify important features such as product defects. BERT (Devlin, et. al.) has recently been a popular pre-trained language translation model. The objective in this study is to see how these text-based approaches perform at capturing product quality for service parts in online reviews. We found that content analysis composed of a word dictionaries versus the BERT showed significant performance differences with BERT achieving a 90% better F1 score. Each provide certain interesting insights to decision-makers and when incorporated together via our approach has potential to more useful for assortment decisions than BERT alone.

137 A Data-driven Pathwise Sampling Strategy for Online Anomaly Detection

Dongmin Li[1], Miao Bai[2], Xiaochen Xian[3], [1]University of Florida, Gainesville, FL, [2]University of Connecticut, Storrs, CT, [3]University of Florida, GAINESVILLE, FL, Contact: dongmin.li@ufl.edu

We propose a data-driven strategy for quick anomaly detection with moving vehicle-based sensors. We integrate statistical process control and mathematical optimization to monitor the system and adaptively sample from suspicious locations based on real-time data. We provide theoretical investigations and present its performance in a numerical study on wildfire detection.

138 Heterogenous Spatial Recurrence Quantification Analysis of Whole Slide Images for Invasive Ductal Carcinoma Detection

Yujie Wang, Cheng-Bang Chen, University of Miami, Miami, FL, Contact: yxw509@miami.edu

Prior research has shown that the complex geometric patterns of medical images, providing rich and precise information to the tissues or cells, directly correlate with cancer progression. However, little has been done in investigating the relationship between spatial recurrences and tumor degree. Recurrence analysis provides a novel angle to estimate the recurrence structures and patterns of images. Based on this study, we developed heterogenous recurrence analysis to carry the image heterogeneous properties, which are usually neglected by RQA.

139 "Propose and Review": Interactive Bias Mitigation of Machine Classifiers

Tianyi Li[1], Zhoufei Tang[2], Tao Lu[2], Xiaoquan (Michael) Zhang[3], [1]Chinese University of Hong Kong, HongKong, China; [2]Southern University of Science and Technology, Shenzhen, China; [3]Tsinghua University, Shenzhen, China.

We develop a solution framework for mitigating algorithmic bias in machine-learning classifiers. Alice (e.g., the firm) proposes using data to build a target classifier, and Bob (e.g., the regulator) builds a bias-proof classifier to protect sensitive dimensions from being discriminated on; specific measures of algorithm fairness and a priori definition of bias terms are exempted in this "propose and review" scenario. The method reduces separability of Bob's classifier and preserves separability of Alice's classifier, obviating the fairness-utility tradeoff by separating two classifications. A detailed case study shows good bias-mitigation performance at 10/12 machine classifiers.

140 Enhancing Semi-supervised Classification at Disconnected Social Communities

Miaozhe Han[1], Jeremy Yang[2], Tim Li[3], [1]The Chinese University of Hong Kong, Shatin, Hong Kong; [2]Harvard University, Cambridge, MA, [3]Chinese University of Hong Kong, Hong Kong, China. Contact: miaozhehan@link.cuhk.edu.hk

We challenge two practical difficulties in node classification on social networks: (A) consider semi-supervised classification where labeling rate on graph nodes is small; (B) consider network data consisting of disjoint communities/subgraphs. For (A), we use graph convolutional neural networks to enhance classification accuracy in semi-supervised environments. We consider graph convolution in the spectral (GCN, Kipf and Welling, 2016) or spatial (GraphSAGE, Hamilton et al., 2017) domain. For (B), we realise classification on the entire network by establishing inter-community connections via link prediction (Zhao et al., 2021) or spectral method (Li, 2022).

141 Predicting Transactional Fraud on The Ethereum Blockchain with Graph Neural Networks

Charity Mwanza, The University of Alabama in Huntsville, Huntsville, AL, Contact: cm0260@uah.edu

Blockchain-based currencies have gained popularity in recent years. This is evident by the increased creation of alt-tokens and the advent of decentralized finance. However, the increased adoption also leads to unethical behaviors among individuals looking to thwart the open nature of the blockchain. This work explores the use of graph neural networks to detect fraudulent transactions on the Ethereum blockchain. We hope that we can design an interpretable, systematic approach to identifying such transactions for the well-being of the blockchain.

142 Genetic Data on The Blockchain and The Transformation of Marketing

Sunil Erevelles[1], Camelia R. Taheri[1], Anthony Erevelles[2], [1]University of North Carolina, Charlotte, Charlotte, NC, [2]The Management Mind Group, Charlotte, NC, Contact: sunil.erevelles@uncc.edu

Genetic data represents a seminal paradigm shift, likely to radically transform marketing in the future. The capacity of genes to predict consumer behavioral traits may far exceed the predictive capabilities of current Big Data or behavioral paradigms. Consumers' genetic data account for around 50% of their behavioral traits. However, Genetic Big Data can only practically and ethically be used with the blockchain, which provides the necessary trust, security, privacy, transparency and disintermediation. The authors use their original indigenous theory development, inductive realist approach to propose, support and test a theoretical framework to accelerate future academic research.

143 An Economic Model of Consensus on Distributed Ledgers

Hanna Halaburda[1], Zhiguo He[2], Jiasun Li[3], [1]NYU Stern, New York, NY, [2]The University of Chicago, Chicago, IL, [3]George Mason University, Fairfax, VA, Contact: jli29@gmu.edu

Many new blockchain applications build on the Byzantine fault tolerance (BFT) problem. While traditional BFT protocols assume most system nodes are honest, blockchains nodes are subject to strategic incentives. We develop an economic framework for analyzing such cases, with explicit incentive considerations where non-Byzantine nodes are Knightian uncertain about Byzantine actions. The consensus process then induces a dynamic game with coordination and cheap talk flavor. We characterize all equilibria, in some of which rational leaders withhold messages. These findings enrich traditional BFT protocols. We also study how progress in communication technology affects equilibrium outcomes.

144 User'S Multi-role and Development Trajectory of Tokenized Digital Platform

Tim Li[1], Xiaoquan Michael Zhang[2], [1]CUHK Business School, HONG KONG, China; [2]Tsinghua University, Beijing, China. Contact: tianyi.li@cuhk.edu.hk

We develop a model for blockchain platforms' development trajectory. Model dynamics rely on the feedback between platform utility change and platform adoption. Consider a typical platform participant simultaneously playing three roles - user, investor, and laborer, corresponding to blockchains' three utilities: providing service for transaction/interaction, providing medium for digital investment, and providing workspace for online labor. Model describes a three-phase development trajectory: a chaotic initial stage of platform launch, an intermediate stage of rapid growth, and a mature stage of stable market cycles. Model well fits 112 real-world token price series and remains robust.

145 Black Lives Matters: A Bertopic and Sentiment Score Text Analysis

Maggie Xia[1], Xinyuan Wei[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia State University, Atlanta, GA, Contact: mxia43@gatech.edu

The struggle for black liberation has evolved over the decades, and this study strives to analyze how the Wall Street Journal (WSJ) and New York Times (NYT) cover topics related to racial equality before and after the death of Floyd. We scrape ten years worth of articles from these two sources and select the articles containing at least one of our list of keywords. Furthermore, we run a BERT topic model (specifically BERTopic) - a transformer-based model for natural language processing to create clusters of topics to summarize our articles. The model yielded two main clusters. Additionally, we examine a sentiment analysis of the articles using the Loughran-McDonald sentiment score for both sources.

146 State-level Policy Stigma and Disparities in Quality of Life Among Transgender and Gender Nonconforming Individuals

Min Kyung Lee, Yuehwern Yih, Purdue University, West Lafayette, IN, Contact: lee1239@purdue.edu

The number of transgender-specific policies in the U.S. has increased, including protective and discriminatory policies affecting the transgender community. Transgender-specific stigmatizing policies may increase negative representations and limit access to resources. Using predictive modeling, this study examines the association between state-level policy and QoL among transgender individuals in the U.S.

147 Welfare-guided Seeding with Time-constrained Data Collection

Carlos Hurtado[1], M. Amin Rahimian[2], Md Sanzeed Anwar[3], Dean Eckles[4], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, [3]University of Michigan, Ann Arbor, MI, [4]MIT, Cambridge, MA, Contact: cah259@pitt.edu

Fair influence maximization often relies on simplifying assumptions that do not apply to real-world scenarios: network structure fully known, time independency of the utility influencing a node, and categorization of individuals into easily defined groups to measure inequality. We propose an efficient seeding algorithm with a network query phase bounded by some deadline while aiming to reduce the inequality under different fairness schemes. Our theoretical performance guarantees demonstrate how the quality of the outcome depends on measurement resources such as sample size, time spent in data collection, and allocation to nodes with low endowments.

148 Optimal Energy Management with Variable Generation and Storage

Helena Garcia Jaimalis[1], Rodrigo A. Carrasco[2], [1]Universidad Adolfo Ibañez, Santiago, Chile; [2]Universidad Adolfo Ibanez, Santiago, Chile. Contact: hegarcia@ alumnos.uai.cl

Due to climate change concerns, governments have pushed for higher penetration of variable and intermittent energy sources. Although storage systems are currently expensive, their price has dropped significantly and are considered the key to dealing with variability. We consider a small microgrid, connected to the main grid, with storage capacity and a variable source of generation. This talk presents a novel approach to computing relevant scenarios to use in a stochastic optimization problem, which computes optimal recommendations to manage the energy. We show that our approach achieves a significant improvement over the current management policies, validating it in a real prototype.

149 Planning and Operation of Power to Gas Energy Systems

Ali Elkamel, Mohammed Alkatheri, University of Waterloo, Waterloo, ON, Canada. Contact: aelkamel@uwaterloo.ca

The increase in the share of intermittent renewable energy generation systems within the power grid without adequate energy storage leads to increased events of supply and demand mismatch. To address this issue, this talk analyzes the conversion of excess electricity to hydrogen through the water electrolysis process. The produced hydrogen is then injected into and distributed via the existing natural gas infrastructure. A mathematical programming approach to plan and operate a power to gas energy hub that can provide hydrogen to fuel cell vehicles and to natural gas end users is presented.

150 Grace: A Grid that is Risk Aware for Clean Electricity - Risk Aversion Effects

Dalia Patino-Echeverri, Duke University, Durham, NC, Contact: dalia.patino@duke.edu

In this presentation, we will discuss progress made on the ARPA-E-funded project GRACE. We will discuss the effects of different approaches to characterize uncertainty, the methods used to create libraries and corresponding search algorithms and preliminary results on the economic benefits obtained.

151 OPTIMAL LAYOUT DESIGn of OFFSHORE WIND PARk for MAXIMUM POWER GENERATION

Md Imran Hasan Tusar[1], Bhaba R. Sarker[2], [1]Louisiana State University, Baton Rouge, LA, [2]Louisiana State University, Baton Rouge, LA, Contact: mtusar1@lsu.edu

OWE (Offshore Wind Energy) has the potential to be a driving factor in social, economic, and environmental development. The goal of this study is to formulate a model to maximize power generation including crucial variables/ parameters of this study area.

152 Redesign Supply Chain for Transactive Energy Operations in The Manufacturing-microgrid-climate Nexus

Tongdan Jin[1], Honglin Li[2], Shriyank Somvanshi[1], Clara Novoa[3], [1]Texas State University, San Marcos, TX, [2]The University of Texas at Dallas, Dallas, TX, [3]Texas State University, San Marcos, TX, Contact: tj17@txstate.edu

Manufacturing supply chain operations are undergoing a paradigm change driven by the growing use of renewable microgrid energy. Traditional supply chain network design usually focuses on materials, information and cash flow, yet the implication of microgrid technology is not adequately addressed. We propose a first-of-its-kind to design supply chain network in the nexus of manufacturing, renewables and climate for both commodity and transactive energy operations. The model is tested on a three-echelon network covering ten candidate locations over 8760 planning periods with a wide range of wind and weather profiles. Useful managerial insights are also derived.

153 Characterizing The Relatedness of Offshore and Onshore Wind Using Patent Analysis

Yiwen Wang, Anna Goldstein, Erin Baker, Univ of Massachusetts-Amherst, Amherst, MA, Contact: yiwwang@umass.edu

As a promising technology for efficient clean power generation, offshore wind energy remains more costly than onshore wind energy due to less learning experience accumulated. This research aims at answering to what degree offshore wind technology is an offshoot of onshore wind technology and to what degree it is novel. We quantify the relatedness between offshore and onshore wind technologies by investigating their patenting activities.

154 Learning to Accelerate Globally Optimal Solutions to The AC Optimal Power Flow Problem

Fatih Cengil[1], Harsha Nagarajan[2], Russell Bent[2], Sandra D. Eksioglu[1], Burak Eksioglu[1], [1]University of Arkansas, Fayetteville, AR, [2]Los Alamos National Laboratory, Los Alamos, NM, Contact: mfcengil@uark.edu

This study proposes machine learning-based (ML) methods to accelerate solutions for the AC Optimal Power Flow (ACOPF) problem. We use Optimality-Based Bound Tightening and choose a subset of variables whose tightening of bounds provides the best improvement for the ACOPF problem. We observe up to 6.3x speed-up on different-scale instances.

155 Measuring Household Net Energy Burdens

Eric Scheier, Emergi, San Francisco, CA, Contact: eric@scheier.org

Energy inequity is an issue of increasing urgency. Few policy-relevant datasets evaluate the energy burden of typical American households. Here, we develop a framework to measure systematic energy inequity among critical groups that need policy attention. We find substantial instances of energy poverty in the United States - 1 in 5 households experience energy poverty as presently defined as spending more than 6% of household income on energy expenditures, and more than 5.2 million households above the Federal Poverty Line face energy poverty. We recommend the

United States develop a more inclusive federal energy poverty categorization that increases assistance for household energy costs.

156 The Role of Microgrids in Advancing Energythe Role of Microgrids in Advancing Energy

Kehinde Abiodun, Colorado School of Mines, GOlden, CO, Contact: kaabiodun@mines.edu

Microgrids can play a role in advancing energy equity by (i) extending access to electricity in areas where national grids do not reach, and (ii) enhancing a power system's resilience --- the ability to adapt to and rebound from unanticipated shocks --- in times of disaster(s) such as extreme weather events or power outages on the centralized grid.

157 Stochos: Opportunistic Maintenance for Offshore Wind Farms Under Uncertainty

Petros Papadopoulos, Rutgers University, Piscattaway, NJ, Contact: petros.papadopoulos@rutgers.edu

STOCHOS, short for the stochastic holistic opportunistic scheduler is a maintenance scheduling approach tailored to address the unique challenges and uncertainties in offshore wind farms. Scenarios are generated using a probabilistic forecasting framework which adequately characterizes the temporal dependence in key input parameters. Evaluated on a real-world case study from the U.S. North Atlantic where several large-scale offshore wind farms are currently in development, STOCHOS demonstrates considerable improvements relative to prevalent maintenance benchmarks, attesting to its potential merit towards enabling the economic viability of offshore wind energy.

158 Variable Renewable Energy Participation in U.S. Ancillary Services Markets: Economic Evaluation and Key Issues

James Hyungkwan Kim, Fredrich Kahrl, Ryan Wiser, Cristina Montañés, Will Gorman, Lawrence Berkeley National Laboratory, Berkeley, CA, Contact: hyungkwankim@lbl.gov

VRE participation in AS markets could provide a new source of revenues for VRE resource owners to offset declining energy and capacity values and a new tool for power system operators to address emerging system constraints. Using a price-taker dispatch model and historical prices to estimate the economic value of VRE participation in AS markets across ISO/RTO markets, average simulated incremental revenues from regulation market participation were $1-33/MWh (+1-69%) for hybrid (battery-paired) VRE owners. The analysis highlights the value of separate upward and downward regulation products and suggests that ISOs/RTOs might consider initially focusing on enabling hybrid VRE provision of AS.

159 Is There a Role for a Mid-duration Storage Technology in Variable Renewable Electricity Systems with Long- and Short-duration Storage?

Anna X. Li[1,2], Jacqueline Dowling[1], Edgar Virguez[3], Tyler Ruggles[3], Nathan S. Lewis[1], Ken Caldeira[4], [1]California Institute of Technology, Pasadena, CA, [2]Carnegie Institution for Science, Palo Alto, CA, [3]Carnegie Institution for Science, Palo Alto, CA, [4]Carnegie Institution for Science, Palo Alsto, CA, Contact: axli@caltech.edu

We use a macroscale energy model based on multiple years of historical U.S. weather and demand data, in which gaps between wind/solar generation and demand may be balanced by three storage technologies: short-duration (Li-ion), long-duration (Power-to-Gas-to-Power (PGP) with hydrogen), and a hypothetical technology (Storage X) with parameterized energy/power-capacity costs. Three technologies may coexist when Storage X competes for the role of short-duration or long-duration storage, or acts as mid-duration storage between energy/power-capacity costs of PGP and Li-ion. In all systems, total system cost benefits are small compared to a system with only long- and short-duration storage.

160 California Hydrogen Infrastructure and Zev Adoption Towards a Carbon Free Grid in 2045

Behdad Kiani, UC Irvine, Irvine, CA

California has the ambitious goal of achieving a 60% renewable electricity grid by 2030 and 100% carbon free grid by 2045. The author has developed an optimization model to study possible roles for hydrogen in a VRE intensive future grid with a large Zero Emission Vehicle fleet, comprised of both BEVs and FCVs. In particular, we study whether we can provide sufficient seasonal storage for a 100% zero carbon electricity grid and the potential role of H2 infrastructure in a BEV/FCEV combination for a sustainable path towards a zero-emission energy system. The role of hydrogen infrastructure in seasonal storage for balancing VRE generation while meeting demand for hydrogen vehicles has been studied.

161 A Study on The Selection Method and Case of Promising Energy Technologies in Korea's CCS Sector Through Energy Long-term Forecast and Expert's Focus Group Interview

Seongkon Lee, Kyungtaek Kim, Jiseok Ahn, Korea Institute of Energy Research, Daejeon, Korea, Republic of. Contact: seongkon74@gmail.com

Energy technology's role has been crucial for coping with climate change issues and 2050 carbon neutral strategy. This study derived promising technologies in the CCS sector according to the 3 stages. First stage analyzed the long-term outlook reports such as IEA and IRENA. And the outlook for the energy industry, current status, issues, and future prospects were derived through this. Second stage derived future promising technology candidates and promising technologies in Korea's CCS sector through expert surveys and FGI. Third stage derived the timing of realizing the selected promising technologies. The results of this study will be used as core data for energy policy in Korea's CCS sector.

162 Estimation of Willingness to Pay for Tax on Electric Vehicle Charging Using Contingent Valuation Method: A Case Study of South Korea

Sung-Eun Chang[1], HyungBin Moon[2], JongRoul Woo[1], [1]Graduate School of Energy and Environment (KU-KIST Green School), Korea University, Seoul, Korea, Republic of; [2]Pukyong National University, Busan, Korea, Republic of. Contact: sechang@korea.ac.kr

Due to the environmental impact of fuel vehicles, sales of electric vehicles (EV) are increasing worldwide. South Korea has a high fuel tax and some of which covers the costs of transportation infrastructure, while EV users bear no tax burden. In order to secure equity and tax revenue, it is necessary to impose a tax on EV users. This study identifies willingness to pay (WTP) for tax on EV charging based on questionnaire survey. The result shows that the WTP has a significant relationship with only income. The mean WTP value is 1,917 KRW (12.78% of the existing charging costs) when they charge 60kW EV. The obtained results will help policy makers to design an appropriate EV charging rate and to supports for EV use.

163 Public Acceptance of The Hydrogen Fueling Station in South Korea: A Discrete Choice Experiment Approach

Kyuil Kwak, JongRoul Woo, Korea University, Seoul, Korea, Republic of. Contact: kwakke91@korea.ac.kr

Recently, in order to achieve carbon neutrality, developed countries including Korea are paying attention to hydrogen as a next-generation clean energy. Hydrogen vehicles and refueling infrastructure are complementary goods and both must spread in a balanced way to be successful. Considering the high penetration rate of hydrogen cars in Korea, public acceptability issues must be overcome and hydrogen refueling station(HRS) infrastructure must be increased. In this study, we analyze the public acceptance of HRS by conducting a discrete choice experiment with the Bayesian multinomial logit model. Based on the results, we quantitatively analyze the MWTP for the construction of HRS.

164 Research on the impact of Time-of-use on EV charging behavior and Resolving the Curtailment of Renewable Energy; with the Case of Jeju Islands, South Korea

So Young Yang[1], JongRoul Woo[2], HyungBin Moon[3], [1]Energy Environment Policy and Technology, Graduate School of Energy and Environment(KU-KIST Green School) Korea University, Seoul, Korea, Republic of; [2]Energy Environment Policy and Technology, Graduate School of Energy and Environment (KU-KIST Green School) Korea University, Seoul, Korea, Republic of; [3]Pukyong National University, Busan, Korea, Republic of. Contact: soyoun0923@korea.ac.kr

While the expansion of both EV and renewable energy is the most popular strategy for a state to achieve its greenhouse gas reduction goal, the increasing curtailment is becoming another issue. It's because the peak hour of renewable energy generation and patterns of EV charging is not usually in the same time slot of a day. Thus, this paper analyzes the charging pattern of both regular EV users and tourist EV users to find out WTP for changing the charging patterns in Jeju Islands. Then, how much curtailment could be decreased will be shown via each TOU scenario built on the WTP analysis.

165 NewRamp: Day Ahead Market Clearing Under Uncertainty

Michael C. Caramanis[1], Panagiotis Andrianesis[2], [1]Boston University, Boston, MA, [2]Boston University, Boston, MA, Contact: mcaraman@bu.edu

Several weather forecasts/ensembles converted to renewable generation available capacity are routinely available in the SPP service teritory. A robust optimization approach is employed to determine endogenously determined reserve requirements under worst case wind availability. Market clearing and Reliability Unit Commitment result from this robust optimization approach and compared to current practive. Numerical results are presented and discussed.

166 Analyzing The Effects of Line Switching Protocols on D-facts Optimal Allocation Optimization

Eduardo J. Castillo Fatule[1], Jose Espiritu[2], Yuanrui Sang[3], [1]University of Texas at El Paso, El Paso, TX, [2]Texas A&M University Kingsville, Kingsville, TX, [3]The University of Texas at El Paso, El Paso, TX

Distributed Flexible AC Transmission Systems (D-FACTS) and their allocation are new topics that are gaining traction in the field of power systems. They are a simple yet effective tool for improving power flow control and power system flexibility. However, they alone may not always be enough to improve a heavily congested system. Line switching, on the other hand, refers to the practice of switching transmission lines off in order to isolate faulty lines and reconfigure power flow. This study proposes analyzing the combination of D-FACTS device allocation along with line switching practices in order to further improve transmission networks and minimize costs.

167 Disparate Impacts of Extreme Flooding and Power Grid Failures in Different Communities

Gizem Toplu-Tutay[1], John Hasenbein[2], Erhan Kutanoglu[2], [1]The University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, Austin, TX, Contact: gizem@utexas.edu

Extreme natural disasters impact different communities differently and increase structural inequalities. Flooding and freezes can cause wide-scale power outages, which can be life-threatening to residents who require continuous power for medical devices (e.g., home oxygen machines). In this research, we address these structural inequalities by (1) explicitly considering the disparate impacts of such disasters on different communities, particularly the least fortunate ones, and (2) offering stochastic optimization models with equity metrics that produce a variety of resilience investment solutions. The case study focuses on communities that the ERCOT serves in Texas.

168 Transformative Innovation Policies in Energy Sector and The Impacts on Innovation and Profitability of The Firms

Amirsalar Jafari Gorizi, Anna Fung, American University, Washington DC, DC, Contact: aj2917a@student.american.edu

The rise of cleantech companies may be a response to the environmental forces. Many of these companies aim to increase sustainability in their operations with so-called transformative innovation policies. While much of the current literature has been focused on the tradeoffs between sustainability and profitability in different sectors, the role of transformative innovation policies on innovation and financial performance has been usually neglected. In this study, we aim to assess the impact of non-market factors on companies' abilities to create transformative innovation policies and to see how such policies impact innovation and investment in companies across the cleantech industry.

169 A Leader-follower Game Theoretic Approach for Training Reinforcement Learning Agents

Lan Hoang[1], Michail Smyrnakis[2], [1]IBM, Daresbury, United Kingdom; [2]Science and Technology Facilities Council, Daresbury, United Kingdom. Contact: lan.hoang@ibm.com

This work presents a game-theoretic formulation of multi-agent curriculum learning to improve agent learning and provide game equilibrium insights. The learning is defined by a leader - follower cooperative game. Under this setup the leader can choose among several MDPs which one is the best one given follower's actions. Each follower then chooses how it will be solving its task using an algorithm that combines opponent modelling techniques (estimates of leader's and other followers' actions) and reinforcement learning. We observed that under this framework in the agents needs only a small number of epochs to converge to a desired solution, compared to the reinforcement learning agent baseline.

170 Time Heals: A Trust Game Experiment of Anger

Kamyar Kamyar[1], Marco Palma[2], Ian Krajbich[3,4], [1]The Ohio State University, Columbus, OH, [2]Texas A&M University, College Station, TX, [3]The Ohio State University, Columbus, OH, [4]The Ohio State University, Columbus, OH, Contact: kamyar.5@osu.edu

Do people remain angry over time when treated unfairly in cases involving monetary stakes? To find out, we study the effect of time on anger in economic decision making, using a game-theoretical framework and lab experiments. Low degrees of cooperation have been indicated to bring up anger. We study how cooperation changes where subjects have to wait before making a decision, and over time. Also, to elicit the degree of anger resulted from lack of cooperation, we employ choice-process data measures of Galvanic Skin Response and NN-based face-reading software. These measures are intended to examine how people react to different cooperations, and how those emotions dissipate during the delay period.

171 Equilibrium Modeling and Solution Approaches Inspired by Nonconvex Bilevel Programming

Stuart Harwood[1], Francisco Trespalacios[1], Dimitri Papageorgiou[1], Kevin C. Furman[2], [1]ExxonMobil, Annandale, NJ, [2]ExxonMobil, Houston, TX

Many solution methods for Nash equilibrium rely on the sufficiency of first-order optimality conditions for the players' decision problems. However, these methods are only heuristics when the players are modeled by nonconvex optimization problems. In contrast, this work approaches

Nash equilibrium using theory and methods for the global optimization of nonconvex bilevel programs. We introduce the idea of minimum disequilibrium as a solution concept that reduces to traditional equilibrium when equilibrium exists. We propose a method to find minimum disequilibrium and show that this method can find a pure Nash equilibrium even when the players are modeled by mixed-integer programs.

172 Should PGA TOUR Golf Professionals Consider Their Adversary's Strategy in Match Play?

Nishad Wajge[1], Gautier Stauffer[2], [1]Lynbrook High School, San Jose, CA, [2]University of Lausanne, Lausanne, Switzerland. Contact: nishad.wajge@gmail.com

In this work, we analyze putting strategies in golf when professional golfers are in one-on-one competitions (match-play). We use Markov Decision Processes and 2-player turn-based stochastic games to compute the optimal adversary-independent and dependent strategies of the golfers and compare the performances under different scenarios. Our findings show that surprisingly, for mid-range putting (less than 25 feet), it does not pay off significantly to adjust to the adversary's statistics and strategies. We, therefore, advise professional golfers to focus on the independent strategy for at least mid-range putting. Further work is in progress to cover a broader range of conditions.

173 Implementation of An Algorithm Solving for Pure Nash Equilibria on An Integer Programming Game Using Rational Generating Function

Tzu-Ting Chen, Yu-Ching Lee, National Tsing Hua University, Hsinchu City, Taiwan. Contact: niniwiwichen@gmail.com

In our research, we implement an algorithm to find all Pure Nash Equilibria (PNE) on Integer Programming Game (IPG). Based on the existing studies, we can encode sets of strategies into rational generating functions and efficiently enumerate the PNE. This algorithm is implemented by Python, SageMath, a mathematical computation software system, and LattE, computer software that we use to compute rational generating functions. Moreover, we examine the algorithm on a simple IPG: a 3-player normal form problem. The presented result shows that we are able to find all PNE of the n-player IPG in an acceptable run time.

174 How The Brand Equity Influences a Firm'S Default Risk During a Recession: The Role of The Operating Risk and Cost of Debt Financing

Chi Zhang, Butler University, Indianapolis, IN

The COVID-19 pandemic caused both a public health emergency and a global economic crisis. As a result, public debt in many markets has surged to levels not seen in 50 years. In such an environment, firms are also expected to have significantly higher default risk. Using the sample of 17979 firm-year observations data of all A-listed, non-financial Chinese firms between 2011 and 2020, we first examine the impact of brand equity on a firm's default risk and then analyze the mechanism underlying the effect. In addition, we explored the extent to which the effect varies based on product market competition.

175 Aerial Autonomous Vehicles in Support of Material Handling in Production Enterprises

Julio Jiménez-Sarda[1], Alice E. Smith[2], Daniel F. Silva[2], [1]Auburn University, Auburn, AL, [2]Auburn University, Auburn, AL, Contact: jzj0098@auburn.edu

Current events show that our logistics chain is fragile, and that current technology is not enough to keep up with increasing demand. Many systems rely heavily on human operators who require simple and standardized instructions. Especially in dynamic and flexible manufacturing processes, it is hard to generate optimized actionable schedules. Autonomous vehicles may help alleviate this production bottleneck. Through a combination of exact methods, heuristics, simulation, and physical trials, our focus is on developing the models and software tools for planning and performing automated material handling operations, in support of production environment, using autonomous aerial vehicles.

176 The Revival of Urban Manufacturing

Shantanu Bhattacharya, Lieven Demeester, Arnoud De Meyer, Singapore Management University, Singapore, Singapore. Contact: shantanub@smu.edu.sg

The location of industrial facilities in post-industrial society was primarily mixed. In the last century, the detrimental effects of heavy manufacturing on the adjoining residential communities sparked a shift to the model of land zoning. But in recent years, there has been an increased interest in the mixed-use of land spaces. This paper uses a stakeholder value model to provide a framework for manufacturers considering the option of urban manufacturing to locate their manufacturing unit in an urban location. The paper adopts a five-pillar approach to stakeholder value, and provides recommendations for best practices to manufacturers who are considering the option of urban manufacturing.

177 Autonomous Control of UAVs Combat Maneuver Using Incremental Reinforcement Learning

Hajun Hwang[1], Jongkwan CHOI[2], Hyeonmin Kim[1], Changouk Kim[1], [1]Yonsei University, Seoul, Korea, Republic of; [2]Yonsei University, Seoul, Korea, Republic of. Contact: hajuny1115@gmail.com

Currently, various studies using reinforcement learning are being conducted on the automation and control of unmanned aerial vehicles (UAVs) that can eliminate human errors in manned aircraft. However, in reinforcement learning, it is difficult to design accurate reward functions to achieve desired goals. In this work, to solve the above problem, we propose incremental learning that can efficiently learn from easy to desired goals by incrementally increasing the difficulty of learning. The proposed method was validated using JSBSim, and in the case of incremental learning, the goal was achieved in 3502 episode by gradually increasing the difficulty, but in other cases, the goal was not achieved.

178 Modular Reinforcement Learning Framework for UAVs Combat Mission

Jongkwan Choi, Hyeonmin Kim, Hajun Hwang, Changouk Kim, Yonsei University, Seoul, Korea, Republic of. Contact: jk-choi@yonsei.ac.kr

Combat unmanned aerial vehicles (UAVs) are actively being studied because of their low maintenance costs and ease of responding to the rapidly changing battlefield environment. Existing UAVs control models have limitations in that expert knowledge is essential, flexible decision-making is difficult, and it is not realistic. We propose a combat UAVs control model that can effectively learn through a deep reinforcement learning model based on modular learning in a realistic 6-DOF simulation environment. It first divides a complex air engagement mission into simplified modules and applies an optimized reward function to each module to learn it.

179 Algorithms for Telerobotic Camera View Frame Placement Problem

seonghun Park[1], Manish Bansal[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech., Blacksburg, VA, Contact: seonghun@vt.edu

Telerobotic cameras installed on Unmanned Ground or Aerial Vehicles enable multiple autonomous agents on the battlefield to interact with a remote physical environment using shared resources. Thus, the efficient and effective positioning of camera frames is one of the challenges for telerobotic camera systems. In this poster, we present exact and approximation algorithms for the system with single and multiple cameras, respectively, with continuous-resolution and rectangular shape of request. We also conduct the simulation study in which human agents and automated agents cooperate to find the hidden object by implementing our algorithm.

180 Optimizing Potential Information Gain over Space and Time for Multi-INT Fusion

Esther Jose[1], Rajan Batta[2], [1]University at Buffalo, Buffalo, NY, [2]University at Buffalo (SUNY), Buffalo, NY, Contact: estherjo@buffalo.edu

ISR (Intelligence, Surveillance, and Reconnaissance) satellites are used to collect different types of data (such as radar and video) from areas of interest. Information fusion is used to improve the value of the data obtained. We present an optimization model to determine the times, locations, and types of data that need to be collected by different satellites to maximize the total information value. Our model takes into account the fact that while some satellites have the ability to do data fusion on-board, others do not, and will have to communicate data to an external processor. This approach allows for the model to be used with older satellites and newer, more advanced satellites as well.

181 Decision Support for Study Program Selection Using Text Clustering

Kalen Goo, Alessandro Hill, California Polytechnic State University, San Luis Obispo, CA, Contact: kgoo@calpoly.edu

Prospective students struggle with choosing a program that best fits their interests. Curriculum data is often provided as a list, making it hard to identify relationships between various courses and programs. This project takes a network-analytics approach to enhance university study program exploration. Extracted keywords from course description data are vectorized using the Term-frequency-inverse document frequency (TF-IDF) statistic and then formed into related word groups through K-Means clustering. The connections between word clusters and programs serve as a decision support tool for students, allowing them to discover the most relevant programs with respect to their interests.

182 The Optimality Gap of Biobjective Convex Quadratic Programs is $O(\sqrt{t})$

Burla E. Ondes[1], Susan R. Hunter[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN

We provide upper bounds on the Hausdorff distances between the efficient set and its discretization in the decision space, and between the Pareto set (also called the Pareto front) and its discretization in the objective space, in the context of biobjective convex quadratic optimization on a compact feasible set. Our results imply that if t is the dispersion of the sampled points in the discretized feasible set, then the Hausdorff distances in both the decision space and the objective space are O(√t) as t decreases to zero.

183 Interpretable and Automated Detection of Illicit Massage Businesses

Margaret Tobey, NC State University, Raleigh, NC, Contact: mgtobey@ncsu.edu

Illicit massage businesses (IMBs) across the US profit illegally from the sexual exploitation of workers, many of whom are victims of human trafficking. Data about massage businesses is available from many sources including review websites. With insight from domain experts, we extract and engineer meaningful features from text and location-based data. We propose natural language processing models for detecting IMB reviews and business-level risk score models for predicting likely IMBs. These models can assist stakeholders by automating some steps of the investigative process. The interpretability of the proposed models provides transparency and increases stakeholder confidence.

184 Organizational Intervention Frameworks & Methodologies for Workplace Well-being & Beyond

Carley Chiasson, Tzvetanka Dobreva-Martinova, Director General Military Personnel Research and Analysis, Ottawa, ON, Canada. Contact: carley.chiasson@forces.gc.ca

Organizational interventions can bridge the gap between research, policy, and practice, producing important positive outcomes for employees and organizations. Interventions provide the means for implementing policies/strategies as they can be tailored to specific settings and individuals within an organization. A review of organizational health psychology literature revealed resources suitable for the Defence research context that can facilitate psychosocial health and well-being related initiatives. These theories, models, tools, and approaches could help establish research-based frameworks to develop, implement, and evaluate interventions within organizations.

185 A Two-Regime Analysis of The Covid-19 Vaccine Distribution Process

Sharika J. Hegde, Hani S. Mahmassani, Karen Smilowitz, Northwestern University, Evanston, IL

A framework is developed to assess the performance of the COVID-19 vaccine distribution process that is sensitive to the unique supply-side and demand-side constraints exhibited in the United States' initial vaccine rollout. The two-regime queuing framework analyzes service rates that represent system capacity to vaccinate (first regime) and hesitancy-induced throughput (second regime). The former reflects the inherent ability of the nation in its various jurisdictions to mobilize, while the latter reflects a critical area for public policy to protect the population's health and safety.

186 Analytical Assessment of Snow Risk for Massachusetts Bay Transportation Authority

Xiaotong Ding, Boston University, Boston, MA, Contact: clairext@bu.edu

Massachusetts Bay Transportation Authority (MBTA) managers plan for a winter storm by mobilizing its labor and equipment, and scheduling contractors. This poster focuses on snow characteristic predictive modeling using upcoming storm forecast data. Using Boston snow records over 21 years, the work included feature significance scoring using correlalograms, features significance validation, and second-order polynomial regression model development to predict snow water ratio. The models predict snow related risks, including hard-to-remove heavy snow, train engine clogging fluffy snow, and parking spaces lost to snow. Hourly risk severities are visualized for use by MBTA decision makers.

187 Job Shop Scheduling Using Graph-based Imitation Learning

Je-Hun Lee[1], Hyun-Jung Kim[2], [1]KAIST, Daejeon, Korea, Republic of; [2]KAIST, Daejeon, Korea, Republic of. Contact: swi02050@kaist.ac.kr

The job shop scheduling problem is an NP-hard combinatorial problem. The dynamic environment where jobs arrive dynamically is often shown in practice and dispatching rules are widely used for scheduling the environment. However, dispatching rules do not perform well in general. In this study, we propose a graph neural network(GNN)-based imitation learning method to schedule the JSSP. The scheduling agent learns the optimal policies and then can be applied to large unseen JSSP instances. It shows better performance than GNN-based reinforcement learning(RL) methods and dispatching rules for several known JSSP benchmark instances. It also performs well in dynamic job arrival environments.

188 A Timed Petri Net-based Optimization Approach for Flexible Manufacturing System Scheduling

Jeongsun Ahn[1], Hyun-Jung Kim[2], [1]KAIST, Deajeon, Korea, Republic of; [2]KAIST, Daejeon, Korea, Republic of. Contact: jeongsun@kaist.ac.kr

Flexible manufacturing systems (FMSs), which can easily adapt to changes in job types, have been widely used in manufacturing areas. Most existing studies on scheduling of FMSs have focused on developing heuristic algorithms due to the high complexity of the problem. Therefore, we propose a novel mixed integer programming (MIP) and a branch and bound (B&B) algorithm based on a timed Petri net (TPN) to obtain an optimal schedule. A ready time-based lower bound (RLB), a transition index marking (TIM) -based dominance rule, and deadlock prevention constraints can efficiently reduce the search space.

Monday, 2 PM–3:15 PM

MD01

CC - Room 101

Analytics for Policing and Urban Public Service Operations, Session II

General Session

Session Chair

He Wang, Georgia Tech, Atlanta, GA

Session Chair

Yao Xie, ISyE Georgia Tech, Atlanta, GA

1 **The Unreported: Estimating Actual Violent Crime Rates Through Geo-temporal Correlation of Reported Crimes to Emergency Room Visits**

Matthew Hudnall, Dwight Lewis, Jason Parton, University of Alabama, Tuscaloosa, AL

A 2018 US Department of Justice report suggests that more than half of suspected violent crimes in the US go unreported. This is unfortunate because recent research suggests that the recidivism rate of Federal violent offenders is statistically higher when compared to individuals that originally committed Federal non-violent crimes. Other research indicates that there is a high spatial correlation between violent crime offenses and point-of-origin incidents in emergency medical service data. Given these considerations, we analyzed the potential in the utility of emergency room data and its ability to 1) identify the relative proportion of violent crimes unreported to the Alabama Law Enforcement Agency and 2) inform law enforcement and community partners as to levels of estimated unreported crimes to promote better community trust and engagement with law enforcement.

2 **Reinforcement Learning for Police Patrol and Dispatch**

Matthew Repasky, Minghe Zhang, He Wang, Yao Xie, Georgia Institute of Technology, Atlanta, GA, Contact: mwrepasky@gatech.edu

We apply reinforcement learning techniques to study fair and efficient police patrol policies under fixed dispatch strategies. We study the interaction of multiple police patrollers using multi-agent approaches and utilize information about historical crime patterns and hotspots to guide policy learning. In collaboration with the Atlanta Police Department (APD), this work aims to meet the needs of the citizens of Atlanta, balancing fairness considerations with effective response to crime. We use data provided by the APD to compare the effectiveness of our approach to current patrol policies, to understand the aspects of current strategies which can be improved, and to develop a policy which suits the partitioning of the city into zones and beats. Developing learned, collaborative patrol policies can also inform strategies for departments around the world.

3 **Low-Rank Spatio-temporal Crime Network Modeling**

Zheng Dong, Georgia Institute of Technology, Atlanta, GA, Contact: zdong76@gatech.edu

Understanding the mechanism of city crimes is a long-standing but significant problem. In this study, we utilize a low-rank spatio-temporal point process model to capture the complex dependency of different types of crimes in the urban area of Valencia, Spain. A distance based on the city street network and the information of city public facilities are employed to characterize the regional crime situation. Numerical results using real data from the recent decade demonstrate our model’s performance and strong power to reveal interesting patterns in the city crime events. This study contributes to strengthening city layout network analysis as a reliable tool for understanding and capturing the underlying mechanism of criminality.

Monday, 2 PM–3:15 PM

MD02

CC - Room 102

Data-driven Insights into Technology, Careers, and Mobility

General Session

Session Chair

Morgan Frank, 1</sup

1 **Network Constraints on Worker Mobility**

Morgan Frank, Pittsburgh, PA

How do skill requirements among occupations shape the present and future of worker's careers? We model a network of occupations connected by the similarity of skill requirements.Using two resume data sets, we show that skill similarity predicts career transitions with increasingly-granular skill data leading to better performance. A new measure for skill specialization based on workers' embeddedness in their economy's occupation network predicts career dynamics.Job changes that decrease embeddedness correspond to increased wages and workers tend to decrease their embeddedness over their careers. The combined embeddedness of city pairs corresponds to increased migration and flights.

2 Work2vec: Measuring The Latent Structure of The Labor Market

Sarah H. Bana[1], Erik Brynjolfsson[2], Daniel Rock[2], Sebastian Steffen[3], [1]Chapman University, Orange, CA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT Sloan, Boston, MA, Contact: sbana@stanford.edu

Job postings provide unique insights about the demand for skills, tasks, and occupations. Using the full text of data from millions of online job postings, we leverage natural language processing (NLP) in a machine learning model with over 100 million parameters to classify job postings' occupation labels. We extract measurements of the topology of the labor market, building a "jobspace" using the relationships learned in the text structure. Our measurements of the jobspace imply expansion of the types of work available in the U.S. labor market from 2010 to 2019. We compare change rates across occupations, finding substantial heterogeneity across categories.

3 Dynamic Product Embedding for Heterogeneous Purchase Network: An Application to Omnichannel Retail

Mohsen Bahrami[1], Yan Leng[2], Vinicius Brei[3], [1]MIT, Cambridge, MA, [2]University of Texas at Austin, Austin, TX, [3]Universidade Federal do Rio Grande do Su, Rio Grande, Brazil. Contact: bahrami@mit.edu

Leveraging representation learning methods with dynamic high-dimensional consumer data, our research makes both methodological and substantive contributions. Methodologically, it contributes to the growing literature of AI applications to understand market structure by developing a dynamic method to identify complementary and competitive relationships. Substantively, our research studies unique omnichannel retail, examining the dynamic product relationships amidst and post-COVID. Our unique dataset enables us to understand consumer purchases from a holistic perspective, rather than using online or offline data separately. We can capture lifestyle, purchase funnel decisions, and consumption patterns changes. Based on these patterns, our contributions will help marketers decide which products should be prioritized during turbulent times.

Monday, 2 PM–3:15 PM

MD03

CC - Room 103

OR in Practice: Opportunities, Challenges, and Best Practices

General Session

Session Chair

Filippo Focacci, Decision Brain, Paris, France.

1 Presenter

Alessandro Mancuso, Kone

Operations Research applications are extremely valuable to industries and the public in becoming more resilient, efficient, and sustainable. Despite the resolution of many theoretical and computational challenges (and many yet to be resolved), the industries and the public still face some of the toughest challenges in deploying such Operations Research applications to the end-users. Specifically, the optimal outcome may not please the end-user (e.g. a field technician), who would instead choose a different solution (e.g. the next work order) for a planning or scheduling optimization problem. It is then crucial to deploy change management principles to boost user acceptance, such as multiple optimal choices, solution explanations or positive messages about the impact of the proposed solutions.

2 Presenter

Michael S. Watson, Northwestern University / Independent, Evanston, IL

The machine learning movement presents both a challenge and an opportunity for the INFORMS community. It is a challenge because we risk being ignored and forgotten. It is a an opportunity because we can bring tools (like optimization) and a different modeling framework to solve many more problems. This talk will highlight how we can best ride the wave of machine learning and bring solutions we know increase the types of problems we can solve.

3 Or in Practice: Opportunities, Challenges, and Best Practices

Delman Lee, TAL Group, Hong Kong, Hong Kong.

Businesses are constantly looking for ways to differentiate and be one step ahead of others. They often look towards technologies for that edge. In an information rich world, where there are many new technologies or technical buzz of the moment, businesses need to discern the hype from reality. Operations Research (OR) remains an important discipline for many industries. In this session, I will discuss why OR is still important to our industry and my "wish list" for both practitioners and the scientific community. I will also highlight benefits and difficulties we encountered at TAL in leveraging OR in our company.

4 Examples of Challenging Scientific Problems Emerging from Academic-industry Collaboration

Stéphane Dauzère-Pérès, Mines Saint-Etienne, Gardanne, France. Contact: Dauzere-Peres@emse.fr

A successful collaboration between academics and industrial often requires a significant setup time and implementation time. Moreover, a significant hurdle is that the two parties usually have different goals: Publications for academics and practical achievements for industrial. However, new relevant, challenging and original scientific problems can emerge from tackling practical problems. This talk provides several examples of such problems in manufacturing and logistics that led to publications in international journals.

Monday, 2 PM–3:15 PM

MD04

CC - Room 104

Recent Advances in Reinforcement Learning

General Session

Session Chair

Will Wei Sun, Purdue University

1 Safe Optimal Design with Applications in Online and Offline Policy Learning

Ruihao Zhu, Purdue Krannert School of Management, Chicago, IL

Motivated by practical needs of experimentation and policy learning, we study the problem of safe optimal design. Specifically, our goal is to develop a logging policy that efficiently explore different actions to elicit information while achieving competitive rewards with a baseline production policy. We first show that a common practice of mixing the production policy with randomized exploration, despite being safe, is sub-optimal in maximizing information gain. Then, we propose a safe optimal logging policy via a novel water-filling technique for the case when no side information about the actions' expected rewards is available. We improve upon this design by considering side information and also extend our approaches to the linear contextual model to account for large number of actions.

2 Neural Contextual Bandits with Deep Representation and Shallow Exploration

Pan Xu[1], Zheng Wen[2], Handong Zhao[3], Quanquan Gu[4], [1]California Institute of Technology, Pasadena, CA, [2]DeepMind, Fremont, CA, [3]Adobe Research, San Jose, CA, [4]UCLA, Los Angeles, CA

We study a general class of contextual bandits, where each context-action pair is associated with a raw feature vector, but the reward generating function is unknown. We propose a novel learning algorithm that transforms the raw feature vector using the last hidden layer of a deep ReLU neural network (deep representation learning), and uses an upper confidence bound (UCB) approach to explore in the last linear layer (shallow exploration). We prove that under standard assumptions, our proposed algorithm achieves O(\sqrt{T}) finite-time regret up to logarithmic factors, where T is the learning time horizon. Compared with existing neural contextual bandit algorithms, our approach is computationally much more efficient since it only needs to explore in the last layer of the deep neural network.

3 Modeling Consumer Choice and Optimizing Assortment Via The Threshold Multinomial Logit Model

Zifeng Zhao, University of Notre Dame, Notre Dame, IN

This paper incorporates the random threshold effects into the classical multinomial logit model, and studies the associated operations problems such as estimation and assortment optimization. The derived model is referred to as the threshold multinomial logit model (TMNL) with the newly proposed threshold Luce model as a limiting case. The TMNL model can alleviate the independence of irrelevant alternatives property and allow more flexible substitution patterns. We develop a maximum likelihood based estimation to calibrate the proposed model and establish its statistical properties. Our numerical study shows that the new model can improve the goodness of fit and prediction accuracy of consumer choice behavior. We characterize the optimal strategy and develop efficient solutions for the associated assortment optimization problems under the TMNL model.

4 Policy Optimization Using Semi-parametric Models for Dynamic Pricing

Jianqing Fan, Yongyi Guo, Mengxin Yu, Princeton University, Princeton, NJ

With the development of e-commerce and the massive real-time data in online platforms today, feature-based dynamic pricing has become increasingly important as an online decision problem. In this work, we study feature-based dynamic pricing with semi-parametric feedback structure (naturally caused by unknown market noise distribution). We propose a dynamic learning and decision algorithm that makes use of the classical idea of the tradeoff between exploration (statistical estimation) and exploitation (reward optimization) with tools from semi-parametric statistics. Under mild conditions, the proposed algorithm achieves near-optimal regret in terms of dependence on the time horizon. Simulations and real data experiments demonstrate the superior finite-sample performance of our algorithm.

Monday, 2 PM–3:15 PM

MD06

CC - Room 106

Data Analytics Applications in Customer Service and Customer Behavior

General Session

Session Chair

John Angelis, University of Lynchburg, Lynchburg, VA

1 **Fool Me Once, Shame on Me, Fool me Twice, It's Business as Usual**

Rajendran S. Murthy[1], John N. Angelis[2], [1]Rochester Institute of Technology, Rochester, NY, [2]University of Lynchburg, Lynchburg, VA, Contact: rajsmurthy@saunders.rit.edu

Data breaches and misuse of data are on the rise. These breaches represent a significant threat to consumer privacy. From the firm's perspective, prior research shows that apologies harm the stock price of the firm but justifying or blaming the data breach appear to have no positive or negative effects on the stock price. Conceivably, the consumers have followed suit, choosing to ignore the problem. Cybersecurity education and prior experience did not result in meaningful change customer behavior as expected lending support to a general fatigue in consumer privacy protection efforts.

2 **Exploring The Link Between Customer-facing Firms and The Interactions with Csr, Ceo Pay, Employee Pay, and Firm Profits**

Patti Miles[1], John N. Angelis[2], [1]University of Maine, Orono, ME, [2]University of Lynchburg, Lynchburg, VA, Contact: angelis@lynchburg.edu

Customer-facing firms often have a large wage inequality between the CEO's pay and that of the median employee. Yet, customers still seem to flock to these firms. Recent research suggests wage inequality for customer-facing firms may harm customer satisfaction but seems to have mixed effects on profitability. Thus, we utilize a data set of some 1500 firms to explore if firm investment in CSR may mediate the relationship between wage inequality and profitability. We do find that customer-facing firms have higher wage inequality, but the question remains, does increasing CSR offset the effects of higher wage inequality. This study uses a mediated regression model, examining firms by industry. The contribution of this research is the unique data set: pulled from the KLD, Compustat, and the SEC (for median employee pay, CEO pay ratio, and CEO pay).

3 **You said it was on sale, why can't I find it on the shelf? Understanding customer behaviour around stock-outs**

Sriram Sambasivam, Kinaxis, Edison, NJ

The supply chain crisis has made stock-outs a regular occurrence for most consumers. At the same time, demand forecasting is a critical input for inventory planning operations. To better align a firm's demand with its supply, it is important to understand how shopping patterns (consumer demand) are impacted by the interplay between inventory (supply constraints) and marketing activity (e.g., advertising, promotions, shelf displays). The study of shopping patterns can then be organized as the following questions:
1.What are the main dimensions of stock-out induced substitutions?
2.Does marketing activity serve to bait consumers towards out-of-stock items?

Monday, 2 PM–3:15 PM

MD07

CC - Room 107

Data Analytics in Social Media Platforms and Information Systems

General Session

Session Chair

Derya Ipek Eroglu, Virginia Tech, Blacksburg, VA

Session Chair

Onur Seref, Virginia Tech, Blacksburg, VA

1 **Can a Chatbot Provide Emotional Support? Customization in Personified Chatbot**

Sagar Mahesh Badve, Alan Gang Wang, Wenqi Shen, Virginia Tech, Blacksburg, VA

With advances in technological capabilities, there has been a boom in the chatbot industry. However, though chatbots are being used widely in various domains, there is still a dearth of empirical research regarding the examination of incorporating anthropomorphic attributes of behavior and humanization in chatbots. As such, customization in the conversational skill of a chatbot plays an important role in the development and utility of the chatbot. Rooted in the concepts of anthropomorphism and human-to-human communication, this research examines the effects of customizing a personified chatbot's ability to converse on the perceived emotional support of the chatbot. Along with this, this research also assesses the impacts of the mediating effects of social presence on emotional support.

2 **When The Views Change: Design-motivated Persuasive Communication on a Reddit Community**

Derya Ipek Eroglu, Onur Seref, Michelle Seref, Virginia Tech, Blacksburg, VA, Contact: deryaipek@vt.edu

Social media allows more people to be connected while leading to more polarization. Online environments fostering good faith discussions could satisfy this need, like CMV (ChangeMyView) community of Reddit. In CMV, users post their opinions, and others challenge these opinions with different perspectives. If a redditor is successful, s/he wins a Delta, a reward with a specific purpose. We study two phenomena in the ChangeMyView: challenger strategies to persuade the OP and the way the readers process the comments and change their view. We design a mixed-methods research methodology. We share our findings and future research directions in the effort for a better future social media design.

3 **Dimensionality Reduction Learning**

Onur Seref, Virginia Tech, Blacksburg, VA, Contact: seref@vt.edu

Embeddings have become an integral part of the state-of-the-art natural language models and methods, especially in vector semantics, capturing meaning and context. There are many different methods for creating embedding vectors, which are contained in high-dimensional spaces. Visualizing embedding vectors provide valuable insights, and require nonlinear dimensionality reduction (NDR) techniques. NDR methods, however, do not usually provide an explicit mapping from the high dimensional input space to the low dimensional output space. We study different methods to learn such mappings generated by popular NDR methods and present our results on embeddings from different corpora.

Monday, 2 PM–3:15 PM

MD08

CC - Room 108

Advanced Data Analytics for Complex Systems / Use Inspired AI

General Session

Session Chair

Phat Huynh, North Dakota State University, Fargo, ND

Session Chair

Trung Le, North Dakota State University, Fargo, ND

Session Chair

Subrahmanyam Aditya Karanam, National University of Singapore, Singapore, Singapore.

1 **Koopman Spectral Analysis of Intermittent Dynamics in Complex Systems: A Case Study in Pathophysiological Processes of Obstructive Sleep Apnea**

Phat Huynh, North Dakota State University, Fargo, ND

Koopman operator theory and Hankel alternative view of Koopman (HAVOK) model have been widely used to decompose the chaos of the complex system dynamics into an intermittently forced linear system. Although the statistics of the intermittent forcing have been proposed to characterize intermittencies in the HAVOK model, they were not adequate to attribute for the mode switching of nonlinear dynamics. The paper proposed a new intermittency dynamics analysis approach to characterize the intermittent phases, chaotic bursts, and local spectral-temporal properties of various intermittent dynamics modes using spectral decomposition and wavelet analysis. To validate our methods, the intermittency behavior of apneic events in obstructive sleep apnea disorder was selected as the case, in which heart rate variability (HRV) features were extracted.

2 **Physical-statistical Learning in Resilience Assessment for Power Generation Systems**

Yiming Che, Binghamton University, Vestal, NY

Extreme natural disasters and the relentless penetration of the intermittent renewable energy have brought resilience of the power generation systems into sharp relief. we adopt a high-order physical model to characterize the full-detail sub-transient behaviors in synchronous generator dynamics, and consequently utilize basin stability (BS) to quantify system resilience against potentially large perturbations. This high-fidelity model has not been extensive probed in estimate of BS, largely owing to the tremendous computational overhead involved. We conduct sensitivity analysis to pick out the most critical system states, whose perturbation exerts huge impact and hence are sensitive on BS or system resilience. Following this, we develop a diversity-enhanced active learning framework to sequentially identify the informative perturbed states.

3 Follow Your Heart or Listen to Users? The Case of Mobile App Design

Subrahmanyam Aditya Karanam[1], Ashish Agarwal[2], Anitesh Barua[3], [1]National University of Singapore, Singapore, Singapore; [2]University of Texas at Austin, Austin, TX, [3]University of Texas-Austin, Austin, TX, Contact: karanam@nus.edu.sg

This study investigates the relative efficacies of developer-initiated and user-suggested product features. App developers constantly incorporate innovative or imitative ideas based on technological advancements. Similarly, users also suggest innovative and imitative ideas through reviews. We find that the developer should follow their own gut while innovating and listen to their users while imitating. This is one of the first attempts to examine the relative demand impact of product features initiated by developers vs suggested by users for the existing studies in the imitation research have majorly looked at different kinds of imitation such as pure vs creative, deceptive vs non-deceptive, etc. This study also adds to the user-innovation research by noting that user-suggested innovation is helpful only when these suggested features are implemented as-is.

4 Short-video Marketing in e-commerce: Analyzing and Predicting Consumer Response

Yutong GUO[1], Chao BAN[2], Xiao LIU[2], Khim Yong GOH[1], Xixian PENG[3], Jiang YANG[2], Xiaobo LI[2], [1]National University of Singapore, Singapore, Singapore; [2]Alibaba Group, Hangzhou, China; [3]Zhejiang University, Hangzhou, China. Contact: yutong.guo@u.nus.edu

This study analyzes and predicts consumer viewing response to e-commerce short-videos (ESVs). We construct a large-scale ESV dataset that contains consumers' average viewing durations labels and human-annotated content attributes. Employing the econometric model, we empirically find that product description, product demonstration, pleasure, and aesthetics are four key determinants of ESV consumer viewing response. Further, we design a multimodal-multitask framework to predict consumer viewing response to ESVs. We propose the information distillation module to extract the shared, special, and conflicted information from ESV multimodal features and utilize the hierarchical multitask classification module to capture feature- and label-level dependencies. We conduct a set of experiments to evaluate the prediction performance of our proposed framework.

Monday, 2 PM–3:15 PM

MD09

CC - Room 109

AAS, RAS, and Location Analysis Flash Session

Flash Session

Session Chair

Mattia Cattaneo, Dalmine

1 Arc Routing Problems in Combined Drone/truck Fleets

Sung Hoon Chung, Binghamton University, Binghamton, NY, Contact: sxc447@gmail.com

This research advances planning methods for combined drone/truck fleets to serve critical societal needs. We provide a novel approach to cover large service areas using combined drone/truck fleets, focusing on applications characterized by arc routing, which includes energy transmission infrastructure monitoring, urban police patrolling, rural and suburban mail delivery, roadway pavement inspection, and traffic monitoring. A novel mixed-integer linear programming formulation and adaptive heuristics based on decomposition, dynamic programming, partitioning, large neighborhood search, and machine learning for efficient operations of the combined fleets are proposed.

2 Routing with Privacy for Drone Package Delivery Systems

Geoffrey Ding[1], Alex Berke[1], Karthik Gopalakrishnan[1], Kwassi Degue[1], Hamsa Balakrishnan[1], Max Zhaoyu Li[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]University of Michigan, Ann Arbor, Ann Arbor, MI, Contact: maxzli@umich.edu

Drones are increasingly being used to deliver goods from vendors to customers. To safely conduct these operations at scale, drones are required to broadcast position information as codified in remote identification (remote ID) regulations.

However, location broadcast of package delivery drones introduces a privacy risk for customers using these delivery services: Third-party observers may leverage broadcast drone trajectories to link customers with their purchases, potentially resulting in a wide range of privacy risks. We propose a probabilistic definition of privacy risk based on the likelihood of associating a customer to a vendor given a package delivery route.

3 Lower Altitude Airspace Management for Advanced Air Mobility

Sean Calhoun, CAL Analytics, OH

Federated Unmanned Traffic Management (UTM) and Advanced Air Mobility (AAM) ecosystems operating in lower altitude airspace will be extremely complex. CAL Analytics is currently working with various organizations to develop concepts and technologies which will enable AAM participants to operate in an efficient and safe manner, but also provide infrastructure and airspace authorities with enhanced situational awareness of the airspaces state and overall performance. The results of this work will assist in the adaptation of appropriate lower altitude airspace management and contingency actions to maintain the safety across the entire National Airspace System (NAS).

4 Provably Good Region Partitioning for On-time Last-mile Delivery

John Gunnar Carlsson[1], Sheng Liu[2], Nooshin Salari[3], Han Yu[1], [1]University of Southern California, Los Angeles, CA, [2]University of Toronto, Toronto, ON, Canada; [3]University of Toronto, Richmond Hill, ON, Canada. Contact: hyu376@usc.edu

On-time last-mile delivery is expanding rapidly as people expect faster delivery of goods. This paper studies the optimal region partitioning policy to minimize the expected delivery time in a stochastic and dynamic setting. This policy assigns every driver to a subregion, that drivers will be dispatched to their own territories. We characterize the structure of the optimal partitioning policy and show its expected on-time performance converges to the flexible dispatching policy in heavy traffic. We develop partitioning algorithms with performance guarantees. We demonstrate the efficiency of the region partitioning policy via numerical experiments using synthetic and real-world data sets.

5 Real-time Retiming for a Mixed Railway Line Via An Optimization-simulation Approach

Hugo Meunier[1,2], Sylvain Baro[1], Valéria Borodin[2], Stéphane Dauzère-Pérès[2], Juliette Pochet[1], [1]SNCF Réseau, Paris Cedex 06, France; [2]Ecole Des Mines de Saint-Etienne, Gardanne, France. Contact: h.meunier@emse.fr

Automated control systems, such as the Communication Based Train Control (CBTC) system, are deployed on dense suburban lines. CBTC trains follow a moving block principle, whereas non-CBTC trains respect a fixed block system. These two types of trains have different performances, and specific rules are applied when they are both operated on a line. Hence, modelling a mixed traffic is required to provide feasible retiming solutions. The timetable and the route of trains are modelled using a conjunctive graph, where blocking constraints for each type of trains model the operating rules. The approach is validated on the infrastructure of the E railway line in Paris, using a microscopic simulation engine.

6 Improving Train Routing Efficiency

Gunnar Feldmann, Peiheng Li, Clark Cheng, Norfolk Southern Corporation, Atlanta, GA

Train routing is at the heart of any operating plan. At Norfolk Southern (NS) it is usually developed by the Network Planning and Optimization group (NPO) either manually or utilizing some greedy algorithms due to its intrinsic complexity. The resulting plans are often not optimized. To fully tackle this routing problem, we have developed an efficient modeling and solution framework. With complete train options, it significantly improves train routing efficiency in terms of lower train starts and higher utilization rate. Instead of a single optimal train plan, it generates a set of plans in favor of different KPI's. Furthermore, it has zero dependencies and features a built-in parallel architecture.

7 A Max-min Fairness-based Multimodal Multicommodity Approach to Improve Supply Chain Performance

Osamah Moshebah, Andrés D. González, Samuel González, University of Oklahoma, Norman, OK

Disruptions in supply chains can cause considerable damage and loss. Given the supply chain's scale and complexity, it is vital to understand how disruption could impact the performance of supply chains. Also, itis critical to know how disruptions could affect different communities and economic sectors. We propose a mixed-integer linear programming model to enhance performance in multimodal-multicommodity supply chains by ensuring a max-min fair distribution while seeking a cost-effective distribution strategy. The results show that integrating fairness with a cost-efficient distribution strategy help maintain and recover supply chains' performance than only focusing on reducing costs.

8 Obnoxious Facility Location in Multiple Dimensional Space

Pawel J. Kalczynski[1], Atsuo Suzuki[2], Zvi Drezner[3], [1]California State University-Fullerton, Fullerton, CA, [2]Nanzan University, Nagoya, Japan; [3]California State University Fullerton, Fullerton, CA, Contact: pkalczynski@fullerton.edu

The obnoxious facility location problem in higher dimensions is optimally solved by a modification of the Big-Cube-Small-Cube global optimization method. This approach is suitable for problems of maximizing the minimum of many convex functions (or minimizing the maximum of concave functions) that are not necessarily differentiable. No specifically designed bounds are required. The general purpose bounds proposed in this paper do not employ derivatives of the functions.

9 An Optimization Framework for Assessing Sustainable Transport Network

Emanuele Besana[1], Sebastian Birolini[2], Mattia Cattaneo[3], Renato Redondi[1], [1]University of Bergamo, Bergamo, Italy; [2]University of Bergamo, Dalmine (BG), Italy; [3]University of Bergamo, Dalmine, Italy. Contact: emanuele.besana@unibg.it

The airline industry has been traditionally regarded as one of the major contributors to the environmental burden. Whilst electric aircrafts are expected to revolutionize short-medium haul routes in next decades, air transport operators have been recently struggling to promote potential network strategies to mitigate the environmental impact. The paper aims at proposing a multi-objective optimization model that can support central authorities to assess network structure, by encompassing economic and environmental targets, while ensuring an adequate level of service to passengers. A case-study for the global air transport network is presented to show the benefits of the proposed approach.

Monday, 2 PM–3:15 PM

MD10

CC - Room 110

Reinforcement Learning for Decision Making in Networks and Combinatorial Spaces

General Session

Session Chair

Haipeng Chen, 1</sup

1 Planning and Learning Policies for Independent but Budget-coupled Markov Decision Processes Using Reinforcement Learning

Jackson A. Killian, Harvard University, Cambridge, MA, Contact: jkillian@g.harvard.edu

Multi-action restless multi-armed bandits (RMABs) are a powerful framework for constrained resource allocation in which N independent Markov processes are managed; the shared resource constraint makes planning a combinatorial challenge. I will present two papers introducing algorithms for the online (dynamics unknown at start) and robust (uncertain dynamics) settings, both of which require new RL techniques for multi-action RMABs. First, we design two Q-learning based procedures which take a “charge-for-acting”-aware approach inspired by the problem’s Lagrangian relaxation which either provably (but slowly) or empirically (but quickly) converge to optimal policies. The second paper advances these ideas to a full deep RL learning framework using N “charge-for-acting”-aware arm networks and a new “⍰-network” which learns to manage budget allocations.

2 Bandit Data-driven Optimization for Crowdsourcing Food Rescue Platforms

Ryan Shi, Steven Wu, Rayid Ghani, Fei Fang, Carnegie Mellon University, Pittsburgh, PA, Contact: ryanshi@cmu.edu

Food rescue platforms match food donations to organizations that serve underprivileged communities, and then rely on volunteers to transport the food. Previous work has developed machine learning models for food rescue volunteer engagement. However, there are four main pain points that keep such a machine learning model from being actually useful in practice: small data, data collected only under the default intervention, unmodeled objectives due to communication gap, and unforeseen consequences of the intervention. We introduce bandit data-driven optimization, which combines the advantages of online bandit learning and offline predictive analytics in an integrated framework. We propose PROOF, a novel algorithm for this framework and formally prove that it has no-regret. PROOF performs better than existing baseline on food rescue volunteer recommendation.

3 A Deep Reinforcement Learning Framework for Column Generation

Amine M. Aboussalah, University of Toronto, Toronto, ON, Canada. Contact: amine.aboussalah@mail.utoronto.ca

We propose RLCG, the first Reinforcement Learning (RL) approach for Column Generation (CG). Unlike typical column selection rules which myopically select a column based on local information at each iteration, we treat CG as a sequential decision-making problem, as the column selected in an iteration affects subsequent iterations of the algorithm. This perspective lends itself to a Deep RL approach using Graph Neural Networks to represent the variable-constraint structure in the LP formulation. We perform an extensive set of experiments using the publicly available BPPLIB benchmark for the Cutting Stock Problem (CSP) and Solomon benchmark for the Vehicle Routing Problem with Time Windows (VRPTW). RLCG converges faster and reduces the number of CG iterations by 22.4% for CSP and 40.9% for VRPTW on average compared to a commonly used greedy policy.

Monday, 2 PM–3:15 PM

MD11

CC - Room 111

Learning Algorithms in Personalized Medicine

General Session

Session Chair

Talayeh Razzaghi, University of Oklahoma

1 EARLY DETECTIOn of PREECLAMPSIA USINg a SCALABLE DEEP NEURAL NETWORK ALGORITHM

Rachel Bennett, Talayeh Razzaghi, University of Oklahoma, Norman, OK, Contact: rachel.l.bennett-1@ou.edu

Preeclampsia (PE) is a hypertensive complication that develops around the 20th week of pregnancy in women. Several studies have developed predictive models for early detection of PE; however, most EHR datasets suffer from a high class imbalance when it comes to early detection of PE. This makes it difficult for traditional algorithms to learn from the data. On the other hand, deep learning has benefited from the spike in available data. However, deep learning becomes computationally expensive for too large or complex data. This talk attempts to deal with the vast amount of data with class imbalance by a scalable multilevel approach for deep learning. We will show the computational results of this approach for early PE detection.

2 Early Detection of Parkinson's Disease Using Questionnaire Data

Mohammad Derakhshi[1], Talayeh Razzaghi[2], Mohammad Javad Feizollahi[3], [1]University of Oklahoma, Norman, OK, [2]University of Oklahoma, School of Industrial and Systems Eng, Norman, OK, [3]Georgia State University, Atlanta, GA, Contact: deraxsi@ou.edu

Early detection of Parkinson's disease (PD) remains crucial for prescribing a successful personalized medicine for PD patients. However, as each PD patient may experience a unique set of symptoms, early diagnosis of PD still is a significant challenge. Nonetheless, questionnaire data appears to better expose this uniqueness in experiencing PD symptoms. A significant barrier in this regard is the lack of curated reliable-size datasets for the training purpose. To cope with this challenge, we propose a federated learning-based model that incorporates missing features to predict high-risk patients who are likely to develop PD.

3 Data-driven Sepsis Treatment Strategy Using Longitudinal Ehr Data

Akash Gupta[1], Senthil Nachimuthu[2], [1]California State University - Northridge, Northridge, CA, [2]University of Utah, Salt Lake City, UT

Sepsis is one of the leading causes of death in Intensive Care Units (ICU). The strategy for treating sepsis involves the infusion of intravenous (IV) fluids and administration of antibiotics. Because of the rapid change in patient's health, determining the optimal quantity of IV fluids is a challenging problem. In this study, we employ hidden Markov model to develop data-driven treatment strategies. The proposed prescriptive model first determines the best predictive model to estimate mortality probability. The selected model is then embedded in an optimization formulation to derive the optimal amount of IV fluid.

4 Covid-19 Propagation Modeling for Sub-populations

Charles D. Nicholson, University of Oklahoma, Norman, OK

Using unsupervised learning, distinct sub-populations across the United States have been identified -- each unique along a feature spectrum that affects COVID-19 propagation and disease outcomes. In this talk, the critical inherent county-level factors that influence disease propagation are detailed, the sub-populations are described, and the predictive modeling efforts that take these unique properties into account for enhanced forecasting and decision-making are discussed.

Monday, 2 PM–3:15 PM

MD12

CC - Room 113

Scenario-based Decision-making Under Uncertainty

General Session

Session Chair
Isabella Sanders, 1</sup

1 Instance Space Analysis and Instance Generation Implications for The Multidemand Multidimensional Knapsack Problem

Matthew Scherer, Air Force Institute of Technology, Dayton, OH, Contact: matthew.scherer@afit.edu

Effectiveness of solution procedures for optimization problems are rated through empirical testing of a variety of test instances. This work applies instance space analysis (ISA) towards the multidemand multidimensional knapsack problem (MDMKP) to examine the effect of instance configuration and solution procedure performance. From this viewpoint a new set of instances are explored with desirable, more robust characteristics to provide unique structure to the MDMKP. This research then examines how using these more robust instances impacts the solution effectiveness of selected algorithms.

2 Naval Defense Resource Allocation Problem Under Random Threats

Zeyu Wang, Miguel Lejeune, George Washington University, Washington, DC, Contact: zywang@gwu.edu

Anti-ship missiles have become major threats against the Navy due to the increasing role of information capability. Today's surface fleet must be capable to detect, track and engage adversaries' anti-ship missiles, and have the structural integrity to survive damage sustained in combat. We propose a stochastic programming model to allocate air defense resources to naval task groups. Our problem maximizes the protective coverage level of a task group while considering the impact of defense workload. We provide a reformulation framework and develop bounding strategies to obtain a mixed-integer linear programming problem. We analyze the performance of the proposed method and provide practical insights for the Navy.

3 Multi-fidelity Models Incorporating Vehicle and Communications Failure Rates to Design Maritime Environmental Survey Operations

Danielle Morey[1], Randall Plate[2], Cherry Yu Wakayama[3], Zelda B. Zabinsky[4], [1]University of Washington, Seattle, WA, [2]Naval Information Warfare Center Pacific, San Diego, CA, [3]Spawar, San Diego, CA, [4]University of Washington, Seattle, WA, Contact: dmorey43@uw.edu

In maritime environmental survey operations, a design challenge is to optimally configure unmanned underwater vehicles (UUVs) to transport data from sensor nodes to a centralized depot. Multiple low-fidelity analytic models target specific metrics of interest with sensitivity to UUV failure rates and provide intuition behind design characteristics. High-fidelity simulation models provide a detailed description of node/packet-level performance with failures. Both low- and high-fidelity models highlight the trade-off between a cluster being visited by multiple UUVs for increased reliability versus being visited by a single UUV to isolate the impact of UUV failure. This is beneficial for decision making and is adaptable for varying scenarios.

4 Forecasting Bankruptcy Within Department of Defense Suppliers Using Linear Discriminant Analysis

Isabella Sanders, United States Military Academy at West Point, West Point, NY

Annually, purchasing divisions within the Department of Defense (DoD) analyze their needs and decide whether to renew existing contracts or sign new contracts with government suppliers. Supplier financial stability is a concern when assessing such contracts for selection. This paper presents an accurate bankruptcy risk assessment model that examines financial stability. Though several bankruptcy models exist in literature, a standard model is not accepted across the DoD. In this work, we build two new samples of DoD bankrupt and nonbankrupt firms consisting of respective financial and accounting variables drawn from 10-K statements. We then train, validate, and test a novel linear discriminant model using a subset of such variables. We evaluate the new model's accuracy alongside popular bankruptcy models in literature for comparison. When using the DoD samples, this new model outperforms the models from literature and shows promise to make a significant impact on the DoD procurement process.

5 Maintenance Prediction Models for Military Helicopters

Ashley Ulricson[1], Jake Killian[2], Isabella Sanders[3], [1]USMA, Ashland, NH, [2]Harvard University, Cambridge, MA, [3]United States Military Academy at West Point, West Point, NY

Military vehicles undergo scheduled and unscheduled maintenance. For helicopters, scheduled maintenance is typically scheduled on a time determined basis, i.e. monthly or based on flight hours. However, this maintenance scheduling is typically suboptimal. We use sequential pattern mining in combination with multi-linear regression to help predict maintenance needs. Early results show improvements in helicopter downtime for maintenance work.

Monday, 2 PM–3:15 PM

MD13

CC - Room 114

Network Models in Optimization and Their Applications

Joint Session

Session Chair

Yajun Lu, Jacksonville State University, Jacksonville, AL

1 **A Decomposition Branch-and-cut Algorithm for The Maximum Cross-graph K-club Problem**

Hao Pan[1], Balabhaskar Balasundaram[2], Juan Sebastian Borrero[2], [1]US Xpress Inc, Duluth, GA, [2]Oklahoma State University, Stillwater, OK, Contact: hao.pan2016@gmail.com

The analysis of social and biological networks often involves modeling clusters of interest as cliques or their graph-theoretic generalizations. The k-club model, which relaxes the requirement of pairwise adjacency in a clique to length-bounded paths inside the cluster, has been used to model cohesive subgroups in social networks and functional modules/complexes in biological networks. However, if the graphs are time-varying, or if they change under different conditions, we may be interested in clusters that preserve their property over time or under changes in conditions. To model such clusters, we consider a cross-graph k-club model. In this paper, we consider the canonical optimization problem of finding a cross-graph k-club of maximum cardinality. We introduce algorithmic ideas to solve this problem and evaluate their performance on some benchmark instances.

2 **Accelerating The Calculation of Makespan Used in Scheduling Improvement Heuristics**

Golshan Madraki, Clarkson University, Potsdam, NY

Most scheduling heuristics iteratively perturb a trial schedule and recalculate the makespan in each iteration. We decrease the computation time of these scheduling heuristics by accelerating the calculation of makespan (longest path in the graph) in each iteration. Scheduling perturbations are represented by edge additions and deletions in the graph. The major contribution of this study is that our algorithm executes once to update the length of the longest path regardless of the number of added and deleted edges. Our experiments show that our algorithm is the best in all cases.

3 **On The Allocation of Non-scheduled Traffic in a Time-aware TSN Network**

Neil Diaz[1], Natarajan Gautam[2], [1]Texas A&M University, College Station, TX, [2]Syracuse University, Manlius, NY, Contact: nodiaz@tamu.edu

Time-sensitive Networking (TSN) is a set of protocols to ensure latency bounds and guarantees to in-sync traffic flows in Ethernet networks. However, randomly arriving, best-effort, or non-scheduled traffic still needs to be transported under this synchronized network, creating the challenge of finding network parameters. This study investigates how to allocate non-scheduled traffic in a time-aware TSN network, so that flows in this traffic experience minimal latency. To that end, we model the setting as a network of polling systems and develop a heuristic algorithm to solve the nested combinatorial problem arising from finding (1) the routes between the source and destination of each flow; (2) the order in which flows should be allocated; (3) the time slots where flows need to be at each node's output port. We present an extensive evaluation of the approach's performance.

Monday, 2 PM–3:15 PM

MD14

CC - Room 115

Smart Cities Flash Session

Flash Session

Session Chair

Jeroen Belien, KU Leuven, Brussel, Belgium.

1 **Empirical Analysis of Electric Vehicles' Charging Patterns: Case Study from Shanghai**

Zhi Li[1], Zhengtian Xu[2], Zhibin Chen[1], [1]NYU Shanghai, Shanghai, China; [2]The George Washington University, Washington, DC, Contact: zhengtian@gwu.edu

Numerous policies have been launched across countries and regions to address the potential impediments to EV adoption surrounding the high purchase price, restricted driving range, insufficient charging infrastructure, among others. Many policies such as subsidy programs, while being effective in stimulating EV adoption initially, have seen declining effects. To facilitate the design of more targeted EV policies, it is critical to understand how potential EV users will use and charge their vehicles. Based on a representative data set from active EVs in Shanghai, this study conducts an empirical analysis to reveal users' charging patterns and shed light on the potential policy implications.

2 **Modeling and Control of Mixed Autonomy Traffic Flow**

Mingfeng Shang, University of Minnesota, MN

The emergence of vehicle automation may potentially transform the landscape of transportation systems. Such automation ranges from SAE Level 1, e.g., partially automated vehicles (AVs) with adaptive cruise control (ACC), to SAE Level 5, e.g., fully automated vehicles without human intervention. While many benefits have been shown in fully automated traffic flow, it remains unclear how mixed autonomy will influence traffic characteristics. This work develops high-fidelity models for mixed autonomy traffic and investigates how AVs will impact human-piloted traffic flow. Some recent modeling and simulation work are conducted to understand how AVs may be able to influence traffic flow.

3 Electric Vehicle Charging Scheduling in Multi-unit Dwellings: Modeling and Numerical Experiments

Ruolin Zhang[1], Eleftheria Kontou[2], Horesh Noah[3], Yan Zhou[3], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University of Illinois at Urbana-Champaign, Urbana, IL, [3]Argonne National Laboratory, Lemont, IL, Contact: ruolin3@illinois.edu

Residents of multi-unit dwellings (MUDs) are more likely to have limited access to residential charging, resulting in higher charging costs and reduced flexibility. We formulate the charging session scheduling problem as Job Shop Scheduling Problem (JSP) and propose an efficient heuristic solution algorithm based on dispatching rules to optimize charging session scheduling in MUDs. We apply our model in three numerical experiments in Chicago, New York City, and Los Angeles, with different MUDs' characterizations. We obtain the scheduling results and compare them with an unmanaged charging scheme to showcase our algorithm's advantages in terms of solution quality.

4 Understanding Charging Dynamics of Fully-electrified Taxi Services Using Large-scale Trajectory Data

Tian Lei[1], Shuocheng Guo[2], Xinwu Qian[3], Lei Gong[4], [1]Shenzhen Technology University, Shenzhen, China; [2]The University of Alabama, Tuscaloosa, AL, [3]The University of Alabama, Tuscaloosa, AL, [4]Shenzhen Technology University, Shenzhen, China. Contact: sguo18@crimson.ua.edu

An accurate understanding of "when, where and why" of charging activities is crucial for the optimal planning and operation of E-shared mobility services. In this study, we leverage a unique trajectory of a city-wide electric taxi (ET) fleet of over 20,000 in Shenzhen, China, which is one of the first studies to investigate charging behavioral dynamics of a fully electrified shared mobility system from both system and individual levels. We reveal remarkable regularities in infrastructure utilization, temporal and spatial charging dynamics as well as individual driver level charging preferences. The results will deliver important justifications for further studies on the modeling of ET system.

5 Empirical Study on Response Delay of Production Automated Vehicles

Xiaopeng Li[1], Xiaowei Shi[2], [12]University of Michigan, Ann Arbor, MI

6 On The Potential of Smart Materials Collection Using Internet of Things in Closed-loop Supply Chains

Jeroen Belien[1], Simon De Jaeger[1], Philippe De Bruecker[2], Liesje De Boeck[3], [1]KU Leuven, Brussel, Belgium; [2]Odisee, Brussel, Belgium; [3]KU Leuven, Brussels, Belgium. Contact: jeroen.belien@kuleuven.be

The introduction of sensor technologies and the Internet of Things (IoT) has opened the door to transform traditional, static waste collection into 'smart' or 'dynamic' waste collection. The sensors provide real-time information about the fill levels of containers which enable collection vehicles to adapt their routes dynamically as a function of these fill levels. By means of an extensive, empirical study involving six months data of all glass containers emptied in Belgian's main regions, Flanders and Wallonia, this paper quantifies the benefits of smart collection, as opposed to static collection.

Monday, 2 PM–3:15 PM

MD15

CC - Room 120

Medical Decision Making

General Session

Session Chair

Narges Mohammadi, 1</sup

1 The Impact of Introducing Release Times for Operating Rooms on Surgery Waiting Times

Guang Cheng[1], Mitchell H. Tsai[2], Joel Goh[3], [1]National University of Singapore, Singapore, Singapore; [2]University of Vermont Medical Center, South Burlington, VT, [3]NUS Business School, Singapore, Singapore. Contact: gcheng@u.nus.edu

Release policy for operating room allocation has been shown that is inefficient in improving operating room utilization. However, its impact on surgery waiting time is understudied. This study aims to evaluate the impact of the 7-day release policy on surgery waiting times. Our data contained surgery records from May 1, 2018, to November 08, 2019 in University of Vermont Medical Center. We showed that the 7-day release policy can significantly reduce surgery waiting time. Although previous studies have demonstrated that release time policies could not improve operating room utilization, they can reduce surgery waiting time, which is an important indicator of patient access to surgical services.

2 A Defender-Attacker-Defender Approach to Two-stage Robust Optimization in Kidney Exchange with Heterogeneous Uncertainty

Carolina Riascos, Merve Bodur, Dionne Aleman, University of Toronto, Toronto, ON, Canada. Contact: carolina.riascos@mail.utoronto.ca

Two-stage robust optimization models for the kidney exchange problem follow the structure of a defender-attacker-defender game model to re-arrange transplants when the ones selected in the first stage end up cancelled due to medical and non-medical reasons. In the second stage, a candidate solution from the first stage is recovered according to several recourse policies. Unlike previous works in the literature, our uncertainty set considers that vertices and arcs fail following both a homogeneous and heterogeneous probability. We propose a reformulation of the attacker's problem as a feasibility-seeking problem, which allows our approach to optimally solve more instances with long cycles and long chains than current state-of-the-art approaches, particularly for the full-recourse policy, when tested on publicly available instances.

3 Improving Access to Care, and Patient and Provider Outcomes: The Efficacy of Telemedicine Adoption

Jane Iversen[1], Aravind Chandrasekaran[2], [1]The Ohio State University, Columbus, OH, [2]The Ohio State University, Columbus, OH, Contact: iversen.15@buckeyemail.osu.edu

The Covid-19 pandemic has accelerated the adoption of telemedicine by providers and their patients, but its efficacy is still unknown. This research, therefore, investigates the efficacy of telemedicine adoption and practices on improving access to care, patients' experiential quality and health outcomes as well as provider burnout outcomes, before and during the COVID-19 pandemic.

4 Optimal Hearing Loss Screening for Patients with Cystic Fibrosis Disease

Narges Mohammadi, Mohammadreza Skandari, Imperial College Business School, London, United Kingdom. Contact: n.mohammadi19@imperial.ac.uk

Patients with cystic fibrosis disease experience frequent pulmonary exacerbation and require antibacterial treatments. Intravenous aminoglycosides are the primary choice but they cause hearing loss. To detect possible hearing loss, there are several hearing assessment methods available. In this research, we propose evidence-based optimal hearing loss screening strategies to detect the hearing loss of CF patients and improve their health status. To this end, we build a partially observable Markov decision process (POMDP) model to find policies that optimize the net monetary benefit (NMB) of hearing screening for a pediatric CF population. Moreover, we develop a novel algorithm to generate all possible optimal policies lying on the cost-effectiveness frontier for all willingness to pay (WTP) values in the finite number of iterations.

Monday, 2 PM–3:15 PM

MD16

CC - Room 121

Assessing the Effectiveness of COVID-19 Mitigation Strategies Using Simulation Modeling

General Session

Session Chair

Sait Tunc, Virginia Tech, Blacksburg, VA

Session Chair

Marie Jeanne Rabil, Blacksburg, VA

1 Measuring The Impact of Schools' Interventions Measurements on Covid-19 Spread in The Us: A Decision Support Tool

Dima Nazzal[1], Pinar Keskinocak[2], Akane Fujimoto Wakabayashi[3], Sara Alnasser[1], Colin Diggs[1], Zhang Peibo[1], Mohammad Alit[1], Haocheng Yin[1], Wanmeng Liu[1], Nicoleta Serban[2], [1]Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, [3]ISyE/Georgia Tech, Atlanta, GA

We present an extended susceptible-infectious-recovered (SIR) model to simulate COVID-19 spread in a K-12 school setting. The model projects infections based on different levels of intervention (masking, vaccination, and surveillance testing). Sensitivity analysis is conducted to test the robustness of the simulation model. The model is embedded into a decision-support tool, which takes as input school-specific information and displays the corresponding case projections under three mitigation scenarios.

2 Periodic Vaccination Against COVID-19

Jade Xiao[1], Turgay Ayer[1], Jagpreet Chhatwal[2,3], [1]Georgia Institute of Technology, Atlanta, GA, [2]Harvard Medical School, Boston, MA, [3]MGH Institute for Technology Assessment, Boston, MA, Contact: jadexiao@gatech.edu
Waning immunity to SARS-CoV-2 and the inevitability of viral mutations will necessitate a large-scale periodic booster vaccination program. Fast-paced, high-volume vaccination may quickly extinguish an epidemic, but it may have an unintended downstream effect of creating a surge in population susceptibility later when vaccinated people lose their immunity all at the same time. We conducted a simulation study to show how staggering vaccinations over time maintains population susceptibility and therefore incident deaths at a constant, manageable level; whereas rapidly vaccinating a large portion of the population in a single pulse leads to large recurrent epidemics between booster rounds.

3 Screening for Safe Opening of Universities Under Omicron and Delta Variants of Covid-19: When Less is More

Marie Jeanne Rabil[1], Sait Tunc[2], Douglas R. Bish[3], Ebru Korular Bish[3], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Blacksburg, VA, [3]University of Alabama, Tuscaloosa, AL
As new COVID-19 variants emerge, and disease and population characteristics change, screening strategies may need to evolve. We develop screening strategies for the safe operation of college campuses, which can be customized based on population demographics and vaccination status. Our model considers co-circulating variants with different disease dynamics, and variant- and dose-dependent vaccine efficacy, and provides multidimensional metrics on infections/hospitalizations/deaths; peak daily hospitalizations; and the tests required. Using the Spring 2022 academic semester as a case study, we provide key guidelines on effective and efficient routine screening strategies.

4 One Year of Modeling Covid-19 Transmission to Support Policymakers in Connecticut

Olga Morozova[1], Zehang Richard Li[2], Forrest W. Crawford[3], [1]The University of Chicago, Chicago, IL, [2]University of California, Santa Cruz, Santa Cruz, CA, [3]Yale University, New Haven, CT, Contact: olga.morozova@aya.yale.edu
To support policymakers in Connecticut, we developed a flexible compartmental SEIR‐type model of SARS‐CoV‐2 transmission and COVID‐19 disease progression. Our goals were to provide projections of infections, hospitalizations, and deaths, and estimates of important features of disease transmission and clinical progression. The approach takes advantage of our unique access to Connecticut public health surveillance and hospital data. We calibrated the model to data on deaths and hospitalizations and developed a novel measure of close interpersonal contact to capture changes in transmission risk over time and used multiple local data sources to infer dynamics of time‐varying model inputs. The model was used to meet the changing requirements of policymakers and officials in Connecticut from March 2020 to February 2021.

Monday, 2 PM–3:15 PM

MD17

CC - Room 122
Modeling and Optimization in Healthcare II
Contributed Session

Session Chair
Quinlan Buchlak, Monash Health, Clayton, Australia.

1 Systematic Literature Review of Opioid Epidemic Disease Models

Chelsea Spence[1], Mary Beth Kurz[2], Thomas Sharkey[2], Bryan Miller[2], Corey Kalbaugh[2], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, Contact: cspenc2@g.clemson.edu
In 2020, 64,183 people died due to opioid overdoses in the United States. Disease models can be used to track the spread of opioid use and abuse as well as determine the effectiveness of interventions. This systematic literature review considers disease models of the opioid overdose epidemic. The goals of the literature review are to identify which opioids are modeled, what types of modeling techniques are applied, how models are validated, and what data sources are used.

2 Not Just for Snacks: Designing and Evaluating Vending Machines as a Harm Reduction Strategy for Substance use and Addiction

Reyhaneh Zafarnejad, Paul M. Griffin, Pennsylvania State University, State College, PA, Contact: rzz5164@psu.edu
Harm reduction is an evidence-based approach that has been widely adopted for lowering the adverse consequences of substance use disorder in Europe and Canada. Although not universally accepted in the US, it has the potential to decrease the burden from substance-related overdose and HCV and HIV cases and can help overcome traditional barriers associated with addressing disease of despair-related harm. We develop a multi-level, coupled agent-based

optimization framework for the location and allocation management of smart vending machines as destigmatized venues to engage with hard-to-reach, underserved populations, customized to the specific needs of the community, and estimate the resulting impact based on a pilot program in Pennsylvania.

3 Predictors of Quality of Life Improvement at 12-month Follow-up in Anterior Endoscopic Skull Base Surgery

Quinlan D. Buchlak[1], Nazanin Esmaili[2], Christine Bennett[3], Yi Yuen Wang[4], James King[5], Tony Goldschlager[1], [1]Monash Health, Melbourne, Australia; [2]University of Notre Dame Australia, Sydney, Australia; [3]University of Notre Dame Australia, Sydney, Australia; [4]St Vincent's Hospital, Melbourne, Australia; [5]Royal Melbourne Hospital, Melbourne, Australia.

Patients with pituitary lesions experience quality of life (QoL) decrements. We aimed to detect associations with QoL and train supervised classifiers to predict QoL at 12 months (N=451). High preoperative QoL was associated with institution, diabetes and lesions at the planum sphenoidale / tuberculum sella site. Low preoperative QoL was associated with gender, vision-related presentation, diabetes, secreting adenoma and the cavernous sinus site. Top quartile change in postoperative QoL at 12-month follow-up was negatively associated with hypercholesterolaemia, acromegaly and intraoperative CSF leak. Positive associations were detected for lesions at the sphenoid sinus site and deficient endocrine function. Classifiers performed well. It was possible to predict change in QoL using perioperative data.

Monday, 2 PM–3:15 PM

MD18

CC - Room 123

Pierskalla Award Session

Award Session

Session Chair

Andrew A. Li, CMU Tepper, Pittsburgh, PA

Session Chair

Kyra Gan, Carnegie Mellon University, Pittsburgh, PA

1 An Instrumental Variable Forest Approach for Detecting Heterogeneous Treatment Effects in Observational Studies

Guihua Wang[1], Jun Li[2], Wallace Hopp[2], [1]The University of Texas at Dallas, Richardson, TX, [2]University of Michigan - Ann Arbor, Ann Arbor, MI

This study addresses the ubiquitous challenge of using big observational data to identify heterogeneous treatment effects. This problem arises in precision medicine, targeted marketing, personalized education, and many other environments. Identifying heterogeneous treatment effects presents several analytical challenges including high dimensionality and endogeneity issues. We develop a new instrumental variable tree (IVT) approach that incorporates the instrumental variable method into a causal tree (CT) to correct for potential endogeneity biases that may exist in observational data. Our IVT approach partitions subjects into subgroups with similar treatment effects within subgroups and different treatment effects across subgroups. The estimated treatment effects are asymptotically consistent under a set of mild assumptions. Using simulated data, we show our approach has a better coverage rate and smaller mean-squared error than the conventional CT approach. We also demonstrate that an instrumental variable forest (IVF) constructed using IVTs has better accuracy and stratification than a generalized random forest. Finally, by applying the IVF approach to an empirical assessment of laparoscopic colectomy, we demonstrate the importance of accounting for endogeneity to make accurate comparisons of the heterogeneous effects of the treatment (teaching hospitals) and control (nonteaching hospitals) on different types of patients.

2 An Optimization Framework for Customized Targeted Mass Screening of Non-uniform Populations under the Availability of Multiple Schemes and Tests

Jiayi Lin[1], Hrayer Aprahamian[1], George Golovko[2], [1]Texas A&M University, College Station, TX, [2]The University of Texas Medical Branch, Galveston, TX

We study the problem of designing optimal targeted mass screening of non-uniform populations. Mass screening is an essential tool that is widely utilized in a variety of settings, e.g., preventing infertility through screening programs for sexually transmitted diseases, ensuring a safe blood supply for transfusion, and mitigating the transmission of infectious diseases. The objective of mass screening is to maximize the overall classification accuracy under limited budget. In this paper, we address this problem by proposing a proactive optimization-based framework that factors in population heterogeneity, limited budget, different testing schemes, the availability of multiple assays, and imperfect assays. By analyzing the resulting optimization problem, which is a mixed integer nonlinear programming problem, we establish key structural properties which enable us to develop an efficient solution scheme. To achieve this, we take advantage of a reformulation of the problem as a multi-dimensional fractional knapsack problem and identify an efficient globally convergent threshold-style solution scheme that fully characterizes an optimal solution across the entire budget spectrum. Using real-world data, we conduct a geographic-based nationwide case study on targeted COVID-19 screening in the United States. Our results reveal that the identified screening strategies substantially outperform conventional practices by significantly lowering misclassifications while utilizing the same amount of budget. Moreover, our results provide valuable managerial insights with regards to the distribution of testing schemes, assays, and budget across different geographic regions.

3 Drone Network Design for Cardiac Arrest Response

Justin J. Boutilier[1], Timothy C. Y. Chan[2], [1]University of Wisconsin - Madison, Madison, WI, [2]University of Toronto, Toronto, ON, Canada.

Cardiac arrest claims more than 400,000 lives each year in North America and drone-delivered automated external defibrillators have the potential to be a transformative innovation in the provision of emergency care for cardiac arrest. This paper provides a realistic framework that can be leveraged by system designers and/or EMS personnel seeking to investigate design questions associated with a drone network. Using real data from an area covering 26,000 square kilometers around Toronto, Canada, we find that an objective function focused on improving the tail of the response-time distribution is well-suited for use in practice because the model provides equitable solutions that reduce the entire response-time distribution and corresponds to the real-world metrics, on which EMS systems are most commonly evaluated. We estimate that the response-time reductions achieved by the drone network are associated with up to a 76% higher survival rate and 144 additional lives saved each year.

4 Identifying the Bottleneck Unit: Impact of Congestion Spillover in Hospital Inpatient Unit Network

Song-Hee Kim[1], Fanyin Zheng[2], Joan Brown[3], [1]Seoul National University, Gwanak-gu, Korea, Republic of; [2]Columbia University, New York, NY, [3]Keck Medicine of USC, Los Angeles, CA

We use 5-year data from a hospital with 16 inpatient units to empirically examine whether and how much congestion propagates through the network of inpatient units. We find that the magnitude of the congestion spillover is substantial in our study hospital. We then use counterfactual analyses to empirically identify the bottleneck unit---the unit that has the biggest impact on system performance when an intervention is applied to increase its capacity.

Monday, 2 PM–3:15 PM

MD19

CC - Room 124
Operating Room Scheduling
Contributed Session

Session Chair
Jaeyoung Kim, Clemson University, Clemson, SC

1 A Linear Program (lp) Model for Elective Surgery Scheduling: A Case Study in An Italian Hospital

Reinaldo Crispiniano Garcia[1], Rafael Leite Patrão[2], João Mello da Silva[3], [1]Universidade de Brasilia (UnB) - www.orlab.com.br, Brasilia, Brazil; [2]KU Leuven, Leuven, Belgium; [3]Universidade de Brasilia (UnB), Brasilia, Brazil. Contact: rcgar@yahoo.com

The urban population is increasing worldwide. This demographic shift generates great pressure over public services, specially the health-care ones. A very expensive health care service is the surgery one being then required to improve the efficiency of the surgical centers. This work proposes an integer linear programming model (ILP) considering the case-mix planning (CMP) and the master surgical scheduling (MSS) problems. The developed model uses a data set from a hospital of the city of Turin, Italy. The results are very promising showing a reduction from 240 weeks to 144 weeks to empty the surgical waiting list (WL). Moreover, if changes to the hospital actual situation is implemented including the introduction of two new surgical teams into one of the hospital's specialties, the time to empty the surgical WL can decrease to 79 weeks.

2 Data-driven Robust Scheduling of Elective Patients

Nan Yang, Jingui Xie, Technical University of Munich, Heilbronn, Germany. Contact: nanyangemail@gmail.com

Hospital beds are important medical resources, and the scheduling of elective admissions by enforcing quotas could help to avoid bed shortages. However, the scheduling of elective admissions faces challenges mainly due to the uncertainty in the emergency admissions and the long stays. In this paper, we propose a robust satisficing model to determine the quotas of elective admissions, which would best attain an acceptable admission target under extreme uncertainties. We solve the robust satisficing model by reformulating it to an equivalent mixed integer programming (MIP) problem. We do simulation tests for the proposed robust satisficing model as well as the existing robust optimization model based on the MIMIC-IV dataset.

3 Reducing or Time Mismatches Using Data-Driven Operations Scheduling

Jaeyoung Kim[1], Ahmet Colak[2], Lawrence Fredendall[2], Robert Allen[2], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, Contact: jaeyouk@clemson.edu

Operating room (OR) time allocations play a central role in increasing surgical care productivity. In this paper, we collaborate with a leading South Carolina hospital to study the drivers and impact of OR time allocation mismatches between scheduled and realized surgery times. Our empirical findings indicate that using granular data inputs from a hospital's electronic health record system can improve the OR time predictions and reduce scheduling mismatches significantly. Also, we apply the operations management newsvendor model to find the optimal safety capacity OR time. We find that using both our prediction models and the newsvendor model can significantly reduce the total OR cost. Our findings present novel empirical insights for OR practitioners and researchers in reducing scheduling mismatches and improving OR time reservation decision-making.

Monday, 2 PM–3:15 PM

MD20

CC - Room 125

Collective Decision Making

General Session

Session Chair

Rupert Freeman, University of Virginia, Charlottesville, VA

1 Generalizing The Robust Bayesian Truth Serum

Jens Witkowski[1], David C. Parkes[2], [1]Frankfurt School of Finance & Management gGmbH, Frankfurt Am Main, Germany; [2]Harvard University, Boston, MA, Contact: j.witkowski@fs.de

The Bayesian Truth Serum (BTS) truthfully elicits private signals with regard to an unknown world state when this ground truth is unobservable. However, it is difficult to explain to respondents and ensures proper incentives only as the number of respondents n goes to infinity. The Robust Bayesian Truth Serum (RBTS) provides proper incentives for any $n \geq 3$ but is restricted to binary signals. We present an elicitation mechanism that generalizes RBTS to an arbitrary number of signals and any $n \geq 2$. Moreover, this new mechanism has a simpler, more intuitive form than both BTS and RBTS and is thus easier to explain to respondents.

2 Fair and Efficient Allocations Without Obvious Manipulations

Alexandros Psomas, Purdue University, West Lafayette, IN, Contact: apsomas@cs.purdue.edu

We consider the fundamental problem of allocating a set of indivisible goods among strategic agents with additive valuation functions. It is well known that, in the absence of monetary transfers, Pareto efficient and truthful rules are dictatorial, while there is no deterministic truthful mechanism that allocates all items and achieves envy-freeness up to one item (EF1), even for the case of two agents. In this paper, we investigate the interplay of fairness and efficiency under a relaxation of truthfulness called non-obvious manipulability (NOM), recently proposed by~\citet{troyan2020obvious}. We show that this relaxation allows us to bypass the aforementioned negative results in a very strong sense. Specifically, we prove that there are deterministic and EF1 algorithms that are not obviously manipulable, and the algorithm that maximizes utilitarian social welfare (the sum of agents' utilities), which is Pareto efficient but not dictatorial, is not obviously manipulable for $n \geq 3$ agents (but obviously manipulable for $n=2$ agents). At the same time, maximizing the egalitarian social welfare (the minimum of agents' utilities) or the Nash social welfare (the product of agents' utilities) is obviously manipulable for any number of agents and items. Our main result is an approximation preserving black-box reduction from the problem of designing EF1 and NOM mechanisms to the problem of designing EF1 algorithms. En route, we prove an interesting structural result about EF1 allocations, as well as new ``best-of-both-worlds'' results (for the problem without incentives), that might be of independent interest.

3 Representational Robustness in Participatory Budgeting

Lodewijk L. Gelauff, Stanford University, Stanford, CA, Contact: lodewijk@stanford.edu

It is often desirable to ensure that the outcome of a decision making process such as participatory budgeting is a representation of the whole population. This talk will discuss recruiting a demographically diverse cohort through allocation of advertising resources under diversity constraints implemented by either advertisers themselves (highly targeted campaigns) or the auctioneer (welfarist allocation with negative externalities). Opinion diversity may not always be captured effectively through demographic information and we will discuss how opinion clusters in complex high-dimensional processes can be used to improve opinion representation. This is based on joint work with Ashish Goel, Aleksandra Korolova, Kamesh Munagala, Zeyu Shen and Sravya Yandamuri.

4 Efficient Crowdsourcing Via Multimodal Elicitation

Yeawon Yoo[1], Joshua Grassel[2], Adolfo Raphael Escobedo[2], [1]Johns Hopkins University, Ellicott City, MD, [2]Arizona State University, Tempe, AZ

In various areas of group decision-making and crowdsourcing, independent human judgments are gathered and then aggregated with the goal of obtaining a wiser collective judgment. It is well known that the choice of input elicitation and the aggregation method employed can significantly affect the quality of the collective judgment. This study conducts a crowdsourcing experiment where participants are asked to estimate the number of dots within a set of images using both ordinal (ranking) or cardinal (rating) estimates. It compares a series of optimization-based aggregation models and traditional voting rule-based methods and shows that improved ordinal and cardinal estimations are obtained when the inputs are aggregated via multimodal aggregation methods. Moreover, this work provides empirical evidence of the efficiency of multimodal aggregation.

5 Simple Algorithms for Strong Fairness/efficiency Guarantees

Yair Zick, University of Massachusetts

We present recent results on simple algorithms for the fair allocation of indivisible resources. We advocate for the use of simple algorithmic techniques - i.e. ones that are easy to implement and understand by non-expert stakeholders - in real-world applications.We focus on two high-impact application domains: assigning course seats to university students, and assigning academic reviewers to papers in large CS conferences.The mechanisms we propose are rather intuitive, but through either combinatorial preprocessing, or careful analysis, we show that they are able to provide strong fairness guarantees, as well as high social welfare.Based on joint works with Nawal Benabbou, Mithun Chakraborty, Ayumi Igarashi, Justin Payan and Vignesh Viswanathan

Monday, 2 PM–3:15 PM

MD21

CC - Room 126

Case Studies in Decision Analysis for Natural Resources Conservation and Management

General Session

Session Chair

Kelly Robinson, US Geological Survey, East Lansing, MI

1 Structured Decision Making to Prioritize Regional Bird Monitoring Needs

Auriel M. V. Fournier[1], James E. Lyons[2], R. Randy Wilson[3], Jeffrey S. Gleason[4], Evan M. Adams[5], Janell M. Brush[6], Robert J. Cooper[7], Stephen J. DeMaso[8], Melanie J. L. Driscoll[9], Peter C. Frederick[10], Patrick G. R. Jodice[11], Mary Ann Ottinger[12], David Reeves[13], Michael A. Seymour[14], Stephanie M. Sharuga[15], John M. Tirpak[16], William G. Vermillion[8], Theodore J. Zenzal[17], Mark S. Woodrey[18], [1]Illinois Natural History Survey, Havana, IL, [2]USGS, Laurel, MD, [3]US Fish and Wildlife Service, Jackson, MS, [4]US Fish and Wildlife Service, Chiefland, FL, [5]Biodiversity Research Institute, Portland, ME, [6]Florida Fish and Wildlife Conservation Commission, Gainesville, FL, [7]University of Georgia, Athens, GA, [8]Gulf Coast Joint Venture, Lafayette, LA, [9]Phoenix Rising LLC, Baton Rouge, LA, [10]University of Florida, Gainesville, FL, [11]USGS South Carolina Cooperative Fish and Wildlife Research Unit, Clemson, SC, [12]University of Houston, Denver, CO, [13]National Fish and Wildlife Foundation, Baton Rouge, LA, [14]Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA, [15]Bureau of Ocean Energy Management, Sterling, VA, [16]US Fish and Wildlife Service, Lafayette, LA, [17]USGS, Lafayette, LA, [18]Mississippi State University, Biloxi, MS, Contact: auriel@illinois.edu

Conservation planning for large ecosystems has multiple benefits but is often challenging to implement because of the multiple jurisdictions, species, and habitats involved. Herein, we show how the Gulf of Mexico Avian Monitoring Network members used structured decision-making to identify bird monitoring priorities. We used multiple tools and techniques to clearly define the problem and stakeholder objectives, and to identify bird monitoring priorities at the scale of the entire northern Gulf of Mexico region. While our example is specific to the northern Gulf of Mexico, this approach provides an example of how stakeholder values can be incorporated into the coordination process of broad-scale monitoring programs to address management, restoration, and scientific questions in other ecosystems and for other taxa.

2 Using Decision Analysis to Address Challenges in Management of White-nose Syndrome in Bats

Vratika Chaudhary, USGS Eastern Ecological Science Center, Turner Falls, MA, Contact: chaudhary.vratika@gmail.com

Global biodiversity declines are accelerating, in part due to the emergence and spread of infectious disease. Managing introduction, establishment, transmission, and effects of disease is challenging due to uncertainty in its epidemiology, severity of impact in host populations, and the efficacy of potential management actions. In addition to having to make decisions under severe uncertainty, natural resource managers often have other constraints and trade-offs to consider while making management decisions for EIDs. In wildlife disease problems, jurisdiction is often fragmented and multiple agencies must collaborate to identify management solutions. A formal decision analysis process can be utilized to address multi-party, multi-objective challenges that an EID poses. We demonstrate use of Structured Decision Making for White-nose syndrome (WNS) in bats.

3 Decision Analysis of Barrier Placement and Targeted Removal to Control Invasive Carp in the Tennessee River Basin

Max Post van der Burg[1], Aaron Cupp[2], David R. Smith[3], Mark Rogers[4], Duane Chapman[5], [1]USGS, Jamestown, ND, [2]USGS, Lacrosse, WI, [3]USGS, Kearneysville, WV, [4]USGS, Cookeville, TN, [5]USGS, Columbia, MO, Contact: maxpostvanderburg@usgs.gov

Controlling range expansion of invasive carp on the Tennessee River is important to conserve the ecological and economic benefits provided by the river. We collaborated with State and Federal agencies to develop a decision framework and decision support model to evaluate strategies to control carp expansion in the Tennessee River. We assessed the efficacy of various barrier strategies on reducing bigheaded carp relative abundance under different patterns and magnitudes of population growth and movement. We codeveloped a carp population dynamics model with the stakeholder group to compare invasive carp management options. The results of our analyses indicated that protecting reservoirs just above the leading edge of carp invasion and removing fish below that point performed best; but performance was sensitive to uncertainty about barrier effectiveness.

4 Using Structured Decision Making to Frame Collaborative Zoonotic Disease Management Problems

Jonathan D. Cook[1], Evan H. C. Grant[2], Michael C. Runge[1], [1]USGS Eastern Ecological Science Center, Laurel, MD, [2]USGS Eastern Ecological Science Center, Turners Falls, MA, Contact: jcook@usgs.gov

Zoonotic disease management is complex and must consider multiple objectives, uncertainty, and disjunct authorities. As an example, the virus that causes COVID-19 has recently been detected in animals, and therefore will require multiple agencies to work collaboratively to reduce spread, the evolution of new variants, and impacts to human, wildlife, and agricultural health. We discuss how structured decision making (SDM) and rapid risk assessment helped navigate this decision problem, including developing a shared understanding of the causal chain that can promote disease transmission. We then used this framework to guide a rapid risk assessment and evaluate opportunities for intervention. We recommend a broader perspective on collaborative decision making for zoonotic diseases, finding that a decision analysis improves transparency and collaboration.

Monday, 2 PM–3:15 PM

MD22

CC - Room 127
Humanitarian and Non-profit Operations
General Session

Session Chair
Shikha Safaya, Scheller College of Business Georgia Institute of Technology, Atlanta, GA

1 A Time-space Network Approach for The Foster Care Visitation Scheduling Problem

Shima Azizi[1], Caroline Johnston[2], Erhun Kundakcioglu[3], Andrew C. Trapp[4], [1]St. John's University, Queens, NY, [2]University of Southern California, Los Angeles, CA, [3]Ozyegin University, Istanbul, Turkey; [4]Worcester Polytechnic Institute, Worcester, MA, Contact: azizis@stjohns.edu

Agencies charged with ensuring foster children regularly visit biological parents can be challenging to accommodate given fixed workforce levels and fluctuating caseloads. We introduce the Foster Care Visitation Scheduling Problem to assign, schedule, and route workers to foster children. We develop a two-phased network-based optimization approach, that 1) preprocesses and pre-computes a time-space network structure, and 2) solves a large-scale integer optimization problem over this network. Our approach improves the consistency of visits and quality of life for foster children, while assisting foster care organizations to better operationalize their resources. We discuss computational experiments on a variety of instances inspired by real data from New York State that reveal encouraging computational performance.

2 A Guide to Formulating Ethics and Fairness in Optimization Models

John Hooker, Violet (Xinying) Chen, Carnegie Mellon University, Pittsburgh, PA, Contact: jh38@andrew.cmu.edu

This talk is a brief guide to formulating equity or fairness in an optimization model. It covers inequality metrics, Rawlsian maximin and leximax fairness, convex combinations of equity and efficiency, alpha fairness and the Nash bargaining solution, the Kalai-Smorodinsky bargaining solution, threshold functions combining efficiency and Rawlsian criteria, and bias metrics used in artificial intelligence. The talk cites a review paper and several online tutorials that cover these topics in greater depth.

3 Community Health Assistant Medication Disbursement in Liberia

Robert Montgomery[1], Baris Ata[2], [1]University of Chicago, Chicago, IL, [2]University of Chicago, Chicago, IL, Contact: rmontgo0@chicagobooth.edu

This paper studies the allocation of iCCM medications between central locations and satellite care providers, known in this setting as Community Health Assistants (CHAs). The model we develop attempts to minimize system costs by optimally positioning treatments at the locations where the patients seek care. Assuming patient demand for care services is normally distributed, we model the inventory levels at all points of care (CHAs and Health Facilities) as two-stage flow systems with medications representing the inputs to the system and demand for these medications as potential outputs.

4 Matching Volunteers to Clients in a Non-profit Organization

Shikha Safaya, Basak Kalkanci, Ravi Subramanian, Georgia Institute of Technology, Atlanta, GA, Contact: ssafaya3@gatech.edu

Non-Profit organizations are often challenged with volunteer retention in the absence of monetary incentives. We consider two distinct policies: incorporating volunteer preferences during task assignment, and pooling all volunteers - irrespective of their preferences - to alleviate supply uncertainty. In doing so, we endogenize the volunteers' decisions to participate in the volunteering activities based on their expectations of the utilities from serving and from their outside options. We derive the equilibrium numbers of volunteers under each policy and identify conditions under which either of the two approaches may be preferred. We extend our analysis to study policy performance when the volunteer pool size is random.

Monday, 2 PM–3:15 PM

MD23

CC - Room 128

Modeling and Analytics in Substance Use

General Session

Session Chair

Qiushi Chen, Penn State University, University Park

1 Profiling The Risk of Major Adverse Cardiovascular Events with The use of Prescription Stimulants from Large Health-network Data

Yifang Yan[1], Qiushi Chen[2], Wen-Jan Tuan[3], Paul Griffin[2], [1]The Pennsylvania State University, University Park, PA, [2]The Pennsylvania State University, University Park, PA, [3]The Pennsylvania State University, Hershey, PA, Contact: yvy5478@psu.edu

With the rapidly growing use of prescription stimulants in the US, concerns have been raised about major adverse cardiovascular events (MACEs) as side effects associated with the use of prescription stimulants. However, there is a lack of research in quantifying the risk of MACEs introduced by prescription stimulants use. To fill this gap, we developed machine learning models to predict MACEs based on individual's prescription stimulants use, demographics, and comorbidities from electronic health records data. We assessed the incremental risk of MACEs by changing the prescription stimulants use among patients who had never been prescribed with stimulants. For patients with high incremental risk due to prescription stimulants uses, we applied Apriori algorithm to characterize the profile of these patients.

2 Estimating County-level Prevalence of Opioid use Disorder: A Bayesian Inference Approach

Zixuan Feng[1], Qiushi Chen[2], Le Bao[3], Paul Griffin[2], Sarah Kawasaki[4], [1]Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, [3]Pennsylvania State University, University Park, PA, [4]Pennsylvania State University, University Park, PA, Contact: zzf5064@psu.edu

Understanding the opioid use disorder (OUD) burden is critical in combating the opioid overdose crisis. Although OUD prevalence estimates have been readily available at the national and state levels, it has been poorly understood at the county level in most states. To fill this gap, we developed a Bayesian hierarchical model to estimate the county-level OUD prevalence, leveraging multiple publicly available county-level opioid-related metrics. We first fitted the model to county-level OUD prevalence estimates that were available in Massachusetts, which showed a satisfactory accuracy with the mean absolute percentage error of 11% from the leave-one-out analyses. We then performed the full data analysis including other states to estimate the OUD prevalence for counties in those states.

3 A Simulation-based Approach to Analyze The Association of Treatment Discontinuation with Unintended Consequences Among Patients Prescribed Long-term Opioids

Carolina Vivas-Valencia[1], Melike Yildirim[1], Huiru Dong[1], Alton Russell[2], Mohammad Jalali[1], [1]Harvard University, Boston, MA, [2]McGill University, Montreal, MA, Canada. Contact: cvivas-valencia@mgh.harvard.edu

Interventions to reduce opioid misuse initiation, such as restrictions on the frequency, strength, or duration of opioid prescriptions, may adversely increase the risk of overdose, heroin use, and suicide. We build a microsimulation with sex-, age-and race-stratified parameters for individuals in long-term opioid treatment and transition probabilities across different dosage levels. We ran scenario-based intervention models to characterize tradeoffs between overdose and suicide rates for opioid dose tapering versus abrupt discontinuation patients.

4 Predicting Adverse Covid-19-related Outcomes Among Individuals with and Without Opioid-related Conditions

Hyojung Kang, Xiaotian Gao, Mihir Sircar, Lalita Takle, University of Illinois at Urbana-Champaign, Champaign, IL, Contact: hyokang@illinois.edu

Opioid-related overdoses and deaths have increased during COVID-19, and opioid use may increase the risk of adverse outcomes from COVID-19. Some This study aims to predict health outcomes including mortality among patients who had COVID-19 with and without opioid-related conditions using a nationwide temporal dataset. We select a control group using propensity score matching and then develop machine learning models to predict risks of adverse outcomes.

Monday, 2 PM–3:15 PM

MD24

CC - Wabash 1

ABET / FICO

Technology Tutorial

1 Introduction to ABET Accreditation and Computing Accreditation

Andy Borchers, Lipscomb University, Nashville, TN, Contact: andy.borchers@lipscomb.edu

Learn why the ABET accreditation process brings value to the more than 4,300 programs at 850 colleges worldwide who have received it and how the Computing Accreditation Commission (CAC) is responsible for reviewing educational programs specifically for the technical disciplines of computer science. Additionally, learn how you can help ABET by becoming a Program Evaluator - the heart of ABET accreditation - who evaluates program materials, visits campuses and participate in accreditation decisions.

2 End-to-End FICO® Xpress Insight Tutorial: From Data to Decisions for Non-Technical Business Users

Baykal Hafizoglu, FICO, San Jose, CA, Contact: baykalhafizoglu@fico.com

You have a team with a great analytics background. They've developed advanced analytical tools using Python, R, or your current optimization solver. They've derived crucial insights from your data and figured out how your decisions shape your customers' behaviors. Now it's time to put these critical analytical insights into the hands of your non-technical business users.In this tutorial, you'll learn how FICO's Xpress Optimization solutions (including Xpress Mosel, Xpress Workbench, Xpress Solver and Xpress Insight) make it possible to embed your analytic models in business user-friendly applications. See how to supercharge your analytic models with simulation, optimization, reporting, what-if analysis, and agile extensibility for your ever-changing business. Plus, you'll discover how to use the new View Designer to reduce GUI development times from minutes to seconds.

Monday, 2 PM–3:15 PM

MD25

CC - Wabash 2

The Role of Microgrids in Advancing Energy Equity Through Access and Resilience

Tutorial Session

1 **The Role of Microgrids in Advancing Energy Equity Through Access and Resilience**

Alexandra M. Newman[1], Destenie S. Nock[2], [1]Colorado School of Mines, Golden, CO, [2]Carnegie Mellon University, Pittsburgh, PA

Microgrids can play a role in advancing energy equity by (i) extending access to electricity in areas where national grids do not reach, and (ii) enhancing a power system's resilience --- the ability to adapt to and rebound from unanticipated shocks --- in times of disaster(s) such as extreme weather events or power outages on the centralized grid. In the developing world, access to electricity remains a challenge in the most interior rural areas, where incomes are low and grid connection costs are prohibitive. In both developing and developed economies, the rise of extreme weather events has made the resilience of power systems a concern. Wildfires, for example, are becoming widespread. For example, the United States saw over 71,000 wildfires burn 10 million acres and more than 12,000 buildings in 2017 alone. This specific economic burden --- in terms of the impact of wildfires on the U.S. economy --- is estimated to be between $71.1 billion and $347.8 billion annually. In addition, there is a social cost incurred by vulnerable populations who (i) may be unable to evacuate from the location of a disaster, or (ii) may not have access to mitigating strategies for failed power systems. In this tutorial, we examine the role of microgrids in electricity access and resilience through a systematic review. With respect to electricity access, we investigate the impact of electricity provision through microgrids on outcomes in rural areas of developing countries. For electricity resilience, we assess the effectiveness of microgrids in providing support to power grids in the aftermath of a disaster. We find that microgrids can provide significant benefits in both settings.

Monday, 2 PM–3:15 PM

MD26

CC - Wabash 3

Emerging Logistics Applications

General Session

Session Chair

Sibel Alumur Alev, University of Waterloo, Waterloo, ON, Canada.

1 **Optimizing Drone Delivery with Recharging Stations**

James F. Campbell, University of Missouri - St. Louis, Saint Louis, MO, Contact: campbell@umsl.edu

Delivery drones (UAVs or UGVs) may improve delivery of small packages due to their high speeds, low transportation costs and low infrastructure needs, although they have a limited range. To extend a drone's range, fixed or mobile recharging stations can be located to recharge or swap drone batteries. This research uses strategic continuous approximation (CA) models to assess how useful are fixed and mobile recharging stations, and multiple recharges per trip, to reduce drone delivery costs. Models for idealized delivery systems provide insights into the optimal deployment of fixed and mobile recharging stations. Results document key characteristics of drones, recharging station costs, and the delivery intensity that make deployment of fixed or mobile recharging stations beneficial.

2 **School or Parking Lot? Selecting Locations for Points of Distribution in Urban Disasters**

Stefan Nickel[1], Hannah Bakker[2], Florian Diehlmann[2], Marcus Wiens[3], Frank Schultmann[4], [1]Karlsruhe Insitute of Technology, Karlsruhe, Germany; [2]KIT, Karlsruhe, Germany; [3]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany; [4]Karlsruhe Institute of Technology, Karlsruhe, Germany. Contact: stefan.nickel@kit.edu

The selection of locations of distribution sites and modes for relief items is a critical part of any public sector response. This is especially challenging in urban areas, where a scarcity of empty buildings leads to the need to spontaneously convert (public) buildings or places into points of distribution. Therefore, we develop an approach to select modes and identify locations for the distribution of goods and apply it towards a hypothetical case study in Berlin, Germany. We show that the presented approach is particularly valuable in situations where a level of service for beneficiaries is desired. Therefore, the present study yields several interesting managerial insights into a yet largely unexplored problem, contributing to an increase in resilience towards future crises.

3 **Reinforcing Schooling Access for Refugees**

Bahar Kara[1], Feyza G. Sahinyazan[2], Sebnem M. Demir[1], [1]Bilkent University, Ankara, Turkey; [2]Simon Fraser University, Burnaby, BC, Canada.

In this study, first we identify the availability and accessibility challenges posed by the county's existing plans of integrating refugees to the national education system. We then develop a planning strategy that is aligned with the local regulations. To improve schooling rates among Syrian refugee children without burdening the existing infrastructure of the host country, we formulate a serşes of mathematical models which are adapted versions of Capacitated Maximum Covering Problem Results of our experimental analysis with the real-life data will be presented.

4 Infrastructure Design for Shared Autonomous Transportation

Sibel Alumur Alev, Omer Burak Kinay, Fatma Gzara, University of Waterloo, Waterloo, ON, Canada. Contact: sibel.alumur@uwaterloo.ca

We introduce the staging facility location and lane deployment problem for shared autonomous transportation. To respond to a call for a trip, an autonomous vehicle (AV) leaves a staging facility, travels between the origin and destination nodes of the trip, and returns to a staging facility. We seek to find the optimal locations of staging facilities utilizing a bi-objective model that minimizes total travel distance and the total AV travel not occurring on AV lanes with respect to a given AV lane deployment budget and a number of staging facilities to locate. We develop a Benders decomposition algorithm with Pareto-optimal cuts and evaluate the trade-offs with optimal solutions on benchmark instances.

Monday, 2 PM–3:15 PM

MD27

CC - Room 138

Advanced Topics on Platform and Service Systems

General Session

Session Chair

Xiaoyue Yan, New York, NY

Session Chair

Li Chen, Cornell University, Ithaca, NY

1 Coopetition in Platform-based Retailing: On The Platform's Entry

Lian Qi[1], Haotian Song[2], Wenqiang Xiao[2], [1]Rutgers University, Piscataway, NJ, [2]New York University, New York, NY, Contact: lianqi@business.rutgers.edu

We study the dynamic incentive interactions between a platform and a third-party seller over two stages, where the seller exerts product-value-enhancement effort in the first stage in anticipation of the platform's potential entry in the second stage. We employ a two-stage Cournot competition model and solve the subgame perfect equilibrium. We characterize the necessary and sufficient conditions to address the questions of what product spaces the platform should enter, how the platform's entry influences the seller's performance, how the seller reacts in her effort decision in the first stage in anticipation of the potential entry of the platform in the second stage, and when the platform should commit non-entry in advance.

2 Platform Competition with Two-sided Multihoming: Network Value and Payment Strategy

Xiaoyue Yan[1], Li Chen[2], [1]Cornell University, New York, NY, [2]Cornell University, Ithaca, NY, Contact: xy393@cornell.edu

Platforms often deal with varying degrees of network effect at the customer and provider sides. In this paper, we investigate how such asymmetric network effect drives platform payment strategy when multihoming exists on both sides. We find competing platforms would adopt a mixed strategy with randomized pricing in equilibrium when the network effect on the weak side is relatively high. Such mixed strategy often includes subsidy as one of the random pricing strategies.

3 On The Supply of Autonomous Technologies for Gig Economy Platforms

Daniel Freund[1], Ilan Lobel[2], Jiayu Kamessi Zhao[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]New York University, New York, NY, Contact: kamessi@mit.edu

A possible future in which autonomous vehicles (AVs) and independent contractors (ICs) are deployed jointly on gig economy platforms opens new challenges for market design. In this work, we investigate the role of the platform's dispatch prioritization on the dynamics of the AV supply chain. AV supply is inelastic due to the high capital expenditure required, but AV suppliers' profit depends on their AVs' utilization. In a hybrid setting where the platform wants to operate with both AVs to serve base demand and ICs to serve peak demand, the platform may be incentivized to prioritize ICs over AVs even when AVs have lower variable cost. The resulting reduction in AV utilization may lead the AV suppliers to underinvest, thus causing a supply chain misalignment. Our work quantifies this misalignment and proposes supply chain contracts to overcome it in different scenarios.

Monday, 2 PM–3:15 PM

MD28

CC - Room 139

Retail Operations

General Session

Session Chair

Aditya Jain, Baruch College, Zicklin School of Business, New York, NY

1 Retail Category Management with Store Brand Sourcing

Yasin Alan[1], Mumin Kurtulus[1], Alexander Maslov[2], [1]Vanderbilt University, Nashville, TN, [2]Vanderbilt University, Nashville, TN, Contact: alexander.maslov@Vanderbilt.Edu

We analyze a retailer's strategic interactions with a national brand manufacturer (NBM) using a setting in which the retailer makes category management and store brand (SB) sourcing decisions and the NBM determines whether it should produce the retailer's SB. We first characterize the conditions under which the retailer prefers to source its SB from the NBM, rather than producing it in-house. We then characterize the conditions under which the NBM agrees to produce the retailer's SB. Notably, we find that the NBM may refuse to produce the retailer's SB when the quality gap between its own product and the retailer's SB is small. Our study also generates insights into the impact of the SB sourcing decisions on the retailer's assortment as well as retail and wholesale prices in the category.

2 Measuring The Influence of Multichannel Digital Advertising on Product Adoption

Aslan Lotfi[1], Xinxue Qu[2], Zhengrui Jiang[3], [1]University of Richmond, Richmond, VA, [2]University of Notre Dame, Granger, IN, [3]Nanjing University, Nanjing, China. Contact: alotfi@richmond.edu

In this study, we model the influence of advertising on product adoption when consumers begin to experience exposure to relevant advertisements from different digital advertising channels before product release. We first introduce a new advertising stock model based on the premise that the contribution of an exposure to an individual's advertising stock is determined by the flow of relevant information received by the individual over time. Next, we incorporate the new advertising stock model into survival analysis to disentangle the effect of clicks and impressions associated with different digital advertising channels on adoptions. Our dataset records adoptions of a new video game and individual exposures, including clicks and impressions, through different digital channels both before and after product release. We compare our model with a benchmark model.

3 Design of Curated Subscription Services in Retailing: Role of Collection Transparency and Consumer Co-curation

Yuanyuan Ding, Karen L. Donohue, Necati Ertekin, University of Minnesota, Minneapolis, MN, Contact: ding0197@umn.edu

Curated subscription services, where customers periodically receive a box of products personalized based on their preferences, are gaining traction as a new business model among retailers (e.g., Stitch Fix, BarkBox). Customers subscribe to such services for a variety of reasons, ranging from convenience to a desire for a fun surprise. While demand for this new business model is increasing, we observe in practice that curated-box retailers use different service designs to offer such services. In this study, we examine the performance of two service design features: collection transparency and consumer co-curation. We use a lab experiment to (i) test how these service design features influence customers' willingness-to-pay for the service and (ii) prescribe what service design is most appropriate for a curated-box retailer depending on the profile of its customer base.

4 Informed Bidding War for An On-demand Service Platform

Marco Bijvank[1], Osman Alp[2], Serasu Duran[3], [1]University of Calgary, Calgary, AB, Canada; [2]University of Calgary, Calgary, AB, Canada; [3]Haskayne School of Business, Calgary, AB, Canada. Contact: marco.bijvank@haskayne.ucalgary.ca

We model an on-demand service platform where customers request service by providing price quotes (or bids) as a multi-priority queue where servers (or contractors) can decide when they work (modeled as taking vacations) and if they select one of the outstanding service requests (i.e., the one with the highest bid price). In particular, a server will vacate if no customer bid exceeds the server's reservation price. These reservation prices are random variables that get updated at customer arrival and departure. Expressions are derived to calculate expected wait times for a given state such that customers can make informed decisions what to expect when they request service for a certain bid price.

Monday, 2 PM–3:15 PM

MD29

CC - Room 140

Empirical Research in Pharmaceutical Supply Chain

General Session

Session Chair
Rachna Shah, University of Minnesota, Minneapolis, MN

Session Chair
Hanu Tyagi, University of Minnesota, Minneapolis, MN

1 The Impact of Transparency on Novelty

Hanu Tyagi[1], Manuel Ignacio Hermosilla[2], Rachna Shah[1], [1]University of Minnesota, Minneapolis, MN, [2]Johns Hopkins University, Baltimore, MD, Contact: tyagi035@umn.edu

Firms are being required to disclose information about their operations. However, being transparent is often misaligned with the firms' incentives. In situations where firms are reluctant about being transparent, external stakeholders, such as regulators and industry watchdogs, may impose transparency requirements on firms. In this study, we study the impact of transparency on novelty. We examine our research question in the context of the pharmaceutical industry. Exploiting an exogenous pro-operational transparency shock, we find that transparency could lead to less novelty. Additionally, we explore the contingency effect of diversification and find that the impact of transparency is stronger for firms with less diversified portfolios.

2 Do Regulators Adequately Control for The Control Arm? An Empirical Analysis of Drug Approvals

John M. Silberholz[1], Xiaoyu Wu[2], [1]University of Michigan Ross School of Business, Ann Arbor, MI, [2]Fuqua Business School, Duke University, Durham, NC, Contact: xiaoyu.wu@duke.edu

For some diseases like cancer, Phase III clinical trials typically compare a new treatment against an active control, which is a standard of care treatment for the disease. Diseases often have multiple standard of care therapies, some of which may yield better or worse outcomes. Therefore, the therapy selected as the active control may make it easier or harder to prove the efficacy of the new therapy. Using a large-scale database of cancer clinical trials, we explore whether Phase III trials selecting weaker therapies for the control arm get an advantage in the drug approval process, using the statistical technique of network meta-analysis to compare the qualities of different standard therapies.

3 Do Drug Shortages Adversely Affect Drug Quality? An Empirical Analysis

Ziheng (Archie) Zhuang[1], In Joon Noh[2], Suvrat Dhanorkar[3], Hui Zhao[3], [1]Smeal College of Business, Pennsylvania State University, State College, PA, [2]Smeal College of Business, Pennsylvania State University, State College, PA, [3]Smeal College of Business, Pennsylvania State University, University Park, PA, Contact: zpz5187@psu.edu

Drug shortages in the U.S. have imposed significant and persistent threats on public health and healthcare systems. While previous research has documented dire consequences of drug shortages in terms of reduced quality of care, substantial loss in health outcomes (even deaths), and increased healthcare costs, this study empirically examines the impact of drug shortages on drug quality. Specifically, we assemble data from multiple databases and test our hypotheses using econometric models. We show that drug quality is negatively affected after the occurrence of shortages. We further conduct moderation analyses and various robustness checks. We argue that the compromise in quality may be due to the time pressure to recover from drug shortages. Our findings bring caution to the FDA and drug manufacturers as they strive to resolve drug shortages.

4 The Impact of Telemedicine on Mental Healthcare Service Usage and Quality: An Empirical Investigation

Yi Tang, Carlson School of Management, Minneapolis, MN

Telemedicine is becoming increasingly popular for mental healthcare delivery especially during the COVID-19 pandemic. In this study, we find empirical evidence that enhancing affordability of and access to telemedicine increases patients' overall usage of mental health services, which ultimately improves mental healthcare quality.

Monday, 2 PM–3:15 PM

MD30

CC - Room 141
Emerging Topics in iFORM: Financing, Supplier Turnover, and Contract Tokenization
General Session

Session Chair
N. Bora Keskin, Duke University, Durham, NC

Session Chair
Yuan-Mao Kao, Baruch College, City University of New York, Jersey City, NJ

1 On The Interplay of Production Flexibility and Financing Strategy

Guoming Lai[1], Peter Ritchken[2], Qi Wu[3], [1]University of

Texas at Austin, Austin, TX, [2]Case Western Reserve, Cleveland, OH, [3]Case Western Reserve University, Cleveland, OH, Contact: qxw132@case.edu

We investigate how the degree of production flexibility interacts with financing choices. The degree of flexibility is controlled by switching costs that allow pausing and restarting of production. We find that the optimal operating policy is jointly determined with the financing choice. Debt levels, not only impact tax shields and bankruptcy costs but also the utilization of production flexibility. Debt induces risk shifting which undermines equityholders' incentive to use flexibility. We further uncover a non-monotone relationship between production flexibility and financial leverage.

2 Contract Tokenization in The Renewable Energy Market

Rowena Gan[1], Rong Li[2], [1]Southern Methodist University, Dallas, TX, [2]Syracuse University, Syracuse, NY, Contact: jingxingg@mail.smu.edu

Endorsed by the blockchain technology, supply chain contracts can be digitally recorded and stored in crypto tokens, which is referred to as being tokenized. Tokenized contracts offer new ways of financing, trading and owning an asset. Using the renewable energy market as a backdrop, we study the impact of contract tokenization on different parties in the supply chain based on their respective incentives.

3 Supplier Turnover: Operational Performance Implications

Kevin Mayo[1], Chris Chen[2], George Ball[3], Kurt M. Bretthauer[2], [1]Washington State University, Pullman, WA, [2]Indiana University, Bloomington, IN, [3]Operations and Decision Technologies, Kelley School of Business, Indiana University, Bloomington, IN

What are the performance impacts to buyers when there is turnover among their suppliers? Using a decade of buyer-supplier relationship data we examine supplier turnover in consumer product firms and find that costs decrease while complaints, as a proxy for quality, increase. While firms may pursue lower costs, they must be careful about potential impacts to quality. Further we find that the relationship strengthens as distance between the buyer and new supplier decreases and reverses when it decreases. We find that when the supplier initiates the turnover the results are flipped. We examine the impact on inventory, gross margin and market share and find no relationship between the amount of turnover and these outcomes, implying that the reductions in cost are price changes that are passed on to the consumer.

4 Digital Voucher Financing and Transfer in a Three-echelon Supply Chain

Yaobin Wu[1], Xiangfeng Chen[1], Xun Xu[2], Gangshu Cai[3], [1]Fudan University, Shanghai, China; [2]California State University-Dominguez Hills, Carson, CA, [3]Santa Clara University, Santa Clara, CA

Blockchain technology has been widely adopted in supply chain finance with the emergence and rapid development of financial technology. In this study, we focus on two of the financing programs facilitated by blockchain — digital voucher financing and transfer — and compare them with traditional bank financing.

Monday, 2 PM–3:15 PM

MD31

CC - Room 142
MSOM/Service Operations Flash Session
Flash Session

Session Chair
Jaesung Lee, Texas A&M University, College Station, TX

1 The Effect of Platform Dynamic Pricing Competition on Sellers

Gang GUO[1], Fabio miessi sanches[2], Srisuma Tang Sorawoot[1], [1]National University of Singapore, Singapore, Singapore; [2]BI Norwegian Business School, Norway, Norway. Contact: gangg@u.nus.edu

Online platforms use aggressive price promotions to build a customer base and compete for market share in the early stages of growth. Sellers pay fees when selling on platforms that compete with their own sales channel, they see an increase in sales but become more dependent on platforms and have less bargaining power as the online market grows. We build a multi-category multi-channel demand model and develop a dynamic pricing game to study this trade-off. We apply the models to the online sales data from a big Indonesian cosmetics firm. We find that online platforms benefit sellers in the short run through subsidization and a bigger marketplace, but the platform can erode its profits in the long run by utilizing increased market power and customer data. We also show that platform leakage is an efficient way for sellers to mitigate the platform's negative impact.

2 Design of Car Rental Programs for Drivers offered by a Ride Hailing Platform

Guiyun Feng[1], Vishal Agrawal[2], Ioannis Bellos[3], Deyin Ji[4], [1]SMU, singapore, Singapore; [2]Georgetown University, Washington, DC, [3]George Mason University, Fairfax, VA,

[4]SMU, Singapore, Singapore.

In order to retain enough drivers to meet demand, ride hailing platforms such as Lyft and Uber are offering short-term car rental agreements aimed at potential ride-serviceproviders who don't have qualified cars to serve riders. In this work, we discuss different designs of the car rental programs and their implications to drivers, riders and the platform.

3 Early or Late Warnings

Feng Tian[1], Shouqiang Wang[2], Feifan Zhang[3], [1]The University of Hong Kong, Hong Kong, China; [2]The University of Texas at Dallas, Richardson, TX, [3]Duke University, Durham, NC, Contact: fengtian@hku.hk

We study how public agencies disseminate early warnings when facing a looming disaster such as an epidemic outbreak. We look at how they trade off the incentives to trigger timely yet costly preemptive actions with the benefits of collecting more accurate information. We characterize the optimal warning policy, which may induce governments to distort their proprietary information.

4 A Methodology to Reliably Estimate The Fill Rates for Overtime Postings in Customer Service Center Planning Process

Farzad Daneshgar, Amazon Corporate LLC, Seattle, WA

A methodology, which applies constrained optimization and statistical techniques, is presented to determine the thresholds for Overtime and Voluntary Time Offs postings as part of the planning process for a Customer Service Center. The proposed model uses the historical fill counts, which is composed of censored data, to train a parametric model to calculate fill rates. Then, the calibrated parameters are used to calculate fill rates for the future postings. Once, the fill rates are calculated, the posting thresholds can be calculated to make sure majority of postings are fully completed. Results shows that by following the proposed methodology we can significantly increase the rate of postings that are fully completed.

5 Service Chain Operations: What to Standardize, and when to Standardize

Lu Kong[1], Kejia Hu[2], Rohit Verma[3], [1]University of South Florida, Tampa, FL, [2]Vanderbilt University, Nashville, TN, [3]Cornell University, Ithaca, NY, Contact: kongl@usf.edu

When should practices and procedures be standardized in a service chain, and when customized? More importantly, what operational aspects should be standardized, and what should be customized? Using evidence from the nursing home industry, we provide managerial implications to service chain operations managers.

6 Remanufacturing Exit Decision Model Under Supply Uncertainty

K Jo Min, Mohammad Sadat, John Jackman, Iowa State University, Ames, IA, Contact: jomin@iastate.edu

In this paper, we consider a remanufacturer faced with a stochastic supply of returned products for remanufacturing where the supply quantity decreases on average with respect to time (eventually). Specifically, for such a remanufacturer, under various conditions of returned product quality and remanufacturing cost, we derive the optimal threshold supply of returned products to exit remanufacturing as well as the corresponding expected time to exit. Managerial insights and economic implications will be discussed, and an illustrative numerical example explaining the key features of our model will be presented (e.g., the profitability of the remanufacturer at exit).

7 A Min-max Policy for Multi-item Joint Inventory Replenishment Problem: Application to Industrial Vending Machines

Yue Zhang, Hao-Wei Chen, University of Toledo, Toledo, OH, Contact: yue.zhang@utoledo.edu

This paper studies a unique multi-item joint inventory replenishment problem to determine the optimal min-max policy that maximizes the expected profit in a finite planning horizon. A simulation optimization framework is applied to determine the optimal inventory decisions.

8 Designing a Make-to-stock Batch Production System with Stochastic Capacity and Stochastic Demand

Antonio Arreola-Risa[1], Bo Li[2], [1]Mays Business School, Texas A&M University, College Station, TX, [2]Ningbo China Institute for Supply Chain Innovation, Ningbo, Zhejiang, China. Contact: tarreola@tamu.edu

Consider a company that is designing a make-to-stock system with a single finished good to be produced in batches of Q units. Batch production time is a random variable whose mean is linear in Q. The finished goods inventory is managed by a (Q,R) policy. Each production batch incurs an ordering cost which is independent of Q. On-hand finished goods are charged a per unit holding cost rate. The finished good is demanded one-unit-at-a-time in a stochastic and stationary fashion. Stockouts are backordered at a per unit penalty cost rate. The company wants to find the values of Q and R that minimize the long-run per-period sum of the ordering, holding and backordering costs. We derive optimization results when demand is a Poisson process and batch production time is an exponential random variable.

9 Deep Reinforcement Learning for Maintenance Planning Under Economic Dependency

Jaesung Lee[1], Salman Jahani[2], Shiyu Zhou[1], [1]University of Wisconsin-Madison, Madison, WI, [2]SAP Labs LLC, Ames, IA, Contact: jaesung.lee@wisc.edu

We consider complex systems with multiple components working together in parallel with economic dependency, where maintenance incurs a high setup cost. In such a system, a policymaker can proactively replace a group of components at a lower cost compared to the corrective maintenance cost. We propose a deep reinforcement learning-based stochastic policy that encourages group maintenance and minimizes maintenance costs. Encouraging group maintenance helps find optimal policy fast. Our framework considers the individualized degradation evolution of each component in the system in planning for maintenance. The performance of the proposed method is validated by the numerical and case studies.

Flash Paper

Anton Ivanov[1], Abhijeet Ghoshal[2], Akhil Kumar[3], [1]University of Illinois at Urbana-Champaign, Champagne, IL, [2]University of Illinois, Champaign, IL, [3]Penn State University, State College, PA

To identify problematic products, we propose a system to automatically screen products and proactively track down potentially problematic ones. This would enable platforms to take prompt actions against offending sellers by removing their products or even banning them from the platform. In contrast to past studies, the novelty of the proposed system comes from its ability to further aid in the managerial decision-making by complementing prediction results with product classification component that directly informs the operator of the potential for a given product to soon become problematic.

Monday, 2 PM–3:15 PM

MD32

CC - Room 143

MSOM/Sustainable Operations Flash Session

Flash Session

Session Chair

Abhay Grover, University of Maryland, College Park, MD

1 Aligning Incentives for Forest Management and Carbon Offset Design

Zhuoyang Liu, Dan Andrei Iancu, Erica Plambeck, Stanford University, Stanford, CA, Contact: zyliu@stanford.edu

How should policymakers better incentivize the private sector to profitably manage working forests in ways that align with social welfare and carbon-neutral goals? To study this question, we build a Markov decision process model to capture the stochastic evolution of forest stands and investigate how forestry companies should optimally adjust their forest management (thinning, harvesting, and restoration) strategies to cope with natural disturbances and uncertainties associated with the timber and carbon offset markets. We derive structural results on the optimal timber management policies and use these to examine how various carbon accounting and crediting policies would impact the companies' profits as well as the long-run carbon stock on working forest stands. We leverage these results to generate insights for policymakers.

2 Budget Provision in Crowdfunding: Information Asymmetry and Cost Transparency

Guangzhi Shang[1], Wayne Fu[2], Xun Tong[3], [1]Florida State Unviersity, Tallahassee, FL, [2]University of Michigan-Dearborn, Dearborn, MI, [3]University of Groningen, Groningen, Netherlands. Contact: gshang@business.fsu.edu

We study the impact of a creator revealing budget information to potential backers on a crowdfunding platform. Such budget provision is analogous to an innovative retail practice of disclosing the sensitive cost information to consumers. We draw on theories on information asymmetry and cost transparency.

3 Feedback Mechanisms to Improve Volunteer Retention

Vinit S. Tipnis[1], Christopher J. Chen[2], Fei Gao[3], [1]Indiana University Kelley School of Business, Bloomington, IN, [2]Indiana University Kelley School of Business, Bloomington, IN, [3]Indiana University Bloomington, Bloomington, IN, Contact: vtipnis@iu.edu

Non-profit organizations rely on volunteers to alleviate some of the financial constraints around employing a large paid workforce. Low volunteer retention is costly and disruptive to operations. In this study, we incorporate volunteer motivations and examine how we can operationalize different feedback mechanisms to increase volunteer retention.

4 Understanding Drivers and Outcomes of Transition to Renewable Energy

Seyed Amin Seyed Haeri[1], Ahmet Colak[2], Safak Yucel[3], [1]Clemson University, Central, SC, [2]Clemson University,

Pendleton, SC, [3]Georgetown University, Washington, DC, Contact: sseyedh@clemson.edu

In this study we examine market and policy drivers of the U.S. electricity grid transition toward renewable energy. We use a spatial model to evaluate the implications of the Renewable Portfolio Standard (RPS) programs that are the most prominent renewable energy incentivizing programs designed and enforced on the state level. We collect a unique panel dataset of the U.S. power plants for 18 years to study, investments in renewables, electricity retail prices, GHG emissions, and conventional power plants' utilizations. We further evaluate the role of the plants' operational flexibility in the U.S. power grid transition.

5 Autonomous Trucking and The Sustainability of The Logistics Industry

Angel Perez Vila, Nathan Kunz, University of North Florida, Jacksonville, FL, Contact: angel.perez@unf.edu

The trucking industry is facing a significant driver shortage, which is only projected to increase in the years ahead. Trucking companies struggle to attract new drivers, due to difficult working conditions, low pay, and long time away from home. Autonomous trucking is a promising innovation that has the potential to address this challenge. Using an intervention-based research approach, we study the operational implications of autonomous trucking for supply chains. We demonstrate that a proper implementation of autonomous operations in supply chains will address existing challenges in the trucking industry while generating positive impacts for small trucking companies and their drivers.

6 Impact of Intermediaries on Humanitarian Donors' Fund Allocation Decisions

Bengisu Urlu[1], Atalay Atasu[1], Antoine Desir[1], Luk N. Van Wassenhove[2], [1]INSEAD, Fontainebleau, France; [2]INSEAD, Fontainebleau Cedex, France. Contact: bengisu.urlu@insead.edu

Donors exhibit risk aversion in funding humanitarian organizations (HOs), a behavior primarily driven by donors' lack of information about the capabilities of HOs on the ground. In turn, a common donor practice is to funnel donations through intermediaries (e.g. UN agencies) who possess better field information. It is, however, also established that this process can expose donor funds to biased intermediary preferences that do not necessarily align with donor preferences. To this end, we study a risk averse donor's fund allocation decision in the presence of intermediaries. Through structural results we explain how optimal funds allocation depends on risk aversion, budget and intermediary bias.

7 Impact of Policy Risks on Regulatory Inspection Outcomes and Quality Performance of Food Operations

Abhay Grover, Adams Steven, Robert H. Smith School of Business, College Park, MD, Contact: akgrover@umd.edu

Managing quality is of great interest to firms, consumers, and regulators, especially via inspections. However, inspection outcomes, specifically regulatory ones, do not always uniformly result in consistent outcomes for similar non-conformance behavior which can lead to severe consequences. One of the reasons is the shift in the U.S. political geography every two-years which exposes manufacturing facilities to differential policy risks. We use political alignment to empirically uncover the impact of time-varying policy risks on quality performance of operations via regulatory inspection outcomes. We identify firm-level strategies to mitigate it and make policy recommendations.

Monday, 2 PM–3:15 PM

MD33

CC - Room 144

MSOM Flash Session II

Flash Session

Session Chair

Neil Desnoyers, Saint Joseph's University, Philadelphia, PA

1 A Robust Queueing Approach for Analysis of Fork-join Queueing Systems

Zhonghao Liu, Northwestern University, Evanston, IL, Contact: zhonghaoliu2022@u.northwestern.edu

Fork-join queueing models arise when a job is copied or divided into sub-tasks and processed parallelly. In this paper, we model the fact-checking process as a generalized (n, c, k) fork-join queue: when a job arrives at a service station with n servers, and sent to c of the n servers, after k of the copies are processed (k <= c), the job is completed. We propose a Robust Optimization approach to approximate the service levels (quantile) of waiting time distribution, and further simplify our approximation using a hierarchy of bounds. Through a numerical study, we show that our robust approximation model is accurate in approximating the quantile of the waiting time distribution and mean waiting time.

2 Product Sharing: A Threat or An Opportunity for Competing Manufacturers?

Tao Li, Santa Clara University, Santa Clara, CA
This paper studies the impact of product sharing on competing manufacturers under a platform's different quality entry barrier strategies. We build a game-theoretic analytical model and study the strategies of two manufacturers, an industry leader producing a high-quality product and an industry follower producing a low-quality product, in three markets: the N-S market where the sharing market does not exist, the L-S market and the H-S market where the platform sets a low and a high entry barrier, respectively. We find that although product sharing makes it easier for the industry leader to survive, it may not improve the survival likelihood of the industry follower. Furthermore, we show that it is not always beneficial for a manufacturer to join the sharing market.

3 Continuous Labor Planning for Ultra-fast Businesses at Amazon

Zeynep Sargut, Ramon Auad, Thomas Fillebeen, Roman Levkin, Amazon, Seattle, WA, Contact: zeyneps@amazon.com
Amazon ultra-fast businesses are exposed to a high level of intra-day customer demand volatility as orders are still being placed close to the customer delivery promise. Furthermore, these businesses are highly labor-intensive and have tight deadlines. In this talk, we present an overview of the continuous labor planning suite where shifts are scheduled continuously for a particular date and intra-day corrective mechanisms are used to recover from misplanning. The objective is to minimize the risk of over-staffing as well as under-staffing to avoid high operational costs and missing customers orders respectively. The focus is on a two-stage approach to plan shifts for a multi-process path business, which is implemented using Mixed-Integer-Programming models.

4 Implications of Commitment by The Supplier in a Supply Chain

Narendra Singh, Nazarbayev University, Nur-Sultan, Kazakhstan. Contact: narendra.singh@nu.edu.kz
The existing literature shows that time inconsistency hurts a centralized firm and that the commitment by the firm to future prices benefits the firm by mitigating the time-inconsistency problem. However, the implications of commitments in decentralized supply chains are not yet fully understood. In this paper, I examine the implications of the commitment by the supplier in a decentralized supply chain consisting of a supplier and a retailer. I show that the supplier's commitment to price benefits the supplier but hurts the retailer and consumers. The supply chain is better off with the commitment for sufficiently low discount factors when the retailer's order quantity is observable.

5 Optimal Storage and Trading for a Commodity in The Presence of Inventory Conversion Flexibility

Amar Sapra[1], Sridhar Seshadri[2], [1]Indian Instiitue of Management-Bangalore, Bangalore, India; [2]University of Illinois, Champaign, IL, Contact: amar.sapra@iimb.ac.in
We consider a multi-period planning model for a commodity-trading firm that procures and sells a commodity. The firm has the flexibility to blend
different grades of the commodity to take advantage of price arbitrage. Our objective is to develop insights on the role of various model parameters on
optimal decisions.

6 Selling Professional Products with Expertise Migration Uncertainty

Jane Gu[1], Pingfan Wang[2], Rachel Rong Chen[3], [1]University of Connecticut, Storrs, CA, [2]University of Science and Technology of China, Hefei, China; [3]University of California-Davis, Davis, CA, Contact: rachen@ucdavis.edu
For professional products such as musical instruments and sports gear, a consumer's quality preference is positively associated with her expertise level. An amateur who initially chooses a low-quality product over a high-quality one may have incentive to upgrade if her expertise has advanced through professional training. Nonetheless, the outcome of professional training is highly uncertain and typically only with a small probability will consumers complete the training period with advanced expertise. This paper examines a firm's strategies to sell professional products when consumer expertise migrates with uncertainty.

7 Maximizing Disability Diversity, Language Diversity and Productivity: A Study in Apparel Manufacturing

Ying Zhang[1], Sriram Narayanan[2], Tharo Soun[3], Kalyanmoy Deb[2], Dustin Cole[2], [1]Clemson University, Clemson, SC, [2]Michigan State University, East Lansing, MI, [3]Amazon, Seattle, WA, Contact: ying6@clemson.edu
We formulate a series of assignment problems, deterministic and stochastic problems to study the implications of employing individuals with disability and language diversity in apparel manufacturing cells on overall team productivity. Our analysis shows that productivity of teams that deploy individuals across multiple types of disabilities is higher than productivity of teams that employed a specific type of disability. Teams that employed both individuals with

disabilities, and without, were slightly better than the teams that deployed only individuals with disabilities. Our results suggest that productivity is not sensitive to increases in disability diversity, but sensitive to simultaneously increasing disability diversity and language diversity to extreme levels.

8 Swift Supplier Development

Rebecca Clemons, Indiana University East, Richmond, IN, Contact: reclemon@iu.edu

A case study of automotive supply chain firms seeks to understand how these firms managed unexpected disruption in the supply base causing a loss of production. Specifically, what methods of communication were used to share information and quickly build trust between buyer and supplier. A secondary area of concern is the impact of the quality experiences during the transition to a new supplier.

9 Extending Experimental Work on The Finitely Repeated Prisoner's Dilemma

Neil Desnoyers, Saint Joseph's University, Philadelphia, PA

Kreps, Milgrom, Roberts and Wilson (1982) and Selten and Stoecker (1986) made notable contributions to theoretical and experimental knowledge of the Finitely Repeated Prisoner's Dilemma. More recently, Mao, Dworkin, Suri and Watts (2017) introduced the concept of "resilient cooperator". A lab experiment adding new information will be discussed.

10 Online Retailer Competition with Referral Services

Kihoon Kim, Korea University, Seoul, Korea, Republic of. Contact: kihoonk@gmail.com

We investigate whether two competing online retailers can be better off by adopting a referral service. When they adopt the referral service, a referral-offering online retailer faces a trade-off between generating additional revenues from referral fees and the risk of exposing its loyal consumers to the price of its referred online retailer. The latter can sell its goods to loyal consumers of the former for a referral fee, and needs to determine its own and referred prices. We allow each online retailer to offer its own referral service and characterize the equilibrium with the possibility of bidirectional referral services.

Monday, 2 PM–3:15 PM

MD34

CC - Room 145

Supply Chain Optimization

Contributed Session

Session Chair

Dawei Jian, University of California-Riverside, Riverside, CA

1 Managing Coins for Depository Institutions in Coin Supply Chains for Improved Circulation

Yiwei Huang[1], Yunxia Zhu[2], Mayukh Majumdar[3], Bala Shetty[3], Chelliah Sriskandarajah[3], [1]Penn State Shenango, Sharon, PA, [2]University of Nebraska-Lincoln, Lincoln, NE, [3]Texas A&M University, College Station, TX, Contact: yuh201@psu.edu

We investigate operation and circulation issues and challenges in coin supply chains from Depository Institutions' perspectives in the context of improving efficiency and effectiveness of circulating coins in the economy. We provide an optimal or near-optimal operating policy for DIs to increase efficiency and effectiveness in packaging, distributing, coordinating, and managing inventory of coins. We further propose a new policy for the Federal Reserve System to increase coin circulation in the economy.

2 Optimal Long-term Procurement Contracts with Risk-averse Suppliers

Mohammad Zolghadr, Mohsen El Hafsi, A. Gary Anderson Graduate School of Management, University of California, Riverside, Riverside, CA

We study an asymmetric information procurement contracting problem faced by a manufacturer that is in a long-term agreement with a risk-averse supplier.Under our inventory model, we characterize the optimal long-term contract and discuss the effect of the supplier's risk-aversion on the manufacturer's profit-maximizing procurement policies.

3 Self-design Fun: Should 3d Printing be Employed in Mass Customization Operations?

Shu Guo[1], Tsan-Ming Choi[2], Sai-Ho Chung[3], [1]University of Liverpool, Liverpool, United Kingdom; [2]National Taiwan University, Taipei, Taiwan; [3]The Hong Kong Polytechnic University, Hong Kong, Hong Kong.

Motivated by the widespread application of three-dimensional (3D) printing in mass customization (MC) programs across various industries and the extant research gap, we explore the influences of 3D printing in MC operations. Following the MC practices, we consider the case when 3D printing brings extra self-design fun to consumers and at the same time changes the cost formula (i.e., the marginal product variety cost) of the MC product. In addition, the roles played by the risk attitudes of the MC manufacturer and consumers, consumer returns, as well as consumers' time sensitive behaviors, are uncovered. The findings not only contribute to the literature but also provide valuable guidance to practitioners for improving MC operations.

4 Managing Channel Profits for Network Goods

Dawei Jian, University of California-Riverside, Riverside, CA, Contact: djian005@ucr.edu

How should manufacturers sell network goods through retail channels? We study this new class of channel contracting problems, where the retailer can privately observe and control the evolving market conditions. The optimal contract resembles the classic second-best in the short run, but converges to the dynamic first-best in the long run. We characterize the dual roles of network effects: despite the well-known efficiency gain, they exacerbate information friction. We also provide new practical guidance: We show private information per se need not hurt channel efficiency. Ignoring information endogeneity, previous study may have overstated the harm of information asymmetry. Our results also shed light on when and why manufacturers should favor incumbent retailers, and improve retailer information capability, despite information asymmetry.

Monday, 2 PM–3:15 PM

MD39

CC - Room 201

Statistical and Optimization Methods for Reinforcement Learning

General Session

Session Chair

Yuxin Chen, University of Pennsylvania, Princeton, NJ

Session Chair

Yuling Yan, 1</sup

1 The Complexity of Infinite-horizon General-sum Turn-based and Simultaneous Stochastic Games

Yujia Jin[1], Vidya Muthukumar[2], Aaron Sidford[3], [1]Stanford University, Mountain View, CA, [2]Georgia Institute of Technology, Georgia, CA, [3]Stanford University, Stanford, CA, Contact: yujiajin@stanford.edu

In the class of infinite-horizon general-sum stochastic games, we study the complexity for finding stationary Nash equilibrium (NE) for both simultaneous and turn-based games (TBSG), where for the latter only one agent is allowed to take action at each state. We prove that computing a multiplayer approximate stationary NE is PPAD-complete in S for both simultaneous and turn-based games, which imply PPAD-hardness for computing stationary coarse correlated equilibria in general-sum simultaneous stochastic games. Further, we also identify some special cases of general-sum TBSGs for which pure stationary NE always exist and are computable in poly(S,A) time. Underlying all of our results are new structural properties for stochastic games that may be of independent interest.

2 Settling The Sample Complexity of Model-based Offline Reinforcement Learning

Yuting Wei, University of Pennsylvania, Philadelphia, PA, Contact: ytwei@wharton.upenn.edu

This work is concerned with offline reinforcement learning (RL), which learns using pre-collected data without further exploration. Effective offline RL would be able to accommodate distribution shift and insufficient data coverage. However, prior algorithms either suffer from suboptimal sample complexities or incur high burn-in cost, thus posing an impediment to efficient RL in sample-starved applications. In this work, we demonstrate that the model-based (or ``plug-in'') approach achieves minimax-optimal sample optimality with minimal burn-in cost. Our algorithms are pessimistic variants of value iteration with Bernstein-style penalties, which do not rely on sophisticated schemes like variance reduction.

3 Advances in Offline Reinforcement Learning and Beyond

Yu-Xiang Wang, UC Santa Barbara, Santa Barbara, CA, Contact: yuxiangw@cs.ucsb.edu

Reinforcement Learning typically requires interactive access to an environment. In real-life applications, deploying an algorithm that learns by trial-and-errors may have serious legal, ethical and safety issues. In this talk, I will present recent technical advances in Offline Reinforcement Learning --- a setting that optimizes decision policies using only offline data. In particular, I will cover ideas and lessons learned in designing offline RL algorithms with optimal sample complexity. I will also cover strong data-dependent oracle inequalities under various settings (e.g. under function approximation). Finally, I will compare online and offline RL and talk about a new result in low-switching RL that gets the best of both worlds.

4 Bellman Residual Orthogonalization for Offline Reinforcement Learning

Andrea Zanette, University of California Berkeley

We introduce a reinforcement learning principle that approximates the Bellman equations by enforcing their validity only along an user-defined space of test functions. Focusing on applications to model-free offline RL with function approximation, we exploit this principle to derive confidence intervals for off-policy evaluation, as well as to optimize over policies within a prescribed policy class. Different choices of test function spaces allow us to tackle different problems within a common framework. We examine in depth the implementation of our methods with linear function approximation, and provide theoretical guarantees with polynomial-time implementations even when Bellman closure does not hold.

Monday, 2 PM–3:15 PM

MD40

CC - Room 202

Applications and Methods for Conic Optimization

General Session

Session Chair

Julio Goez, NHH, Department of Business and Management Science, NULL

1 First-order Conic Optimization Methods for Optimal Control

Yue Yu, The University of Texas at Austin, Austin, TX, Contact: yueyu@utexas.edu

The key challenge in optimal control of dynamical systems in unknown environments is real-time trajectory optimization subject to various physical and operational constraints. To tackle this challenge, we propose a first-order operating splitting method , named the proportional-integral projected gradient method (PIPG). PIPG not only enjoys the best convergence rates for first-order optimization methods, but also automatically and efficiently detects primal and dual infeasibility. We demonstrate the application of PIPG in many challenging optimal control problems, including the rocket landing and quadrotor flight within nonconvex flight corridors.

2 New Barriers and Efficient Oracles for Proper Cones in The Hypatia.jl Solver

Chris D. Coey[1], Lea Kapelevich[2], Juan Pablo Vielma[3], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Google, Cambridge, MA

Although many convex problems are representable with conic extended formulations (EFs) using only the small number of standard cones currently recognized by advanced conic solvers, standard conic EFs can be much larger than natural formulations (NFs) over cones supported by Hypatia. In this talk, we consider two useful classes of cones that we have predefined through Hypatia's generic cone interface: the spectral norm cones and the spectral function cones. We derive efficient/stable barrier oracles, including closed form inverse Hessian operators. For two common subclasses of spectral function cones, we propose new self-concordant barriers with nearly optimal barrier parameters. Across 11 applied examples, Hypatia solves the NFs more efficiently than Hypatia or MOSEK 9 solves the equivalent EFs.

3 Instance-based Linear Relaxations of Semidefinite Programs

Daniel de Roux, Carnegie Mellon University, Pittsburgh, PA, Contact: dderoux@andrew.cmu.edu

We present a simple yet flexible systematic way to create linear relaxations of semidefinite optimization programs using instance specific information. We illus-trate our approach in the setting of the celebrated SDP relaxation for max cut due to Goemans and Williamson. By using the instance at hand, we provide a pair ofclosely related compact linear programs that sandwich the optimal value of the relaxation. We generalize these ideas to the case of Nesterov's π/2 result, and show that our linear relaxations can give significant speed up in commonly used applications of semidefinite programming, such as the sparse PCA problem. We extensively test our methodology on synthetic problems, and show how our ideas perform in practice. We give sufficient conditions that guarantee that the optimalvalue of both our programs match the optimal value of the semidefinite relaxation.

4 On Efficiency and The Jain'S Fairness Index in Integer Assignment Problems

Nahid Rezaeinia, Julio C. Góez, Mario Guajardo, NHH Norwegian School of Economics, Bergen, Norway. Contact: julio.goez@nhh.no

Given two sets of objects A and B, the integer assignment problem consists of assigning objects in A to objects in B. Traditionally, the goal of this problem is to find an assignment that maximizes or minimizes a measure of efficiency, such as utility or cost. Lately, the is growing interest for incorporating a measure of fairness. This paper studies the trade-off between these two criteria, using the Jain's index as a measure of fairness. The original formulation of the assignment problem with this index is a non-linear non-convex problem. We develop two reformulations, where one is based on a convex quadratic objective function and the other one is based on Mixed Integer Second-Order Cone Programming. We use these reformulations in instances of real-world data from an application of assigning personnel to projects, and with randomly generated instances.

Monday, 2 PM–3:15 PM

MD41

CC - Room 203

First-order Methods for Minimax Problems

General Session

Session Chair

Necdet Serhat Aybat, Penn State University, State College, PA

Session Chair

Mert Gurbuzbalaban, Rutgers University, Piscataway, NJ

Session Chair

Yassine Laguel, 1</sup

1 Robust Accelerated Primal-dual Methods for Computing Saddle Points

XUAN ZHANG[1], Necdet Serhat Aybat[1], Mert Gurbuzbalaban[2], [1]Penn State University, University Park, PA, [2]Rutgers University, Piscataway, NJ, Contact: nsa10@psu.edu

We consider strongly convex/strongly concave saddle point problems assuming we have access to unbiased stochastic estimates of the gradients. We propose a stochastic accelerated primal-dual (SAPD) algorithm and show that SAPD sequence, generated using constant primal-dual step sizes, linearly converges to a neighborhood of the unique saddle point, where the size of the neighborhood is determined by the asymptotic variance of the iterates. Interpreting the asymptotic variance as a measure of robustness to noise, we obtain explicit characterizations of robustness in terms of SAPD parameters and problem constants. Based on these characterizations, we develop computationally tractable techniques for optimizing SAPD parameters, i.e., step sizes and momentum parameters, to achieve a desired trade-off between the convergence rate and robustness on the Pareto curve.

2 A Variance-Reduced Stochastic Accelerated Primal Dual Algorithm

Bugra Can[1], Necdet Serhat Aybat[2], Mert Gurbuzbalaban[3], [1]Rutgers University, Newark, NJ, [2]Penn State University, University Park, PA, [3]Rutgers University, Piscataway, NJ

In this work, we consider smooth strongly convex strongly concave (SCSC) saddle point (SP) problems. Such problems arise frequently in machine learning in the context of robust empirical risk minimization (ERM), e.g. distributionally robust ERM, where partial gradients are estimated using mini-batches of data points. Assuming we have access to an unbiased stochastic first-order oracle we consider the stochastic accelerated primal dual (SAPD) algorithm recently introduced in Zhang et al. [2021] for SCSC SP problems as a robust method against gradient noise. We propose efficient variance-reduction strategies for SAPD based on Richardson-Romberg extrapolation and show that our method improves upon SAPD both in practice and in theory.

3 SAPD+: An Accelerated Stochastic Method for Nonconvex-concave Minimax Problems

Xuan Zhang[1], Necdet Serhat Aybat[2], Mert Gurbuzbalaban[3], [1]The Pennsylvania State University, STATE COLLEGE, PA, [2]Penn State University, University Park, PA, [3]Rutgers University, Piscataway, NJ, Contact: xxz358@psu.edu

We propose a new stochastic method SAPD for solving nonconvex-concave minimax problems of the form min max f(x)+□(x,y)-g(y), where f,g are closed convex and □(x,y) is a smooth function that is weakly convex in x, (strongly) concave in y. For both strongly concave and merely concave settings, SAPD+ achieves the best known oracle complexities of O($L\square_y\square^{-4}$) and O($L^3\square^{-6}$), respectively, without assuming compactness of the problem domain, where □y is the condition number and L is the Lipschitz constant. We also propose SAPD+ with variance reduction, which enjoys the best known oracle complexity of O($L\square_y^2\square^{-3}$) for weakly convex-strongly concave setting. We demonstrate the efficiency of SAPD+ on a distributionally robust learning problem with a weakly convex cost and also on a multi-class classification problem in deep learning.

4 A Robust Perspective on Acceleration for Saddle Point Problems

Yassine Laguel, Rutgers University, NJ

Risk averse optimization plays a major role in the design of safe and robust models for decision-making. In this talk, we revisit the bias-variance trade-off of stochastic first-order methods from a robust perspective. Precisely, we study the convergence properties of accelerated methods on saddle-point problems for diverse robustness metrics. We deduce new ways to set the associated hyperparameters in order to stabilise the algorithm at the equilibrium. We illustrate the interest of such approach on a series of numerical experiments inspired from game theory and distributionally robust optimization.

Monday, 2 PM–3:15 PM

MD42

CC - Room 204
Advances in Stochastic Derivative-free Optimization
General Session

Session Chair
Yunsoo Ha, NC State, Raleigh, NC

Session Chair
Sara Shashaani, North Carolina State University, Raleigh, NC

1 Advancing Algorithmic Foundation of Robust Deep Learning Through The Lens of Bi-level Optimization

Sijia Liu, Yihua Zhang, Michigan State University, East Lansing, MI

Adversarial training (AT) is a widely recognized defense mechanism to gain the robustness of deep neural networks against adversarial attacks. In this presentation, we advance AT from the fresh perspective of bi-level optimization (BLO). Inspired by BLO, we design and analyze a new set of robust training algorithms termed Fast Bi-level AT (Fast-BAT), which effectively defends sign-based projected gradient descent (PGD) attacks without using any gradient sign method or explicit robust regularization. In practice, we show that our method yields substantial robustness improvements over multiple baselines across multiple models and datasets.

2 A Projection-free Algorithm for Constrained Stochastic Multi-level Composition Optimization

Tesi Xiao[1], Krishnakumar Balasubramanian[2], Saeed Ghadimi[3], [1]University of California, Davis, Davis, CA, [2]University of California, Davis, Lincoln, [3]University of Waterloo, Waterloo, ON, Canada. Contact: texiao@ucdavis.edu

We propose a projection-free conditional gradient-type algorithm for smooth stochastic multi-level composition optimization, where the objective function is a nested composition of T functions and the constraint set is closed and convex. Our algorithm assumes access to noisy evaluations of the functions and their gradients. We show that the number of calls to the stochastic first-order oracle and the linear-minimization oracle required by our algorithm, to obtain an ϵ-stationary solution, are of order $O_T(\epsilon^{-2})$ and $O_T(\epsilon^{-3})$ respectively. In particular, we provide a high-probability convergence result for T=1. Notably, our algorithm is parameter-free and does not require any (increasing) order of mini-batches to converge unlike the common practice in the analysis of stochastic conditional gradient-type algorithms.

3 Momentum-based Variance-reduced Proximal Stochastic Gradient Method for Composite Nonconvex Stochastic Optimization

Yangyang Xu[1], Yibo Xu[2], [1]Rensselaer Polytechnic Institute, Troy, NY, [2]Clemson University, Clemson, SC, Contact: yibox@g.clemson.edu

Stochastic gradient methods (SGMs) have been extensively used in stochastic optimization. Most of recent methods require a large number of samples in some or all iterations. In this work, we propose a new SGM, named PStorm, for solving nonconvex nonsmooth stochastic problems. With a momentum-based variance reduction technique, PStorm achieves the optimal complexity result $O(\epsilon^{-3})$ to produce a stochastic ϵ-stationary solution, if a mean-squared smoothness condition holds. Different from existing optimal methods, PStorm can achieve the $O(\epsilon^{-3})$ result by using only one or O(1) samples in every update. With this property, PStorm can be applied to online learning problems that favor real-time decisions. As we demonstrate for training neural networks, PStorm can generalize better than other optimal methods which require large-batch training and the vanilla SGM.

4 Work Complexity of Stochastic Derivative-free Trust-region Optimization

Yunsoo Ha, Sara Shashaani, NC State, Raleigh, NC

We focus on the complexity analysis for stochastic model-based derivative free optimization (DFO) with adaptive sampling. The existing literature on assessing stochastic DFO algorithms focuses on ``iteration complexity", which analyzes the number of iterations until achieving a near-optimal solution. However, the iteration complexity cannot reflect the computational burden well because it mainly involves function evaluations. Spending more effort within each iteration could reduce the iteration complexity but would not necessarily reduce the total computation. Hence, we analyze the ``work complexity" or the number of function evaluations until achieving a near-optimal solution.

Monday, 2 PM–3:15 PM

MD43

CC - Room 205
Optimization in Transportation Applications
Contributed Session

Session Chair
Zuhayer Mahtab, University of Southern California, Los Angeles, CA

1 **Optimization and Heursitic Approaches for a Multi-objective Multi-vehicle Routing Problem Considering Human-robot Interactions**
Venkata Sirimuvva Chirala, Wayne State University, Detroit, MI, Contact: go1577@wayne.edu
Unmanned ground vehicles (UGVs) are used in civilian and military applications. In many applications of multirobotic systems, teamwork between human and robots is essential. We consider a multi-objective, multiple-vehicle routing problem in which teams of manned ground vehicles (MGVs) and UGVs are deployed in a leader-follower framework to execute missions with differing requirements for MGVs and UGVs while considering human-robot interactions (HRI). HRI studies highlight the costs of managing a team of follower UGVs by a leader MGV. We develop a combinatorial, multi-objective optimization model that can be solved to optimality by off-the-shelf commercial solvers for small-sized instances of the considered problem. We further develop the variable neighborhood search heuristic to address the challenges that arise when scaling the optimization model.

2 **An Algorithm for The Heterogeneous Dial-a-ride Problem**
Laura Portell, Helena Ramalhinho, University Pompeu Fabra, Barcelona, Spain. Contact: portell.laura@gmail.com
Dial-a-ride problems consist of designing routes for transporting people from a specific origin to a specific destination. In particular, we deal with the transport of people with reduced mobility and consider constraints such as wheelchair and regular seating, heterogeneity of vehicles, grouping of people who have to travel together, time windows or maximum travel time limits of users. We propose a mathematical model and an algorithm for solving the problem and examine its efficiency and service quality. The resulting framework is applied to a real case for the Special Transport Service for People with Reduced Mobility in the city of Barcelona.

3 **Online Algorithms for a Multi-visitor Tourist Trip Design Problem**
Jesse M. Nagel, CWI, Amsterdam, Netherlands. Contact: jesse.nagel@cwi.nl
Tourist destinations can experience large amounts of congestion, causing long queues. Efficiently distributing tourists over tourist destinations results in a better use of resources. Models to create such a distribution have been succesfully developed. Current algorithms for this problem assume the set of users and their wishes to be known in advance. Such information is not always available. Therefore, we introduce an online variant of this problem where tourists are revealed to the algorithm one-by-one. The algorithm must immediately and irrevocably decide which sites a tourist can visit. Algorithms to solve this problem are presented, varying the amount of advance knowledge the algorithm has on the users. We compare these algorithms to those available for the deterministic variant of the problem. Finally, we show bounds on the competitive ratios of the algorithms.

4 **A Branch & Cut & Price Algorithm for The Ride-sharing Problem with Flexible Meeting Points**
Zuhayer Mahtab[1], Maged M. Dessouky[2], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, Contact: mahtab@usc.edu
Ride-sharing systems can provide flexible and cost-efficient commute options to the customers and at the same time reduce traffic congestion and fuel consumption. In this paper, we optimize a ride-sharing system where drivers are regular commuters and take detours to provide rides to customers to recover some of their costs. We propose a branch and cut and price algorithm that can provide an optimized routing plan for the system with service time and capacity constraints and consider flexible pickup and drop-off points. We also consider the possibility of using HOV lanes. Our proposed method can solve small to medium-sized problems (networks of up to 100 nodes) efficiently.

Monday, 2 PM–3:15 PM

MD44

CC - Room 206
Modeling and Optimizing Matching Markets
General Session

Session Chair
Xuan Zhang, Meta, Core Data Science, Belmont, CA

1 **Efficient Matching in Dynamic Labor Markets**

Srinivasa Kartikeya Puranam[1], Michael N. Katehakis[2], [1]Rutgers University, Camden, NJ, [2]Rutgers University, Piscataway, NJ, Contact: kartys.here@gmail.com

We study a multi-period labor market where applicants and employers arrive at random. A job facilitator like an employment agency matches applicants with jobs. Both applicants and employers can reject the match and wait for a better match. Higher compatibility between matched applicant and employer leads to a higher utility for all parties involved. We study this problem from the perspectives of the employer and the facilitator.

2 **Discovering Opportunities in New York City's Discovery Program**

Yuri Faenza[1], Swati Gupta[2], Xuan Zhang[3], [1]Columbia University, New York, NY, [2]ISyE Georgia Tech, Atlanta, GA, [3]Meta, Core Data Science, Menlo Park, CA

Discovery program is an affirmative action policy used by NYC Department of Education to increase admissions for disadvantaged students at specialized high schools (SHS). However, empirical analyses from recent academic years show that the current implementation could violate disadvantaged students' priorities at preferred schools and unintentionally create an incentive for them to under-perform. We thus explore two alternative policies that can be used to address these issues with minimal modification, which are Minority Reserve (MR) and Joint Seat Allocation (JSA). We characterize a condition, which we term as high competitiveness, under which JSA dominates MR. Furthermore, we show that the NYC SHS market satisfies this condition. Thus, we propose that the discovery program can be changed for the better by implementing the JSA mechanism.

3 **A Systematic Approach to Selection Problems**

Carlos Bonet[1], Nicholas A. Arnosti[2], Jay Sethuraman[1], [1]Columbia University, New York, NY, [2]Columbia Business School, Saint Paul, MN, Contact: cbonet23@gsb.columbia.edu

We discuss a systematic approach to *Prioritized Selection Problems*, in which an organization is presented with a set of individuals, and must choose which subset to accept. We assume that the organization has a complete priority ranking of the individuals. Besides, the selection rule may be constrained to select from a pre-defined set of feasible subsets. We identify a natural family of rules—*sequential dictator rules*—and provide an axiomatic characterization. In cases where the feasible subsets are implicitly specified through upper and lower quotas or through reserves, we identify special cases for which there exists a selection that unambiguously selects higher priority individuals than any other feasible selection. We also identify conditions under which this selection can be found in polynomial time, and conditions in which doing so is computationally hard.

4 **Zone Optimization for Public Schools**

Mobin Y.Jeloudar, Stanford, CA

More than sixty years after *Brown v. Board of Education*, segregation by race and class still remains a growing problem in public schools. We explore this issue, in the context of public-school choice in the San Francisco Unified School District (SFUSD). The current choice system for student assignment allows children of elementary school age to apply to any number of schools of their choosing, from the set of *all* schools in the city-wide district. What this results in is an overly complicated system. We use advanced mathematical techniques to design a system in which elementary school education is provided in a more equitable and efficient manner. Our proposed solution begins with the designation of "zones" whereby students are able to apply only to schools that are within the limits of the zone in which they live.

Monday, 2 PM–3:15 PM

MD45

CC - Room 207

AI4OPT: Meta-algorithms Selecting a "Best" Algorithm with AI, and the Use of Pairwise Relationship to Enhance Resiliency of ML Techniques

General Session

Session Chair

Dorit Simona Hochbaum, University of California-Berkeley, Berkeley, CA

1 **Automatic Algorithm Selection for Np-hard Problems with Limits on Computational Resources**

Dorit Simona Hochbaum[1], Roberto Asín-Achá[2], Isaias Huerta[1], Julio Godoy[2], Olivier Goldschmidt[3], [1]University of California-Berkeley, Berkeley, CA, [2]Universidad de Concepción, Concepción, Chile; [3]Make Systems, Berkeley, CA

For NP-hard problems, we address the issue of selecting a "best" algorithm out of a given portfolio subject to a user-specified limit on running time. Current state-of-the-art approaches for such automatic algorithm selection tasks do not consider user-specified limits. We present insights derived from applying such approach for Traveling Salesperson, Graph Coloring and Knapsack problems. For instance, the selected algorithm varies significantly across problem benchmarks and given time limits. This method is demonstrated to perform better than using the single best solver in the portfolio. Our approach is shown to generalize to incorporate additional user-specified limits on memory, energy consumption, number of processing units, etc.

2 Fast Algorithm for the Capacitated Vehicle Routing Problem (CVRP) Using Machine Learning Selection of Algorithm's Parameter

Isaias Ignacio Huerta Vargas[1], Roberto Asín-Achá[2], Dorit Simona Hochbaum[1], Olivier Goldschmidt[3], [1]University of California-Berkeley, Berkeley, CA, [2]Universidad de Concepción, Concepción, Chile; [3]Riverside County Office of Education, Riverside, CA

We present Machine Learning algorithms for automatically determining algorithm's parameters for solving CVRP. We use the sweep algorithm which assigns customers to a truck, in a wedge area of a circle of parametrically selected radius around the depot, with demand up to its capacity. We show how to use Convolutional Neural Network and other Machine Learning Algorithms and compare their performance. We demonstrate that the automatically configured algorithm delivers faster solutions for CVRP with comparable quality of solutions to that of current algorithms. We also present new real world data based on customers locations in Los Angeles and New York city areas, which contribute to the benchmark of Vehicle Routing Problems.

3 An Integer Programming-based Algorithm for Semi-supervised Clustering

Philipp Baumann[1], Dorit Simona Hochbaum[2], [1]University of Bern, Bern, Switzerland; [2]University of California-Berkeley, Berkeley, CA, Contact: philipp.baumann@unibe.ch

We propose a new variant of the k-means algorithm for semi-supervised clustering. The algorithm uses integer programming to incorporate side information about desirable clusters that is given in the form of pairwise relationships between objects. In a comprehensive computational experiment, we demonstrate that our algorithm clearly outperforms the state-of-the-art algorithm in terms of cluster quality and running time. Moreover, we show that it performs particularly well in situations where the pairwise relationships are noisy due to corrupt ground truth.

4 Label Confidence-Supervised Normalized Cut: A Graph-based Classifier that Relies on Pairwise Similarities and Its Robustness Against Label Noise

Torpong Nitayanont, Dorit Simona Hochbaum, UC Berkeley, Berkeley, CA, Contact: torpong_nitayanont@berkeley.edu

Supervised Normalized Cut (SNC) is a graph-based classifier that is based on the Hochbaum's Normalized Cut. SNC relies on pairwise similarities between samples, with the assumption that similar samples tend to share the same label. However, some of the given labels can be inaccurate. SNC is not specifically designed to handle label noise. In this work, we propose a method called Label Confidence SNC (LC-SNC), where two modifications are introduced. The first is the use of label confidence, which tackles the issue of noisy labels. The other modification involves the balance between sample classes. Experimental results show that LC-SNC achieves significantly better performance than SNC, with and without the presence of label noise. It also exhibits decent performance compared to other models that utilize pairwise similarities such as the k-nearest neighbor classifier.

Monday, 2 PM–3:15 PM

MD46

CC - Room 208
Public Sector Transportation Services
General Session

Session Chair
Peter Zhang, Carnegie Mellon University, Pittsburgh, PA

Session Chair
Mark Brennan, Massachusetts Institute of Technology, Cambridge, MA

1 Implementing a Differentiated Ambulance Service Model to Care for Vulnerable Populations

Mark Brennan[1], Justin Steil[1], Jonas Oddur Jonasson[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Sloan School of Management, Somerville, MA, Contact: mbrenn@mit.edu

This study documents more than five years of analytics that drove the policy case, deployment, and retrospective evaluation for an innovative service model that enables a major urban EMS agency to respond quickly and effectively to investigation incidents. We report the pre-intervention analytics in 2017 that built the policy case for service segmentation, a new team that primarily responds to investigation incidents. Next, we report a post-intervention, observational evaluation of its operational advantages and trade-offs. This study documents the descriptive analytics that built the successful policy case for a major change in the healthcare-delivery supply chain in Boston and how this change offers operational advantages.

2 Demand Learning and Supply Optimization for Last Mile Transportation in Low-income Neighborhood

Hao Hao, Peter Zhang, Carnegie Mellon University, Pittsburgh, PA, Contact: pyzhang@cmu.edu

We examine ridership trend of last-mile transportation in low-income neighborhood in the past three years by looking into a detailed dataset including stop-by-stop information, and propose potential ways to improve efficiency amid ridership uncertainty.

3 Optimizing School Schedules in San Francisco

Sebastien Martin, Northwestern University, Kellogg school of management, Cambridge, MA

We developed a multiobjective optimization framework to evaluate the policy tradeoffs of changing start times at the San Francisco Unified School District (SFUSD). We used our methodology to optimize start times for SFUSD's post-COVID reopening in the spring of 2021. In addition, we developed participative tools that SFUSD used to select new start times for the Fall of 2021, satisfying several community priorities, and leading to projected transportation savings of up to $3 million per year

4 Spatio-temporal Point Processes with Attention for Traffic Congestion Event Modeling

Shixiang Woody Zhu, Carnegie Mellon University, Pittsburgh, PA, Contact: shixiangzhu@cmu.edu

We present a novel framework for modeling traffic congestion events over road networks. Using multi-modal data by combining count data from traffic sensors with police reports that report traffic incidents, we aim to capture two types of triggering effect for congestion events. Current traffic congestion at one location may cause future congestion over the road network, and traffic incidents may cause spread traffic congestion. To model the non-homogeneous temporal dependence of the event on the past, we use a novel attention-based mechanism based on neural networks embedding for point processes. To incorporate the directional spatial dependence induced by the road network, we adapt the "tail-up" model from the context of spatial statistics to the traffic network setting.

Monday, 2 PM–3:15 PM

MD47

CC - Room 209

Emerging Rail Technologies - Discussion

Panel Session

Session Chair

Ken Kenjale, Wabtec Corp., Pittsburgh, PA

1 Rail Applications Panel

Ken Kenjale, Wabtec, Indialantic, FL

As the rail industry advances beyond PTC and confronts automated trucking head on, usage of ML/AI and automation are going to be key enablers to remain competitive. In this session we discuss different concepts in these topics which have the potential to improve overall rail performance, from line of road and yard, to maintenance and planning.

2 Panelist

Stefano Rieppi, Norfolk Southern Railway, Roswell, GA

3 Panelist

Rammohan Venugopal, Wabtec, Norcross, GA

Monday, 2 PM–3:15 PM

MD48

CC - Room 210

Maintenance

Contributed Session

Session Chair

Melvin Drent, Eindhoven University of Technology, Eindhoven, Netherlands.

1 Real Time Planning of Maintenance by a Deep Reinforcement Learning Approach in a Semiconductor Assembly Shop

Michael Geurtsen, EIndhoven University of Technology, Eindhoven, Netherlands. Contact: m.geurtsen@tue.nl

In production scheduling and planning, more often than not, the maintenance operations are completely neglected. This is a missed opportunity as maintenance and production activities are deeply intertwined. To bridge this gap and attempt to bend both streams of manufacturing activities together, this study aims to find policies for executing maintenance activities with the goal of maximizing throughput. The maintenance activities are dynamically scheduled in an a shop floor comprised of multiple assembly lines that share limited resources. Policies are derived based on the given flexibility of the maintenance activity, the buffer content of the buffers in-between the machines in the assembly line, and the machine statuses. Deep reinforcement learning methods are developed and compared with both current factory practices and common maintenance policies.

2 **Real-time Integrated Learning and Decision Making for Deteriorating Systems**

Melvin Drent, Eindhoven University of Technology, Eindhoven, Netherlands. Contact: m.drent@tue.nl

We consider condition based maintenance of heterogenous components. We show that a state-dependent control limit is optimal. We provide extensive numerical analysis and show that our model outperforms state-of-the-art. A case study at Philips Healthcare highlights the practical value of our work.

3 **Integrated Approach for Maintenance Optimization: Presentation of An Operational Business Case in Transportation**

Carlyle Deligny, Artelys, Montreal, QC, Canada.

Resource planning is a central issue to improve cost management, productivity, quality of service for the end customer, and more. Artelys Crystal Resource Optimizer is a software specialized in the planning of activities and resources under constraints that accompanies your company during all the stages of its planning process. Artelys develops solutions applied to the optimization of the resource occupation planning for companies in logistics and transportation. The stakes are threefold: minimize operating costs, optimize the operational use of resources, and ensure that the organization's contractual commitments to its subcontractors and employees are respected. This business case will allow us to see how a complete prediction and optimization solution applied to maintenance planning is essential to maximize operational efficiency and minimize costs.

Monday, 2 PM–3:15 PM

MD49

CC - Room 211

Machine Learning/Reinforcement Learning in Vehicle Routing

General Session

Session Chair

Xinwei Chen, 1</sup

1 **Effective Training of Machine Learning Models for Dynamic Time Slot Management**

Liana van der Hagen[1], Barrett Thomas[2], Qihang Lin[2], Niels Agatz[1], Remy Spliet[1], [1]Erasmus University, Rotterdam, Netherlands; [2]University of Iowa, Iowa City, IA

In attended grocery home delivery, it is common to let customers choose a delivery time slot to receive their groceries. To effectively manage the time slot offering, the e-grocer must evaluate the available capacity for each time slot as customer orders come in. This corresponds to finding a feasible solution to the Vehicle Routing Problem with Time Windows (VRPTW) for each new customer and time slot. Instead of checking this feasibility using routing methods, it is possible to use Machine Learning (ML) to predict the feasibility of offering a time slot in this context. The performance of the ML model depends on the quality and quantity of the training data. However, obtaining labeled training data is computationally expensive, as it involves finding feasible solutions for VRPTW instances. In this talk, we focus on ways to interactively select informative training instances.

2 **Dynamic On-demand Crowdshipping Using Constrained and Heuristics-embedded Double Dueling Deep Q-network**

Nahid Parvez Farazi[1], Bo Zou[2], Theja Tulabandhula[2], Tanvir Ahamed[1], [1]Univerisity of Illinois at Chicago, Chicago, IL, [2]University of Illinois at Chicago, Chicago, IL

We propose a deep reinforcement learning (DRL)-based approach for a dynamic on-demand crowdshipping problem in which shipping requests constantly arrive throughout the day. The request pickup and delivery are performed by crowdsourcees, who are ordinary people dynamically arriving at and leaving the crowdshipping system and dedicate their limited available time and carrying capacity to crowdshipping. In return, crowdsourcees get paid by the delivery service provider who periodically assigns requests to crowdsourcees in the course of a day to minimize total shipping cost. To tackle this problem, we employ dynamic DRL training with the Double Dueling Deep Q-Network algorithm. A tailored simulator is developed where the DRL agent is able to use intuitive reasoning-based local search heuristics to make request-crowdsourcee assignments and construct routes.

3 **Maximizing The Service Level over Time in Same-day Delivery with Demand Evolution**

Xinwei Chen[1], Tong Wang[2], Marlin Wolf Ulmer[3], Barrett

Thomas[2], [1]Bucknell University, Lewisburg, PA, [2]University of Iowa, Iowa City, IA, [3]Otto-von-Guericke Universität Magdeburg, Magdeburg, Germany. Contact: xc003@bucknell.edu

Same-day delivery (SDD) has gained particular attention since the COVID-19 pandemic. The increasing demand for SDD brings challenges in how to efficiently deliver the service. Existing research focuses on maximizing the service level with relatively stable customer demand. However, the number of customer requests may evolve depending on the historical service level. For example, in practice, more customers are expected to be attracted if the service level increases in a neighborhood, and vice versa. In this talk, we model the evolution of customer demand in SDD and analytically study the structure of the optimal solution. Using the analytical results, we then develop a deep reinforcement learning approach to maximize the service level over time.

4 On-demand Delivery from Stores: Dynamic Dispatching and Routing with Random Demand

Sheng Liu[1], Zhixing Luo[2], [1]University of Toronto, Toronto, ON, Canada; [2]Nanjing University, Zurich, China. Contact: sheng.liu@rotman.utoronto.ca

Motivated by a large grocery chain store who offers fast on-demand delivery services, we model and solve a stochastic dynamic driver dispatching and routing problem for delivery systems where on-time performance is the main target. We propose a novel structured approximation framework to approximate the value function via a simplified dispatching and routing policy. We analyze the structural properties of the approximation framework and establish its performance guarantee under large-demand scenarios. We then develop efficient exact algorithms for the approximation problem based on Benders decomposition and column generation, which deliver verifiably optimal solutions within minutes.

Monday, 2 PM–3:15 PM

MD50

CC - Room 212

Online Communities and AI adoption

General Session

Session Chair

Jiahui Mo, Clemson University, SC

1 Incorporating Learning Machines into Online Community Governance: Evidence from Wikipedia's Anti-vandal Bots

Lei (Nico) Zheng[1], Feng Mai[2], Bei Yan[2], Jeffrey V. Nickerson[1], [1]Stevens Institute of Technology, Hoboken, NJ, [2]Stevens Institute of Technology, Hoboken, NJ, Contact: lzheng9@stevens.edu

Automated machines that use statistical learning algorithms are increasingly used to govern online communities. This study theorizes and examines the consequence of adopting learning machines in online community's governance. Specifically, we look at how the adoption of a platform-wide, statistical learning-based anti-vandalism bot, ClueBot NG, affects Wikipedia's governance outcome. We find the learning bot significantly reduced the number of vandalism attempts and improved the community's overall response time. But it also introduced second-order effects that created new challenges: vandals learned to attack in novel ways and human editor's response time drastically increased. Our study provides new insights on how the learning machine's unique characteristics can reshape online community governance.

2 The Role of Social Exchange and Active Learning on Crowdsourcing Platforms

Pei Xu[1], De Liu[2], Liang Chen[3], [1]Auburn University, Auburn, AL, [2]University of Minnesota, Minneapolis, MN, [3]West Texas A&M University, Auburn, AL, Contact: pzx0002@auburn.edu

Crowd voting is a relatively inexpensive and scalable way of selecting candidates in crowdsourcing contests. Prior studies have overlooked the dynamic of voters' skillset and social exchange on online crowdsourcing platforms. We empirically investigate how voters' active learning and social exchange could impact voters' performance.

3 The Role of Fair Pay for Performance in The Decentralized Networks: Evidence from Steemit

Woojin Yang[1], Yeongin Kim[2], Chul Ho Lee[3], Tae Hun Kim[4], Yasin Ceran[5], [1]Korea Advanced Institute of Science & Technology (KAIST), Daejeon, Korea, Republic of; [2]Virginia Commonwealth University, Glen Allen, VA, [3]Korea Advanced Institute of Scient & Technology (KAIST), Daejeon, Korea, Republic of; [4]Ajou University, Suwon, Korea, Republic of; [5]Korea Advanced Institution of Science & Technology (KAIST), Daejeon, Korea, Republic of. Contact: dnwls2669@kaist.ac.kr

Social media platforms are increasingly operating on new business models that utilize a distributed ledger, a blockchain. As many blockchain technologies incentivize users with cryptocurrency, designing an effective incentive scheme is essential. This paper empirically examines the impact of fairness in incentive scheme on user activities in a social media. We found fair rewards allocation rule have a positive effect on the quantity and quality of contents generated by a user. Further, we estimate heterogeneous effects depending on capital and reputational resources a user holds. This work contributes to the organizational and IS field by observing the impact of the shift in allocation rule within a community.

4 The Value of Being Smarter: An Empirical Study of Consumers' Willingness-to-pay for Smart Features in Vehicles

Yuanyuan Chen, The University of Alabama, Tuscaloosa, AL, Contact: ychen200@cba.ua.edu

The automobile industry has recently enhanced vehicle driver assistance features by integrating hardware, AI software, sensors, data storage, and connectivity into products that were once composed solely of mechanical and electrical parts, transforming vehicles to become intelligent and connected cars. However, despite the perceived benefits of smart vehicles and the global trend toward vehicle automation, the adoption of smart technology-powered cars has been limited and, in many cases, has fallen short of expectations. As a result, carmakers are concerned about managing and optimizing the adoption of smart cars. In this study, we use monthly car sales data in China from 2010-2020 to study consumers' WTP for different types of AI-powered smart attributes in vehicles. The study has significant managerial implications and policy implications.

Monday, 2 PM–3:15 PM

MD51

M - Santa Fe

Service Science Best Student Paper

Flash Session

Session Chair

Meng Li, University of Houston, Houston, TX

1 Designing Layouts for Sequential Experiences: Application to Cultural Institutions

Ali Aouad[1], Abhishek Deshmane[2], Victor Martinez de Albeniz[2], [1]London Business School, London, United Kingdom; [2]IESE Business School, Barcelona, Spain.

Experience providers - ranging from retail platforms to cultural institutions - need to decide on how to display an assortment of items for physical and digital interactions. In this paper, we develop a data-driven analytics framework to optimize these layout-related decisions for maximum user engagement. We develop a new dynamic choice model, called Pathway MNL, that represents visitor activity as a sequence of conditional logit experiments. Through an ongoing collaboration with the Van Gogh Museum, we validate the model on large-scale logs of visitor activity recorded through audio guides. We uncover significant relationships between visitors' choices and layout-related factors, among others. Finally, we analyze the resulting mathematical program for layout optimization and identify simple layout interventions that can significantly lift visitor engagement.

2 Planning Bike Lanes with Data: Ridership, Congestion, and Path Selection

Jingwei Zhang[1], Auyon Siddiq[2], Sheng Liu[3], [1]UCLA Anderson School of Management, Los Angeles, CA, [2]University of California-Los Angeles, Los Angeles, CA, [3]University of Toronto, Toronto, ON, Canada. Contact: jingwei.zhang.phd@anderson.ucla.edu

Urban bike lane expansion promotes cycling and reduces vehicle traffic, but narrows vehicle lanes and amplifies congestion. We study the bike lane planning problem while accounting for the conflicting effects. In an extensive case study on the City of Chicago with data collected from 8 sources, we first present a consistent estimator for travel-time parameters and then optimize new bike lane locations while enforcing traffic equilibrium. As a result, we estimate that adding 25 miles of bike lanes as prescribed by our model can lift ridership from 3.9% to 6.9%, with at most an 8% increase in driving times.

3 Learning Across Bandits in High Dimension via Robust Statistics

Kan Xu, University of Pennsylvania, Philadelphia, PA

Decision-makers often face the "many bandits" problem, where one must simultaneously learn across related but heterogeneous contextual bandit instances. For instance, a large retailer may wish to dynamically learn product demand across many stores to solve pricing or inventory problems, making it desirable to learn jointly for stores serving similar customers; alternatively, a hospital network may wish to dynamically learn patient risk across many providers to allocate personalized interventions, making it desirable to learn jointly for hospitals serving similar patient populations. We study the setting where the unknown parameter in each bandit instance can be decomposed into a global parameter plus a sparse instance-specific term. Then, we propose a novel two-stage estimator that exploits this structure in a sample-efficient way by using a combination of robust statistics (to learn across similar instances) and LASSO regression (to debias the results). We embed this estimator within a bandit algorithm, and prove that it improves asymptotic regret bounds in the context dimension *d*; this improvement is exponential for data-poor instances. We further demonstrate how our results depend on the underlying network structure of bandit instances. Finally, we illustrate the value of our approach on two real datasets in healthcare operations and dynamic pricing.

4 Split Liver Transplantation: An Analytical Decision Support Model

Yanhan (Savannah) Tang[1], Alan Scheller-Wolf[1], Sridhar R. Tayur[1], Emily R. Perito[2], John P. Roberts[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of California, San Francisco, San Francisco, CA

Split liver transplantation (SLT) is a procedure that potentially saves two lives using one liver, increasing the total benefit derived from the limited number of donated livers available. SLT may also improve equity, by giving transplant candidates who are physically smaller (including children) increased access to liver transplants. However, SLT is rarely used in the US. To help quantify the benefits of increased SLT utilization and provide decision support tools, we introduce a deceased-donor liver allocation model with both efficiency and fairness objectives. We formulate our model as a multi-queue fluid system, incorporating the specifics of donor-recipient size matching and patients' dynamically changing health conditions. Leveraging a novel decomposition result, we find the exact optimal matching procedure, enabling us to benchmark the performance of different allocation policies against the theoretical optimal. Numerical results, utilizing data from UNOS, show that increased utilization of SLT can significantly increase total quality-adjusted life years, reduce patient deaths, and improve fairness among different patient groups.

5 Behavior-Aware Queueing: The Finite-Buffer Setting with Many Strategic Servers

Yueyang Zhong[1], Raga Gopalakrishnan[2], Amy R. Ward[1], [1]The University of Chicago Booth School of Business, Chicago, IL, [2]Smith School of Business at Queen's University, Kingston, ON, Canada.

Service system design is often informed by queueing theory. Traditional queueing theory assumes that servers work at constant speeds. While this is reasonable in computer science and manufacturing contexts, servers in service systems are people, and, in contrast to machines, both systemic and monetary incentives created by design decisions impact their work speeds. We use asymptotic analysis to study how server work speed is affected by managerial decisions concerning (i) how many servers to staff and how much to pay them, and (ii) whether and when to turn away customers, in the context of a finite-buffer many-server queue in which the work speeds emerge as the solution to a noncooperative game. In addition, we characterize the "price of anarchy" by comparing the performance under the equilibrium with that under the optimal solution to the centralized optimization problem.

6 Fair Assortment Planning

Qinyi Chen, MIT, Cambridge, MA

Many online platforms, ranging from online retail stores to social media platforms, employ algorithms to optimize their offered assortment of items (e.g., products and contents). These algorithms tend to prioritize the platforms' short-term goals by solely featuring items with the highest popularity or revenue. However, this practice can then lead to too little visibility for the rest of the items, making them leave the platform, and in turn hurting the platform's long-term goals. Motivated by that, we introduce and study a fair assortment planning problem, which requires any two items with similar quality/merits to be offered similar visibility. We show that the problem can be formulated as a linear program (LP), called (FAIR), that optimizes over the distribution of all feasible assortments. To find a near-optimal solution to (FAIR), we propose a framework based on the Ellipsoid method, which requires a polynomial-time separation oracle to the dual of the LP. We show that finding an optimal separation oracle to the dual problem is an NP-complete problem, and hence we propose a series of approximate separation oracles, which then result in a 1/2-approx. algorithm and a PTAS for the original Problem (FAIR), as well as an FPTAS for a special case of our problem (FAIR) with uniform revenues. The approximate separation oracles are designed by (i) showing the separation oracle to the dual of the LP is equivalent to solving an infinite series of parameterized knapsack problems, and (ii) taking advantage of the structure of the parameterized knapsack problems. Finally, we conduct a case study using the MovieLens dataset, which demonstrates the efficacy of our algorithms and also sheds light on the price of fairness.

7 Structuring Online Communities

Neha Sharma, Kellogg School of Management, Evanston, IL

Online Question and Answer communities were started to supplement customer support services. In contrast to conventional customer support, users in online communities can post questions, and other users with more experience or knowledge can answer these questions. Generally, question answerers get rewards and visibility in the community while the askers gain knowledge if their questions get answered.

We model the community as a multistage stochastic game, where users can ask questions and other more knowledgeable users can answer their questions. We study how users decide to join, leave, and participate in these communities. We link the user participation decisions to the underlying network structure of the community. Finally, we explore community moderation, i.e., the cost of asking questions, as a potential lever to balance user participation (traffic) and user satisfaction.
We find the stationary equilibrium of this game and theoretically show that only a core-periphery network structure can emerge in such communities. This network structure has been empirically observed in most online communities. Furthermore, we find that increasing the user's cost of asking questions does not always decrease the size of the community. Instead, it improves the proportion of questions answered and consequently lowers the rate of users leaving the platform unsatisfied. However, a higher asking cost lowers the participation level in the community. This trade-off between participation and community efficiency results in non-monotonicity in the number of users in the community with the participation cost.

8 When Harry Won't Meet Sally: Gender Disparity in Online Learning Platforms

Zhihan (Helen) Wang, Ross School of Business, University of Michigan, Ann Arbor, MI

Education technology innovations such as Massive Open Online Courses (MOOCs) platforms could potentially enable a more inclusive learning environment by delivering education to traditionally-disadvantaged learners such as women. However, inclusivity does not necessarily translate into equal treatment on the platform. We investigate whether female and male learners benefit equally from forum discussions---typically the only form of interaction available---in online learning platforms. Utilizing a large-scale, interaction-level dataset on 174 courses on Coursera, we uncover an economically sizable and statistically significant disparity between male and female learners in receiving responses to their posts in MOOC discussion forums. On average, female learners' questions are 3.11 percentage points (pp) less likely to receive responses from teaching staff than male learners', which equals 15.2% of the female group average. We investigate possible mechanisms behind the gender disparity using new techniques including textual analysis tools. We show that the disparity is not due to content differences in male and female learners' posts, nor is it attributable to their linguistic styles or the reputation of the posters. Instead, our results are most consistent with a male-driven, gender homophily mechanism---although female staff is gender-neutral in their interactions with learners, male staffs systemically prefer responding to posts from male learners. We additionally show that receiving staff response leads to significant improvement in course passing rates, particularly for female learners. Therefore, the unequal access to information through course forums unfavorably hinders female learners' performance. Our results provide both operational and organizational suggestions to platforms and content providers, including (1) the de-gendering of user identifiers, (2) a content-focused post recommendation system, (3) a gender-neutral user reputation system, and (4) promoting the recruiting of female teaching staff, and (5) staff training that highlights the importance of gender-neutral interactions.

9 Matchmaking Strategies for Maximizing Player Engagement in Video Games

Xiao Lei, University of Hong Kong, Hong Kong, Hong Kong.

We propose a general framework to analyze the dynamic matching problem in online video games, aiming to maximize player engagement. Players have different skill levels, which affect the outcomes of matches, and the win-loss record influences their willingness to remain engaged. We fully characterize the optimal matching policy on a stylized model where there are two skill levels, and players churn only when they experience a losing streak. The optimal policy always matches as many low-skilled players who are not at risk of churning to high-skilled players who are one loss away from churning. Compared to the industry status quo that matches players with the same skill level together, we prove the benefit of optimizing the matchmaking system grows linearly with the number of skill levels. Our framework can also handle the addition of AI bots and pay-to-win system.

Monday, 2 PM–3:15 PM

MD52

M - Lincoln
Industry Job Panel
Panel Session

Session Chair
Cristiana L. Lara, Amazon, Bellevue, WA

1 Moderator

Cristiana L. Lara, Amazon, Seattle, WA

The purpose of this session is to bring visibility to the students and postdocs looking for non-academic positions. Panelists from business and industry will share their experiences. This panel discusses their experiences in the interview process along with the do's & don'ts associated with the job search.

2 **Panelist**
Yankai Zhang, Kinaxis, Kanata, ON, Canada.

Monday, 2 PM–3:15 PM

MD53

M - Denver
Marketing
Contributed Session

Session Chair
Ayush Jain, IBM Research India, Lucknow, India.

1 The Drivers of Review Helpfulness and Review Unhelpfulness

Yoonsun Jeong, University of Texas at El Paso, El Paso, TX, Contact: yjeong@utep.edu
As online reviews become a major factor in the consumer decision making process, firms have started seeking ways to help consumers make informed decisions. To avoid potential information overload, most online retailers provide review helpfulness features by allowing consumers to cast a vote on the (un)helpfulness of a review. Previous research has extensively focused on identifying the drivers of review helpfulness while little attention has been paid to review unhelpfulness. Using an empirical analysis of over 2.5 million reviews across nine product categories from a major online retailer, this research investigates the drivers of both review helpfulness and unhelpfulness. By revealing the asymmetry between the consumers' review helpfulness and unhelpfulness voting behaviors, this study provides practical implications for review platforms.

2 Politicizing Policy Response? Ramifications and Remedies

Min Zhang[1], Chengyue Huang[2], Natasha Zhang Foutz[3], Rui Chen[4], Weiguo Fan[2], [1]The University of Iowa, Iowa City, IA, [2]The University of Iowa, Iowa City, IA, [3]University of Virginia, Charlottesville, VA, [4]Iowa State University, Ames, IA, Contact: min-zhang@uiowa.edu
Politicized policy responses (PPR) have become a serious problem in recent years in the US. Such PPR essential mitigation policies diminish policy effectiveness, instill distrust in science, elevate risky behavior, intensify, and prolong disasters. In this paper, we propose a novel computational framework that can conceptualize and quantify the ramifications and mechanisms of the danger of politicizing policies and advise remedial strategies in social data. The findings suggest that 1) politicized anti-policy messages receive higher engagement and its production is stimulated by existing anti-policy messages. The mechanisms driving those ramifications include widening reach and diverting the persuasion route from central to peripheral. 2) PPR will not only widen the spread of anti-policy messages but also weaken the propagation of pro-policy messages.

3 Green Marketing in Marketing and Related Fields: Theoretical Roots, Research Trajectories, and Research Themes

Shaoshan Wang, Matthew Ting Chi Liu, University of Macao, Macao, Macao.
This study aims to provide the theoretical roots, research trajectories, and research themes and propose promising research avenues for green marketing in marketing and related fields. This study integrated three bibliometric analyses: co-citation analysis, historical direct citation analysis, and co-occurrence analysis. Further, this study also conducted a qualitative review to examine the obtained quantitative results. The findings show that the theoretical roots are characterized by eight groups of cited references. The research trajectories are characterized by two groups. Moreover, the four main research trajectories identified are developed under the influence of pioneering studies. The results also highlight avenues for further research.

4 Decarbonization Framework to Accelerate The Carbon Net-zero Pathway for Enterprises

Ayush Jain[1], Manikandan Padmanaban[2], Jagabondhu Hazra[2], [1]IBM Research, Delhi, India; [2]IBM Research, Bangalore, India.
Enterprises are under significant pressure from investors, consumers, and policymakers to act on climate change mitigation by disclosing their GHG emissions and committing to reduction of emissions from their industrial activities. More than 20% of the world's largest companies have set long term net-zero targets but need technology to measure and reduce their emissions. In this talk, we present a comprehensive framework that includes an augmentation of spatio-temporal contextual data, carbon emissions accounting engine and anomaly detection to identify the performance of individual assets or operations. The framework leverages the explainable AI to derive a useful insight about various influencing parameters and performs counterfactual analysis to recommend the set of optimal values for the intervenable parameters to reduce the overall carbon footprints.

Monday, 2 PM–3:15 PM

MD54

M - Marriott 1
Invited Lecture: Recent Progress in Sampling with Langevin Monte Carlo
General Session

Session Chair
Murat Anil Erdogdu, Stanford University, Stanford, CA

1 **Distinguished Lecture: Recent Progress in Sampling with Langevin Monte Carlo**
Murat Anil Erdogdu, Stanford University, Stanford, CA
This tutorial will focus on the recent progress on thetheory of sampling from a target distribution e^{-f} using the Langevin MonteCarlo (LMC) algorithm. In particular, we investigate the sufficient number ofsteps to reach the ϵ-neighborhood of a d-dimensional targetdistribution as a function of tail-growth and smoothness of the potential f.The results will cover the first convergence guarantees for LMC under severalfunctional inequalities such as the Poincar\'e and log-Sobolev settings.

Monday, 2 PM–3:15 PM

MD55

M - Marriott 2
Queueing Systems: Learning and Optimization
General Session

Session Chair
Qiaomin Xie, University of Wisconsin-Madison, Madison, WI

Session Chair
Xinyun Chen, Chinese University of Hong Kong, Shenzhen, Shenzhen, China.

1 **Reinforcement Learning for Continuous Time Markov Decision Processes**
Xuefeng Gao, Chinese University of Hong Kong, Shatin, NT, Hong Kong.
We consider reinforcement learning for continuous-time Markov decision processes (MDPs) in the infinite-horizon, average-reward setting. In contrast to discrete-time MDPs, a continuous-time process moves to a state and stays there for a random holding time after an action is taken. With unknown transition probabilities and rates of exponential holding times, we derive instance-dependent regret lower bounds that are logarithmic in the time horizon. Moreover, we design a learning algorithm and establish a finite-time regret bound that achieves the logarithmic growth rate. Our analysis builds upon upper confidence reinforcement learning, a delicate estimation of the mean holding times, and stochastic comparison of point processes.

2 **Stability and Optimization of Speculative Queueing Networks**
Neil Walton, University of Manchester, Manchester, United Kingdom.
We provide a queueing-theoretic framework for job replication schemes based on the principle "replicate a job as soon as the system detects it as a straggler". This is called job speculation. The performance and optimization of speculative job execution is not well understood. To this end, we propose a queueing network model for load balancing where each server can speculate on the execution time of a job. Each job is initially assigned to a single server by a frontend dispatcher. Then, when its execution begins, the server sets a timeout. If the job completes before the timeout, it leaves the network, otherwise the job is terminated and relaunched or resumed at another server where it will complete. We provide a necessary and sufficient condition for the stability of speculative queueing networks with heterogeneous servers, general job sizes and scheduling disciplines.

3 **Many-server Asymptotics of The Join-the-shortest Queue Policy**
Debankur Mukherjee[1], Sayan Banerjee[2], Zhisheng Zhao[1], [1]Georgia Tech, Atlanta, GA, [2]University of North Carolina Chapel Hill, Chapel Hill, NC, Contact: debankur.mukherjee@isye.gatech.edu
The Join-the-Shortest Queue (JSQ) policy is a classical benchmark for the performance of many-server queueing systems due to its strong optimality properties. While the exact analysis of the JSQ policy, even under Markovian assumption on the service requirements, is an open question to date, recently, there has been a significant progress in understanding its many-server asymptotic behavior since the work of Eschenfeldt and Gamarnik (Math. Oper. Res. 43 (2018) 867-886). In this talk, we will discuss some of these advances, focusing on its many-server heavy-traffic behavior.

4 **Online Learning for Queueing Systems with Unknown Demand**
Xinyun Chen[1], Guiyu HONG[1], Yunan Liu[2], [1]Chinese

University of Hong Kong, Shenzhen, Shenzhen, China; [2]North Carolina State University, Raleigh, NC, Contact: chenxinyun@cuhk.edu.cn

We investigate the joint pricing and capacity sizing problem for a M/GI/1 system with unknown demand function. In particular, we consider the setting in which manager has no exact information on the system parameters and learns to optimize the control parameters via interacting with the environment. We propose a model-free online learning algorithm with a regret bound of $\tilde{O}(\sqrt{T})$. The algorithm is designed based on online stochastic gradient descent methods with careful analysis on empirical distributions of the queueing data. Effectiveness and robustness of the algorithm are tested via numerical experiments of a variety of representative M/GI/1 examples.<!--EndFragment-->

5 Decentralized Control of a Multi-agent Queueing System

Andrew Lim, National University of Singapore, Singapore, Singapore.

We consider a decentralized stochastic service system where arrival rates and service rates are controlled by different agents. Not surprisingly, the aggregate system is not efficient if agents optimize individual costs in isolation, so the challenge is to come up with incentives under which the collection of decentralized decisions optimizes the system. We characterize transfer payments between agents under which the collection of decentralized decisions coincides with the centralized optimal, and propose a decentralized algorithm for computing the optimal transfers. The transfer payments are related to the VCG mechanism from mechanism design, and the algorithm for computing them is incentive compatible and does not require the services of a mechanism designer to be implemented. Convergence and robustness properties of both mechanisms will be discussed.

Monday, 2 PM–3:15 PM

MD56

M - Marriott 3

PhD Showcase

Flash Session

Session Chair

Braverman Anton, Northwestern University, Evanston, IL

Monday, 2 PM–3:15 PM

MD58

M - Marriott 5

QSR Student Poster Competition

Award Session

Session Chair

Wenmeng Tian, Mississippi State University, Mississippi State, MS

Session Chair

Ruizhi Zhang, University of Georgia, Athens, GA

Session Chair

Xiaolei Fang, North Carolina State University, Raleigh, NC

Session Chair

Hao Yan, Arizona State University, Tempe, AZ

01 Advanced Sensing, Analytics, and Feed-back Quality Control in Metal AM

Rongxuan Wang, Virginia Tech, BLACKSBURG, VA

02 Partial Association between Mixed Data: Assessing the Impact of COVID-19 on College Student Well-being

Zhaohu Fan, Pennsylvania State University, State College, PA

03 Optimal Sensor Inspections for Anomaly Detection in Bayesian Networks

Feiran Xu, University of Miami, Coral Gables, FL

04 RGI: Robust GAN-inversion for unsupervised pixel-wise anomaly segmentation and semantic image inpainting

Shancong Mou, Georgia Institute of Technology, Smyrna, GA

05 Tensor-based Temporal Control for Partially Observed High-dimensional Streaming Data

Zihan Zhang, Georgia Tech, Atlanta, GA

06 Morphological Dynamics-based Anomaly Detection towards In-situ Layer-wise Certification for Directed Energy Deposition Processes

Mahathir Bappy, Mississippi State University, Mississippi State, MS

07 An LSTM-autoencoder based Online Monitoring Approach for Cyber-physical Attack Detection in Additive Manufacturing

Zhangyue Shi, Oklahoma State University, Stillwater, OK

Additive manufacturing (AM) has gained increasing popularity in a large variety of mission-critical fields. The layer-by-layer fabrication scheme of the AM significantly enhances fabrication flexibility, resulting in the expanded vulnerability space of cyber-physical AM systems. This potentially leads to altered AM parts with compromised mechanical properties and functionalities. Furthermore, those internal alterations in the AM builds are very challenging to detect using the traditional geometric dimensioning and tolerancing (GD&T) features. Therefore, how to effectively monitor and accurately detect cyber-physical attacks becomes a critical barrier for the broader adoption of AM technology. To address this issue, we propose a machine learning-driven online side channel monitoring approach for AM process authentication. A data-driven feature extraction approach based on the LSTM-autoencoder is developed to detect the unintended process/product alterations caused by cyber-physical attacks. Both supervised and unsupervised monitoring schemes are implemented based on the extracted features. To validate the effectiveness of the proposed method, real-world case studies were conducted using a fused filament fabrication (FFF) platform equipped with two accelerometers. In the case study, two different types of cyber-physical attacks are implemented to mimic the potential real-world process alterations. Experimental results demonstrate that the proposed method outperforms conventional process monitoring methods, and it can effectively detect part geometry and layer thickness alterations in a real-time manner.

08 Adversarial Learning-assisted Data Analytics in Manufacturing and Healthcare Systems

Yuxuan Li, Oklahoma State University, Stillwater, OK

09 Unsupervised Spectral-band identification for Process Change Detection

Akash Tiwari, Texas A&M University, College Station, TX

10 H-GCN: A Hierarchical Graph Convolutional Network for Defect Classification in L-PBF Additive Manufacturing

Anyi Li, Auburn University, Auburn, AL

Defects innate in laser beam powder bed fusion (L-PBF) process deteriorate the mechanical performance like the fatigue life of L-PBF components. This work presents a novel hierarchical graph convolutional network (H-GCN) to classify different types of defects by a cascading GCN structure with a low-level features (defect features) layer and a high-level features (fabrication conditions) layer. H-GCN can leverage the information from different hierarchies to classify the defects and explore the impact of fabrication conditions on defect features. Simulation results indicate that H-GCN is highly robust to both balanced and unbalanced datasets and can achieve a classification accuracy of 100%.

11 Change Detection in Dynamic High-dimensional Data Streams with Incomplete Components and Uncommon Events

Meng Zhao, University OF Florida, Gainesville, FL

12 Data-driven Adaptive Testing Resource Allocation Strategies for Real-time Monitoring of Infectious Diseases

Xin Zan, University of Florida, Gainesville, FL

Infectious diseases have continued to be a major global public health threat and effective methods are in critical need to quickly detect disease outbreaks. However, limited testing availability that leads to insufficient data poses challenges to effective monitoring in practice. By integrating nonstationary MAB techniques on top of a physics-informed model, this work proposes adaptive allocation strategies to intelligently allocate limited testing resources among communities, which enables collection of high-quality testing data for quick outbreak detection. Theoretical analysis and a comprehensive simulation study are conducted to evaluate the performance.

13 Control Charts for Dynamic Process Monitoring with An Application to Air Pollution Surveillance

Xiulin Xie, University of Florida, Gainesville, FL

14 Federated Generalized Scalar-on-Tensor Regression

Elif Konyar, University of Florida, Gainesville, FL

15 Ranking and combining latent structured predictive scores without labeled data

Shiva Afshar, University of Houston, Houston, TX

16 Federated Gaussian Process: Convergence, Automatic Personalization and Multi-fidelity Modeling

Xubo Yue, University of Michigan, Ann Arbor, Ann Arbor, MI

17 Patch-Based Functional Deviation Characterization and Prediction for Complex Freeform Manifolds in Additive Manufacturing

Weizhi Lin, University of Southern California, Los Angeles, CA

18 Online Nonparametric Monitoring for Asynchronous Processes with Serial Correlation

Ziqian Zheng, University of Wisconsin-Madison, Madison, WI

Existing multivariate statistical process control (MSPC) methods commonly require all data streams have the same sampling interval. In practice, this assumption may not be valid as different sensors can have different sampling rates. In this paper, we first propose a generic nonparametric monitoring scheme to online monitor the asynchronous data streams without considering serial correlation. Then the proposed scheme is extended such that it can handle serially correlated data streams. Specifically, we construct a nonparametric local statistic for each data stream, which is sensitive to mean shifts. To eliminate the influence of different sampling intervals, our innovative idea is to transform the local statistics into time-related statistics according to the sampling intervals. A global monitoring scheme is then constructed based on the sum of top- ; time-related statistics. To extend the proposed method for serially correlated data streams, we further propose a novel estimation method for the pairwise covariance functions and the data streams can be decorrelated accordingly. Numerical simulations and a case study are conducted, showing the effectiveness of the proposed method in handling asynchronous data streams with serial correlation.

19 Online Modeling and Monitoring for Dependent Dynamic Processes under Resource Constraints

Tanapol Kosolwattana, University of Houston, Houston, TX

Adaptive monitoring of a large population of dynamic processes enables cost-effective process control under limited resources. However, existing adaptive monitoring models either ignore the dependency among processes or overlook the uncertainty in process modeling. To design an optimal monitoring strategy that accurately monitors the processes with poor health conditions and actively collects information for uncertainty reduction, a novel combinatorial bandit with a dependent and dynamic arms method is proposed in this study. The efficiency of the proposed method is demonstrated through both theoretical analysis and an empirical study of degradation monitoring of Alzheimer's Disease (AD).

20 Predictive Insights for Dynamic Systems using Bayesian Networks & Recurrent Neural Network

Md Tanzin Farhat, University of Miami, Miami, FL, Contact: tanzinfarhat@miami.edu

A fundamentally new framework to utilize large-scale heterogeneous time-series data from engineering systems to get intelligent insights for degrading systems with hidden states is proposed in this work. For any sensor driven complex system with these hidden states can have significant influence on system dynamics and is difficult to model with traditional approaches. Keeping these hidden states into consideration, prediction of any potential events of interest like remaining useful life along with insights like sensor prediction and hidden state dynamics are some of the literature interests. The proposed approach utilizes recurrent neural networks and Bayesian networks with a state-space structure to capture the hidden states dynamics along with a prediction for events of interest like remaining useful life.

21 Degradation Modeling using Bayesian Hierarchical Piecewise Linear Models: A Case Study to Predict Void Swelling in Irradiated Materials

Ye Kwon Huh, University of Wisconsin-Madison, Madison, WI

We illustrate the use of data-driven degradation model in a nuclear-specific application called void swelling. Void swelling is a complex, radiation-induced degradation mechanism that changes the dimensions of materials and damages the structural integrity. Accurate modeling and prediction of void swelling is crucial in nuclear power plant (NPP) management and maintenance planning. Using a Bayesian hierarchical piecewise linear regression with a real-world void swelling dataset, we address the following three research questions: (1) How can we construct a data-driven degradation model such that its predictions satisfy the physical properties of void swelling? (2) How can we measure the joint effect of multiple experimental factors on the swelling process? (3) How can we accurately predict the future swelling status under limited data availability?

22 Imbalanced Data Classification via Generative Adversarial Network with Application to Anomaly Detection in Additive Manufacturing Process

jihoon Chung, Virginia Tech, Blacksburg, VA

23 **Self-scalable Tanh (Stan): Faster Convergence and Better Generalization in Physics-informed Neural Networks**

Raghav Gnanasambandam, Virginia Tech, Blacksburg, VA

Monday, 2 PM–3:15 PM

MD59

M - Marriott 6

Technometrics Invited Session

General Session

Session Chair

Roshan V. Joseph, ISyE Georgia Tech, Atlanta, GA

1 **An Adaptive Sampling Strategy for Online Monitoring and Diagnosis of High-dimensional Streaming Data**

Ana M. Estrada Gomez[1], Dan Li[2], Kamran Paynabar[3], [1]Purdue University, West Lafayette, IN, [2]Clemson University, Greenville, SC, [3]ISyE Georgia Tech, Atlanta, GA, Contact: amestrad@purdue.edu

Statistical process control techniques have been widely used for online process monitoring and diagnosis of streaming data. In some applications, the sensing system that collects online data can only provide partial information from the process due to resource constraints. In such cases, an adaptive sampling strategy is needed to decide where to collect data while maximizing the change detection capability. We propose an adaptive sampling strategy for online monitoring and diagnosis with partially observed data. The methodology integrates two novel ideas: (i) the recursive projection of the high-dimensional streaming data onto a low-dimensional subspace to capture the spatio-temporal structure of the data; and (ii) the development of an adaptive sampling scheme, balancing exploration and exploitation, to decide where to collect data at each acquisition time.

2 **The Temporal Overfitting Problem with Applications in Wind Power Curve Modeling**

Abhinav Prakash[1], Rui Tuo[2], Yu Ding[3], [1]Texas A&M University, Richardson, TX, [2]Texas A & M University, College Station, TX, [3]Texas A&M University, College Station, TX, Contact: yuding@tamu.edu

When the input variables and the errors in a nonparametric regression are autocorrelated in time, existing model selection methods, like using cross validation, lead to model overfitting. This phenomenon is referred to as temporal overfitting, which causes loss of performance while predicting responses for a time domain different from the training time domain. We will talk about how to avoid temporal overfitting in this presentation. Our solution method is labeled tempGP, available through the R package DSWE.

3 **Locally Optimal Design for A/b Tests in The Presence of Covariates and Network Dependence**

Qiong Zhang[1], Lulu Kang[2], [1]Clemson University, Clemson, SC, [2]Illinois Institute of Technology, Chicago, IL

A/B test, a simple type of controlled experiment, refers to the statistical procedure of experimenting to compare two treatments applied to test subjects. In this talk, we assume that the test subjects of the experiments, are connected on an undirected network, and the responses of two connected users are correlated. We include the treatment assignment, covariate features, and network connection in a conditional autoregressive model and propose a design criterion that measures the variance of the estimated treatment effect. A hybrid optimization approach is proposed to obtain the optimal design based on this cirterion. Through synthetic and real social network examples, we demonstrate the value of including network dependence in designing A/B experiments and validate that the proposed locally optimal design is robust to the choices of parameters.

Monday, 2 PM–3:15 PM

MD60

M - Marriott 7

Quality, Reliability, and Statistics II

Contributed Session

Session Chair

Ayca Altay, Rutgers University, Piscataway, NJ

1 **Design of Accelerated Degradation Reliability Demonstration Test Plan Based on The Wiener Process Model Considering Random Effects**

Hyojung Kim, Seongjoon Kim, Chosun University, Gwangju, Korea, Republic of. Contact: gywnd0107@chosun.kr

Reliability demonstration tests (RDTs) have been widely adopted to verify the reliability requirements of manufacturing products. However, there is a lack of study regarding RDT plans in the case of a stochastic process model considering stress acceleration. In this study, we propose a reliability demonstration test plan based on

the accelerated random-effects Wiener process model. First, we present a motivating example to describe this study and introduce the random-effects Wiener process model for the accelerated degradation data. Second, a reliability demonstration test plan is proposed to determine whether the product can meet the reliability requirement. The numerical study, sensitivity analysis, and OC-curve are presented to evaluate the proposed method. Finally, we illustrated the proposed method using the vehicle ECU IC chip ADT data.

2 Design of Flexible Equivalent Accelerated Life Test Plans

Wigeon Seo, Seongjoon Kim, Chosun University, Gwangju, Korea, Republic of. Contact: wigeon.seo@chosun.kr

The design of the Accelerated Life Test (ALT) has been widely investigated in the literature. Typical ALT is designed to be performed as the initial design without compromising or changing plans during conducting tests. In practice, however, the initial design may not be completed due to various reasons; for example, unexpected equipment failures, test sample losses, etc. In this case, the ALT model fails to yield sufficient accuracy as designed. In this study, we propose an approach for the design of supplementary or alternative ALT plans that are equivalent to the initial design.

3 Modeling Imperfect Rail Track Inspections with Partial or Complete Miss Rates

Ayca Altay, Melike Baykal Gursoy, Rutgers University, Piscataway, NJ, Contact: ayca.altay@rutgers.edu

Imperfections in rail track inspections can occur as partial or even complete oversight of existing defects. Such imperfections cause defects to accumulate on the track. Thus, the number of defects found during an inspection becomes dependent on the outcome of previous inspections. When the defect arrivals follow a Poisson process, zero-inflated Poisson processes can reflect the complete oversight of defects. Furthermore, we model partial defect findings with a binomial miss rate. Using Markov Chain Monte Carlo methods, we aim to unravel the information about two lateral variables: the inspection quality and the remaining defects on the track.

4 Instantaneous and Limiting Behavior of An N-node Blockchain Under Cyber Attacks from a Single Hacker

Xiufeng Xu, Liang Hong, The University of Texas at Dallas, Richardson, TX, Contact: xiufeng.xu@utdallas.edu

Instantaneous and limiting behavior of an n-node blockchain is under continuous monitoring of the IT department of a company but faces non-stop cyber attacks from a single hacker. The blockchain is functional as far as no data stored on it has been changed, deleted, or locked. Once the IT department detects the attack from the hacker, it will immediately re-set the blockchain, rendering all previous efforts of the hacker in vain. The hacker will not stop until the blockchain is dysfunctional. For arbitrary distributions of the hacking and detecting times, we derive limiting and instantaneous functional probability and mean functional time of the blockchain. All these quantities are increasing functions of the number of nodes, substantiating the intuition that the more nodes a blockchain has, the harder it is for a hacker to succeed in a cyber attack.

Monday, 2 PM–3:15 PM

MD61

M - Marriott 8

ENRE Award Session

Award Session

Session Chair

Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX

A Multistage Stochastic Programming Approach to the Optimal Surveillance and Control of the Emerald Ash Borer in Cities

Esra Buyuktahtakin Toy[1], Eyyub Yunus Kibis[2], Robert G. Haight[3], Najmaddin Akhundov[4], Kathleen Knight[5], Charles Flower[5], [1]Virginia Tech, Blacksburgh, VA, [2]Montclair State University, Montclair, NJ, [3]USDA Forest Service, Saint Paul, MN, [4]New Jersey Institute of Technology Newark College of Engineering, Knoxville, TN, [5]USDA Forest Service, Delaware, OH

In this talk, we will present an innovative data-driven stochastic mixed-integer programming modeling and cutting plane approach under decision-dependent uncertainty. We demonstrate our model and the algorithm on one of the most pressing problems of the USDA Forest Service, the Emerald Ash Borer (EAB) infestation killing millions of ash trees in North America. We validate our operations research approach, using 7-years of unique data collected by our collaborators from the USDA Forest service over a large spatial scale in Ohio. Our findings provide critical insight into a long-debated question among foresters: treatment versus removal of the ash trees to save as many trees as possible.

Investments in Renewable and Conventional Energy: The Role of Operational Flexibility

Gurhan Kok[1], Kevin Shang[2], Safak Yucel[3], [1]Koc University, Istanbul, Turkey; [2]Duke University, Durham, NC, [3]Georgetown University, Washington

We study a capacity investment problem for a utility firm to characterize how providing a subsidy for one energy source affects the investment in other sources. We consider two critical factors: First, conventional sources have different levels of operational flexibility---inflexible (e.g., nuclear and coal) and flexible (e.g., natural gas). Second, random renewable energy supply and electricity demand are correlated and nonstationary. We find that renewable and inflexible sources are substitutes, suggesting that a subsidy for nuclear or coal-fired power plants leads to a lower investment level in wind or solar energy. However, wind energy and flexible sources are complements. Thus, a subsidy for flexible natural gas-fired power plants leads to a higher investment in wind energy. This result holds for solar energy if the subsidy for the flexible source is sufficiently high. We validate these insights by using real electricity generation and demand data from the state of Texas.

Right to Repair: Pricing, Profit, Welfare, and Environmental Implications

Luyi Yang[1], Chen Jin[2], Cungen Zhu[3], [1]University of California, Berkeley, Berkeley, CA, [2]National University of Singapore, Singapore, Singapore; [3]Singapore, Singapore.

The "right-to-repair" (RTR) movement calls for government legislation that requires manufacturers to provide repair information, tools, and parts so that consumers can independently repair their own products with more ease. The initiative has gained global traction in recent years. Repair advocates argue that such legislation would break manufacturers' monopoly on the repair market and benefit consumers. They further contend that it would reduce the environmental impact by reducing e-waste and new production. Yet the RTR legislation may also trigger a price response in the product market as manufacturers try to mitigate the profit loss. This paper employs an analytical model to study the pricing, welfare, and environmental implications of RTR.

Reliable Frequency Regulation through Vehicle-to-Grid: Encoding Legislation with Robust Constraints

Dirk Lauinger[1], Francois Vuille[2], Daniel Kuhn[1], [1]EPFL, Lausanne, Switzerland; [2]Etat de Vaud, Lausanne, Switzerland.

Vehicle-to-grid is the idea of meeting the growing demand of electricity storage, e.g., for frequency regulation with batteries of parked electric vehicles. Frequency regulation providers promise to charge or discharge their batteries whenever the grid frequency deviates from its nominal value. They must honor their promises for all frequency deviation trajectories that satisfy certain properties prescribed by EU law. We encode the law in a robust optimization model and find that the penalties for non-compliance with market rules are currently too low. This suggests that "crime pays".

Charging an Electric Vehicle-Sharing Fleet

Long He[1], Guangrui Ma[2], Wei Qi[3], Xin Wang[4], [1]George Washington University, Washington, [2]Alibaba Inc, Hangzhou, China; [3]Tsinghua University, Beijing, China; [4]University of Wisconsin-Madison, Madison, WI

Our work is motivated by the setback of car2go, an electric vehicle (EV) sharing operator, in San Diego, California. We integrate charging infrastructure planning and vehicle repositioning operations that were often considered separately. Our modeling emphasizes the operator-controlled charging operations and customers' EV-picking behavior, which are both central to EV sharing but were largely overlooked. We then develop a queuing network model that characterizes how customers endogenously pick EVs based on energy levels and how the operator implements a charging-up-to policy. The integrated queuing-location model leads to a nonlinear optimization program, which can be solved approximately as mixed-integer second-order cone programs. In a case study of car2go, we further discuss several planning guidelines and operational policies for EV fleet charging.

Monday, 2 PM–3:15 PM

MD62

M - Marriott 9

Learning to Solve Optimization and Control Problems in Power Systems

General Session

Session Chair

Feng Qiu, Argonne National Laboratory, Lemont, IL

Session Chair

Yichen Zhang, ARGONNE NATIONAL LABORATORY

1 Modularized Data-driven Modeling and Control for Transient Dynamics of Networked Microgrids

Yan Li, Daning Huang, The Pennsylvania State University, University Park, PA, Contact: yql5925@psu.edu

Despite the extensive exploration of machine learning (ML) techniques for transient dynamic modeling of microgrids, the nonlinearity and high dimensionality of the system prevent the direct application of the well-developed ML methods. A modularized data-driven method, that leverages Koopman operator theory and graph-based learning, will be presented for the modeling and control of the transient microgrid dynamics in the presence of disturbances. A large-scale system's model and control problem will be partitioned into several smaller sub-problems to alleviate the challenge in the intensive handling of the high-volume high-dimensional data. Simulation examples will be provided to demonstrate the presented methodology.

2 Ensuring Stability in Ai-based Dynamic Control Design for Power Systems

Yichen Zhang, ARGONNE NATIONAL LABORATORY

AI-based dynamic controllers have shown considerable advantages compared with traditional PI controllers in power systems. AI-based dynamic controllers can encode disturbance estimation, state and input constraint satisfaction, and expert knowledge into a strong representation, such as neural networks (NNs). However, the closed-loop systems are usually nonlinear and ensuring stability of such systems is challenging. In this presentation, based on the absolute stability theory, a constrained optimization formulation is derived to ensure the stability of the nonlinear closed-loop system, which can be solved using the barrier method or alternating direction method of multipliers. A frequency control example is with full-order nonlinear model simulation is carried out to verify the effectiveness of the proposed method.

3 Data Driven Grid Dynamics Discovery and Analysis - Challenges and Lessons Learned

Chetan Mishra, Dominion Energy, Blacksburg, VA

Power system analysis has always heavily relied on having access to physics-based models for operation and planning used to conduct simulation studies. However, one of the biggest challenges faced by the system owners/operators today is not having access to transparent and accurate dynamic models of particularly converter interfaced resources such as STATCOMs, solar PV, data centers, and so on. Therefore, with their recent growth, traditional model based analysis practices have been put to test. What makes it even more difficult is that these resources respond significantly differently than well-understood synchronous machines in terms of time scales of dynamics, fault current, uncertainty in output, protection, and other phenomena. To make matters worse, controllers are rarely adapted to changing system conditions in real-world practice, resulting in a plethora of hidden dynamic performance issues waiting to manifest as large instability events.To address these issues, Dominion Energy's Engineering Analytics & Modeling team has been working on developing data-driven approaches to capturing otherwise hidden dynamic performance issues early on, as well as understanding the mechanism behind them through analysis of long term synchrophasor data. This webinar will discuss the difficulties encountered when working with actual measurements rather than simulation data.

Monday, 2 PM–3:15 PM

MD63

M - Marriott 10

The Hydrogen Economy: Challenges and Opportunities in Production, Transportation, and Use

General Session

Session Chair

Tyler Ruggles, Carnegie Science, Stanford

1 Techno-economic Analysis of Hydrogen Supply Chains

Cian Moran, Sajjad Yousefian, Rory F. D. Monaghan, University of Galway, Galway, Ireland. Contact: c.moran50@universityofgalway.ie

Hydrogen is likely to play a key role in future energy systems to decarbonize harder-to-abate sectors and act as a method of large-scale energy storage. Techno-economic analysis of future hydrogen supply chains is crucial to understand the technical challenges and costs associated with hydrogen production, storage, delivery, and demand. This work aims to demonstrate the importance of considering the full hydrogen delivery supply chain whilst also investigating how different aspects of the supply chain interact with each other and influence the levelized cost of hydrogen delivered (LCOH). A number of different scenarios are analysed to identify the key parameters which influence techno-economic and environmental performance of hydrogen supply chains.

2 Hydrogen Production as a Flexible Electricity Load: Considering Grid-tied Systems

Tyler Ruggles, Carnegie Science, Stanford

Low-carbon emission H_2 production is currently challenged by the high capital costs of electrolyzers and the intermittency of wind and solar power. Grid-tied electrolysis can allow high capacity factor operations, thus reducing the contributions of electrolyzer capital costs to the cost of H_2 production.

Modeling 100% grid-tied systems and hybrid systems powered by the grid and on-site renewables is a challenge because electricity markets and tariffs are structured differently in different regions. Here, we explore modeled least-cost H_2 production and supply systems in different geographic regions and show how costs and operations vary by region. We demonstrate the value of flexible operations to reduce electricity costs. We show how this flexibility impacts H_2 storage needs, which are required to ensure meeting H_2 demands from potential customers.

3 Technological Levers and Constraints of Power-to-Gas-to-Power at Scale

Jacqueline A. Dowling, Caltech, Pasadena, CA, Contact: jdowling@caltech.edu

Long-duration energy storage technologies like Power-to-gas-to-power (PGP) with hydrogen may improve the affordability of reliable wind- and solar-based electricity systems. We use historical U.S. weather data and a macro-scale energy model to evaluate capacities and dispatch in least-cost, reliable electricity systems. We investigate which innovations in PGP (including hydrogen storage and energy conversion technologies) would most improve system-wide electricity costs, and which innovations are less important. We find that incremental reductions in conversion-related capital costs affect total system costs more than incremental improvements in round-trip efficiency. PGP with hydrogen storage is a technology option that may facilitate an affordable transition to meet wind and solar mandates beyond 80%, and open a path to 100% carbon-free electricity.

4 Hydrogen Solutions for The Future of Mobility

Cristina Antonini, IET Institute for Energy Technology, Rapperswil, Switzerland. Contact: cristina.antonini@ost.ch

Sustainable H_2 is an important player to decarbonize the mobility sector. However, the current number of installed H_2 refueling station (HSR) is not enough to allow the market for H_2 mobility to take off. Currently, the high investment costs required to build HRS hold back the development of the H_2 infrastructure. To incentivize stakeholders to invest, a modular cost-effective solution is required. For this reason, in cooperation with industrial partners, our research institute decided to realize a low-cost HRS, aiming at cutting the overall costs by half. The refueling station is conceived as a modular solution that can be adapted on clients' needs. The basic module is designed to deliver ca. 140 kg of H_2 over a period of 12 h at 350 bar (possibility to add modules to increase pressure and/or capacity). The prototype will be built throughout the upcoming months.

Monday, 2 PM–3:15 PM

MD64

M - Indiana A

Competition and Platforms

General Session

Session Chair

Gerard P. Cachon, University of Pennsylvania, Philadelphia, PA

1 Centralized Versus Decentralized Pricing Controls for Dynamic Matching Platforms

Ali Aouad, London Business School, London, United Kingdom.

We develop a stylised model to study the impact of centralization versus decentralization of pricing decisions in dynamic matching markets. This issue is motivated by new regulation and public scrutiny on the level of operational control exercised by platforms in the gig economy. Analytically, we provide a comprehensive, easy-to-compute characterization of the unique market equilibrium in several settings. By leveraging these theoretical analyses, we conduct extensive simulations to analyse the social welfare attained by different levels of centralization.

2 Multi-homing Across Platforms: Friend or Foe?

Gerard P. Cachon[1], Tolga Dizdarer[2], Gerry Tsoukalas[3], [1]University of Pennsylvania, Philadelphia, PA, [2]The Wharton School, Philadelphia, PA, [3]Boston University, Boston, MA, Contact: dizdarer@wharton.upenn.edu

Multi-homing gives platforms access to a larger pool of supply; however, it also changes the nature of competition between platforms in a market. It is not clear whether this works to the advantage of platforms or not. In light of this, we ask a fundamental question: When is it better for two-sided platforms to pool their workers? We answer this question through a game-theoretic study. We identify the key trade-offs associated with pooling decision and highlight the key role of scale.

3 Measuring Strategic Behavior in The Gig Economy: Multihoming and Repositioning

Daniel Chen, Gad Allon, Ken Moon, The Wharton School, Philadelphia, PA

Gig economy workers make strategic decisions about where and when to work. We empirically measure two types of strategic behavior: multihoming, an online change between platforms, and repositioning, a physical change between locations. Using a structural model, we show that workers are highly heterogenous in their preferences for both multihoming and repositioning. We provide counterfactual estimates on the effects of proposed firm and regulatory policies aimed at multihoming and repositioning.

4 Market-Based Capacity Management for FBA

Garrett J. van Ryzin, Amazon Corporate LLC, Brooklyn, NY

Fulfillment by Amazon (FBA) is Amazon's third party retail marketplace. In the past decade, FBA has grown rapidly, creating a significant challenge for capacity management. In this talk, we provide an overview of the FBA capacity management problem and describe an innovative market-based mechanism (auction) for capacity recently launched in North America.

Monday, 2 PM–3:15 PM

MD66

M - Indiana C

Market Design in Future Energy Systems

General Session

Session Chair

Iesia Mitridati, ETH Zurich, Zurich, Switzerland.

1 Pricing Non-convexities in The Investment Problem

Nicolas Stevens, 1</sup

Establishing the right pricing rule under non-convexities has been a long-lasting debate, essentially in the context of unit commitment or non-convex day-ahead market clearing in general. Most discussions focus on either (1) the algorithmic challenges of computing such prices or (2) on the short-term incentive properties of these pricing schemes. In our research, we investigate the long-term properties of these prices, studying the investment incentives. We especially focus on the discrete investment problem.

2 Multiscale Design for System-wide Peer-to-peer Energy Trading

Thomas Morstyn, University of Edinburgh, Edinburgh, United Kingdom. Contact: thomas.morstyn@ed.ac.uk

The integration of renewables and the electrification of heating and transport are critical for the transition to net-zero greenhouse gas emissions. Peer-to-peer energy trading offers a new approach for incentivizing the uptake and coordination of distributed energy technologies, with advantages for computational scalability, prosumer autonomy, and market competitiveness. However, unresolved challenges remain for scaling out P2P trading, including enforcing network constraints, managing uncertainty, and mediating transmission/distribution conflicts. The talk will present work towards a new multiscale design framework, with inter-platform coordination mechanisms to align local transactions with system-level requirements, and analytical tools to enhance long-term planning/investment.

3 An Equilibrium Analysis of Risk-hedging Strategies in Decentralized Electricity Markets

Ilia Shilov[1], Helene Le Cadre[2], Ana Busic[3], Gonçalo de Almeida Terça[4], [1]Inria Paris, PSL University / VITO, Paris, France; [2]INRIA Lille—Nord Europe, Villeneuve d'Ascq, [3]INRIA, Paris, France; [4]VITO/EnergyVille, Mol, Belgium. Contact: ilia.shilov@inria.fr

We build several market designs of increasing complexity, from a one-stage market design with inter-agent financial contract trading to a Stackelberg game where an insurance company is a leader and prosumers are followers. The structure of the problem leads to non-existence of solution in the pessimistic formulation of the Stackelberg game. We propose an equivalent reformulation, using a parametrizated generalized Nash equilibrium problem, and characterize the set of Stackelberg equilibria. Then we show that the insurance company can design price incentives to guarantee the existence of a solution of the pessimistic formulation, which is close to the optimistic one. We investigate economic properties of proposed models. We also quantify the impact of the insurance company's incomplete information on the prosumers' risk-aversion levels on its cost.

4 Learning Risk- and Uncertainty-aware Market Solutions

Yury Dvorkin, New York University, Brooklyn, NY

With the advent of machine learning, there is a pressing interest for its application in electricity markets. While the primary focus of current efforts is to improve computational performance and physical accuracy (e.g. modeling ac power flows), there is a need to internalize market design considerations and make electricity market outcomes risk- and uncertainty-informed. This presentation will leverage existing machine learning techniques exploiting saturated operational limits of economic dispatch and optimal power flow problems to produce market outcomes ensuring, provably, revenue adequacy for the market and cost recovery for market participants.

Monday, 2 PM–3:15 PM

MD67

M - Indiana D

Data-Driven Decision-Making Through a Societal Lens

General Session

Session Chair

Chamsi Hssaine, Cornell University, Ithaca, NY

Session Chair

Chara Podimata, Harvard University, Allston, MA

1 Locally Fair Partitioning

Kamesh Munagala, Erin Taylor, Duke University, Durham, NC

We model redistricting political districts as a fair partitioning problem: Given a set of n points in the plane, each belonging to one of two parties, and a parameter k, our goal is to compute a partition of the plane into equal-size regions. The partition should satisfy ``local'' fairness: A region is associated with its majority party, and a point there is ``unhappy'' if it belongs to the minority party. If there is a group of roughly n/k contiguous points where the majority of points are unhappy, then the partition is not fair. When points lie in one dimension, we characterize parameters for which a locally fair partition always exists, and present a polynomial-time algorithm for computing a locally fair partition if one exists. We also present heuristics and empirical results for locally fair partitioning of real-world maps.
Joint with P. K. Agarwal, S-H. Ko, and E. Taylor.

2 Rebounding Bandits for Modeling Satiation Effects

Liu Leqi, Fatma Kilinc-Karzan, Zachary Lipton, Alan Montgomery, Carnegie Mellon University, Pittsburgh, PA, Contact: leqil@cs.cmu.edu

Psychological research shows that enjoyment of many goods is subject to satiation, with short-term satisfaction declining after repeated exposures to the same item. However, proposed algorithms for powering recommender systems seldom model these dynamics. In this work, we introduce rebounding bandits, a multi-armed bandit setup, where satiation dynamics are modeled as linear dynamical systems. Unlike classical bandit settings, methods for tackling rebounding bandits must plan ahead and model-based methods rely on estimating the parameters of the satiation dynamics. We characterize the planning problem, showing that the greedy policy is optimal when the arms share identical deterministic dynamics. To address stochastic unknown satiation dynamics, we propose an algorithm that pulls arms methodically, estimates the system dynamics, and then plans accordingly.

3 Biodiversity Conservation Via Adjustable Robust Optimization

Yingxiao Ye[1], Christopher Doehring[1], Angelos Georghiou[2], Hugh Robinson[3], Phebe Vayanos[4], [1]University of Southern California, Los Angeles, CA, [2]University of Cyprus, Nicosia, Cyprus; [3]Panthera, Missoula, MT, [4]University of Southern California, Los Angeles, CA, Contact: yeyingxi@usc.edu

Human development is a threat to biodiversity and conservation organizations (COs) are purchasing land to protect areas for biodiversity preservation against human impact. Existing methods purchase lands to maximize the value of the protected area with the given budget. However, the budget is usually received progressively over time, and also, the existing models cannot capture the uncertainty in development. We propose a multistage, robust optimization problem with a data-driven uncertainty set to minimize the biodiversity loss due to human impact. We prove that the problem can be reformulated into a robust problem with exogenous objective uncertainty. The numerical results based on real data show that the proposed method reduces conservation loss by 30.69% on average compared to standard approaches used in practice for biodiversity conservation.

4 Dynamic surveying with ressource constraints

Abdellah Aznag, Adam Elmachtoub, Rachel Cummings, Columbia University, New York, NY

Making data-driven decisions affecting large diverse populations requires data collection. We study the problem where the decision maker dynamically allocates their finite resources to collect data, so that they obtain an estimation with minimal variance. When parameters are unknown but can be learned, the problem involves a novel exploration-exploitation dilemma. We describe the problem formally and present a near-optimal algorithm.

Monday, 2 PM–3:15 PM

MD68

M - Indiana E

Algorithmic Causal Inference

General Session

Session Chair

Heng Zhang, Arizona State University, Tempe, AZ

Session Chair

Dennis Zhang, Washington University in St Louis, ST LOUIS, MO

1 Machine Learning and Prediction Errors in Causal Inference

Gad Allon[1], Daniel Chen[2], Dennis Zhang[3], Zhenling Jiang[1], [1]University of Pennsylvania, Philadelphia, PA, [2]Wharton, Philadelphia, PA, [3]Washington University in St Louis, ST LOUIS, MO, Contact: gadallon@wharton.upenn.edu

Machine learning is a growing method for causal inference. We consider a two-stage model where (1) machine learning is used to predict variables of interest, and (2) these predictions are used in a regression model for causal inference. Even when the model specification is otherwise correct, traditional metrics such as p-values and first-stage model accuracy are not good signals of correct second-stage estimates when prediction error exists. We show that these problems are substantial and persist across simulated and empirical data. We propose general methods to identify when prediction errors are biasing estimates and provide consistent corrections for the case where an unbiased subset of the data is available.

2 Machine Learning Based Causal Inference with Multiple A/b Tests on Large-scale Platforms

Zikun Ye[1], Dennis Zhang[2], Heng Zhang[3], Renyu Zhang[4], Zhiqi Zhang[5], Xin Chen[6], [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]Washington University in St Louis, ST LOUIS, MO, [3]Arizona State University, Tempe, AZ, [4]Chinese University of Hong Kong, Hong Kong, China; [5]Washington University in St. Louis, Saint Louis, MO, [6]UIUC, Urbana, IL, Contact: z.zhiqi@wustl.edu

We develop a new framework to estimate and infer HTE overall treatment effect of multiple experiments and identify the optimal experiment combination with partially observable outcomes. We propose a deep learning and semi-parametric statistics framework to estimate the HTE of any experiment combination for each user on the platform.

3 Design and Analysis of Panel Experiments with Interference

Iavor Bojinov[1], Tu Ni[2], Jinglong Zhao[3], [1]Harvard Business School, Somerville, MA, [2]National University of Singapore, Singapore, Singapore; [3]Boston University, Boston, MA, Contact: nitu@u.nus.edu

In panel experiments, a firm sequentially exposes multiple experimental units to random treatments, measures the responses, and repeats the procedure for several periods to quantify the global average treatment effect. Practitioners often worry about interference when conducting panel experiments. We consider the interference for both time-level and unit-level: the outcome of a unit may depend on the treatment of other units, and the outcome of a time period may depend on the treatment of previous periods. We derive a robust design of panel experiments using the minimax framework. We further provide theoretical results for the performance of our design. We finally conduct extensive simulations to study the empirical properties of our results, and conclude with some practical suggestions.

4 Correlated Cluster-Based Randomized Experiments: Robust Variance Minimization

Ozan Candogan[1], Chen Chen[2], Rad Niazadeh[1], [1]University of Chicago, Chicago, IL, [2]New York University Shanghai, Shanghai, China. Contact: cc8029@nyu.edu

Experimentation has become prevalent in improving the operations of online marketplaces. To mitigate the interference among users, a common practice is to use a cluster-based experiment, where the designer partitions the market into loosely connected clusters and assigns all users in a cluster to the same variant. Given the experiment, we assume an unbiased Horvitz-Thompson estimator is used to estimate the average treatment effect. We consider the optimization problem of choosing (correlated) randomized assignments of clusters to treatment and control to minimize the worst-case variance of the estimator. We develop a family of *independent block randomization (IBR)* experiments, and we show that they are (i) asymptotically optimal when the number of clusters grows large and no cluster size dominates the rest, and (ii) have good approximations for any problem instance.

5 The Impact of Social Nudges on User-Generated Content for Social Network Platforms

Zhiyu Zeng[1], Hengchen Dai[2], Dennis Zhang[3], Heng Zhang[4], Renyu (Philip) Zhang[5], Max Max Shen[6], [1]Tsinghua University, Beijing, China; [2]UCLA Anderson School of Management, Los Angeles, CA, [3]Washington University in St Louis, ST LOUIS, MO, [4]Arizona State University, Tempe, AZ, [5]The Chinese University of Hong Kong, Hong Kong, China; [6]University of California Berkeley, Berkeley, CA

To tackle the underprovision of user-generated content, we develop an intervention that leverages peer recognition. Via two field experiments (N=1,671,766) conducted on a video-sharing social network platform, we reveal that receiving peer recognition not only immediately boosts users' video production by 13.21% but also increases users' likelihood of giving recognition to others by 15.57%. Such effects last several days and are bigger when the recognition sender and recipients have a stronger tie. Our social network model,

combined with the experimental data, shows that estimating and optimizing the overall impact of peer recognition on production over the entire platform requires accounting for its diffusion and over-time effects.

Monday, 2 PM–3:15 PM

MD69

M - Indiana F

Empirical and Behavioral Operations Management

General Session

Session Chair

So Yeon Chun, INSEAD, Fontainebleau, France.

Session Chair

Freddy Lim, INSEAD, Singapore, Singapore.

1 Multiple Discrete Choice Models with Copula: An Application to Hotel Standby Upgrades

Ovunc Yilmaz[1], Andrew Vakhutinsky[2], Ruxian Wang[3], Zifeng Zhao[4], [1]University of Colorado Boulder, Boulder, CO, [2]Oracle Labs, Burlington, [3]Johns Hopkins University, Carey Business School, Kensington, MD, [4]Mendoza College of Business, University of Notre Dame, Notre Dame, IN, Contact: ovunc.yilmaz@colorado.edu

Hotels often offer a set of upgrades to their guests after the booking, and guests can request multiple upgrades. Since classical discrete choice models only allow one alternative per customer, we develop a novel multiple-discrete choice model that allows customers to choose more than one alternative and use copula to account for the potential dependence between the choices. We then test this model in a real hotel upgrade data set and compare its performance to several benchmarks.

2 To What Extent Do Workers' Preferences Matter?

Kejia Hu[1], Zhenzhen Jia[2], Vishal Ahuja[3], Jianqiang Hu[2], [1]Vanderbilt University, Nashville, TN, [2]Fudan University, Shanghai, China; [3]Southern Methodist University, Dallas, TX

Our research investigates how preference satisfaction, particularly intrinsic values such as psychological comfort, can improve a worker's service efficiency and quality. Examining a comprehensive dataset linking surgeons' performances to their preferences for operating rooms, we not only confirm the significant role of intrinsic values in driving workers' service efficiency and quality but also quantify the preference satisfaction effect as large enough to serve as a new managerial lever for firms. Our counterfactual analysis demonstrates that preference satisfaction can achieve huge benefits in operation cost saving and patient welfare improvement at little expense.

3 Loyalty Currency and Mental Accounting: Do Consumers Treat Points like Money?

Freddy Lim[1], So Yeon Chun[2], Ville Satopaa[2], [1]INSEAD, Singapore, Singapore; [2]INSEAD, Fontainebleau, France. Contact: freddy.lim@insead.edu

We study how consumers decide to pay with loyalty points or money, and how their attitudes toward points and their payment choices are related to their point earning sources and characteristics. We develop a model of consumers' payment choices and estimate it on airline loyalty program data. We find that mental accounting, subjective perceived value, and reference exchange rate of points play important roles, and consumers' primary points earning source and total earning level are jointly associated with their attitudes toward points and money. We propose a probabilistic segmentation of consumers and show how a firm can implement pricing policies to efficiently target and influence consumers' payment choices through counterfactual analyses.

4 Are Buyers Strategic in Online B2B Reviews?

Hao Ding[1], Mor Armony[2], Achal Bassamboo[3], Ruomeng Cui[1], [1]Emory University, Decatur, GA, [2]New York University, New York, NY, [3]Northwestern University, Evanston, IL

In the digital age, buyers rely heavily on online review information. Our paper studies buyers' strategic behaviors when leaving reviews in a business-to-business (B2B) context. In particular, we explore whether they are less likely to write a review when a supplier's transaction volume increases, hoping thus to curb the supplier's business growth and future bargaining power. We collect the entire review and transaction histories of 4,605 suppliers from Alibaba.com, the largest B2B global sourcing platform. Our dataset includes these suppliers' 62,529 reviews and 455,593 transactions, all timestamped, from February to November in 2017 and 2018. We use a generalized difference-in-differences method that leverages the natural experiment arising from the trade war between the US and China, which caused a sudden change in US buyers' purchasing behaviors, leading to fluctuations in sellers' transaction volumes. These changes served as natural shocks to non-US buyers, because they saw an exogenous change in some sellers' performances. We find that each additional transaction reduces the likelihood for buyers to leave reviews for the seller by 0.9 percentage point. We also find that the review numerical ratings did not significantly change after the shock. The results are mostly in line with our expectations---buyers leave fewer reviews in order to control the seller's growth and leave more when the seller's performance drops. We provide managerial insights on reviews on B2B platforms. The findings suggest that buyers are motivated to manipulate, for their own advantage, information on suppliers that is disclosed to the public on the platform. Therefore, information transparency could be a double-edged sword: disclosing too much information about sellers, such as their transaction histories, could induce buyers' strategic behaviors when leaving reviews. Platform owners should be careful in designing the level of information transparency.

Monday, 2 PM–3:15 PM

MD70

M - Indiana G

Machine Learning Meets Discrete Optimization

General Session

Session Chair

Thiago Serra, Bucknell University, Lewisburg, PA

1 Learning Sparse Nonlinear Dynamics Via Mixed-integer Optimization

Wes Gurnee, Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA

Discovering governing equations of complex dynamical systems directly from data is a central problem in scientific machine learning. In recent years, the sparse identification of nonlinear dynamics (SINDy) framework, powered by heuristic sparse regression methods, has become a dominant tool for learning parsimonious models. We propose an exact formulation of the SINDy problem using mixed-integer optimization (MIO) to solve the sparsity constrained regression problem to provable optimality in seconds. On a large number of canonical ordinary and partial differential equations, we illustrate the dramatic improvement of our approach in accurate model discovery while being more sample efficient, robust to noise, and flexible in accommodating physical constraints.

2 Improving The Stability of Optimal Decision Trees

Jack W. Dunn[1], Ying Zhuo[2], [1]Interpretable AI, Cambridge, MA, [2]Interpretable AI, Boston, MA

Decision tree methods carry a reputation for being unstable - small variations in the training process can have large effects on the derived model. While Optimal Decision Tree methods are less susceptible to these issues than greedy methods, small changes to the training process can still result in large changes in the trained tree. In this work, we present a number of approaches for defining and quantifying instability of decision tree models, and present a framework for understanding and exploring the stability of a particular solution. We consider model training as a multi-objective problem that optimizes both stability and performance, and present some of the tools we have developed to navigate the trade-off between these objectives.

3 Black-box Optimization for Piecewise Constant Functions

Dzung Phan[1], Hongsheng Liu[2], Lam M. Nguyen[1], [1]IBM Research, Yorktown Heights, NY, [2]UNC-Chapel Hill, Chapel Hill, NC, Contact: phandu@us.ibm.com

We propose the StepDIRECT algorithm for derivative-free optimization (DFO), in which the black-box objective function has a stepwise landscape. Our framework is based on the well-known DIRECT algorithm. By incorporating the local variability to explore the flatness, we provide a new criterion to select the potentially optimal hyper-rectangles. In addition, we introduce a stochastic local search algorithm performing on potentially optimal hyper-rectangles to improve the solution quality and convergence speed. Global convergence of the StepDIRECT algorithm is provided. Numerical experiments on optimization for random forest models and hyper-parameter tuning are presented to support the efficacy of our algorithm.

4 The Combinatorial Brain Surgeon: Pruning Weights that Cancel One Another in Neural Networks

Xin Yu[1], Thiago Serra[2], Srikumar Ramalingam[3], Shandian Zhe[1], [1]University of Utah, Salt Lake City, UT, [2]Bucknell University, Lewisburg, PA, [3]Google, Mountain View, CA

Neural networks yield accurate models even if overparameterized. However, carefully removing parameters may produce models with good accuracy. By taking the stance that better parameter pruning depends on the combined effect of removing multiple weights, we revisit one of the classic approaches for impact-based pruning: the Optimal Brain Surgeon. We propose a tractable heuristic for solving the combinatorial extension of OBS, in which we select weights for simultaneous removal, as well as a systematic update of the remaining weights. Our selection method outperforms other methods under high sparsity, and the weight update is advantageous even when combined with other methods.

Monday, 2 PM–3:15 PM

MD71

M - Arizona
Financial Technologies Flash Session
Flash Session

1 **Capacity Planning in Liberalized Electric Markets at Multiple Locations with Demand Risk**

Xinyue Song[1], Maxim Bichuch[1], Benjamin Field Hobbs[2], [1]Johns Hopkins University, Baltimore, MD, [2]Johns Hopkins University, Baltimore, MD, Contact: xsong11@jhu.edu

We investigate the optimal capacity expansion in liberalized electrical markets at two locations, with limited transmission and demand/investment uncertainty. Electricity can be bought and sold at both locations, and the transmission is provided by the system operator. Locational marginal pricing is used in case of congestion. The suppliers of energy are utility maximizers and choose the optimal amount of new capacity among several technologies. We study the Nash equilibrium on the immediate capacity decisions among suppliers at both locations.

2 **Optimal Scenario-dependent Multivariate Shortfall Risk Measure and Its Application in Risk Capital Allocation**

Wei Wang[1], Huifu Xu[2], Tiejun Ma[1], [1]University of Southampton, Southampton, United Kingdom; [2]The Chinese University of Hong Kong, Southampton, Hong Kong. Contact: math.wang21@gmail.com

We propose a novel multivariate shortfall risk measure to evaluate the systemic risk of a financial system, where the allocation weight is scenario-dependent and optimally chosen from a predetermined feasible set. To calculate the proposed risk measure, we reformulate it as a two-stage stochastic program and provide computational procedures. Moreover, we apply the proposed risk measure to the risk capital allocation problem and introduce the scenario-dependent allocation strategy and an associated deterministic allocation strategy. From our numerical tests, we find that the proposed method performs better than some well-known allocation methods and is robust to the data perturbation.

3 **Cyber Risk Assessment for Capital Management**

Wing Fung Chong[1], Runhuan Feng[2], Hins Hu[3], Linfeng Zhang[2], [1]Heriot-Watt University, Edinburgh, United Kingdom; [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]Cornell University, Ithaca, NY, Contact: lzhang18@illinois.edu

Cyber risk is omnipresent but difficult to assess. Although it shows distinct characteristics from conventional risks, most existing cyber risk models in the insurance literature adopt frequency-severity analysis developed for classical P&C risks. In contrast, the cybersecurity literature often views cyber incidents as attacks acting on a set of vulnerabilities. To close the gap in cyber risk modeling between cybersecurity and insurance literature, this study presents a novel cyber risk assessment model based on industry loss data and a company's cybersecurity profile. The analysis leads to a new tool for allocating company resources between cybersecurity investments and loss reserves.

4 **Modeling The Default Risk of Card Loan Considering Individual Behavior Characteristics Based on Deposit and Withdrawal Data of Bank Account**

Norio Hibiki[1], Haruki Kamitake[2], [1]Keio University, Yokohama, Japan; [2]Resona Bank, Co. Ltd., Tokyo, Japan. Contact: hibiki@ae.keio.ac.jp

This study analyzes the deposit and withdrawal data of bank accounts used by card loan borrowers and proposes default risk management technique. Kamitake et al.(2020) analyze bank account data for screening applicants, and construct a model. However, there are no studies that analyze bank account data for managing the default risk while lending money with a card loan or construct a management model. In addition to the variables used in the screening model, we employ some variables observable after lending money, which are related to individual behavior characteristics. We construct a logit model using these variables and examine the model using approximately 60 million observations. The result shows that the accuracy ratios exceed 50%, and the model is effective in practice. We also confirm the robustness of the results through cross-validation and out-of-sample test.

5 **Resolving Conflicts in Crowds: An Application in Earnings Forecasts**

Houping Xiao[1], Shiyu Wang[2], [1]Robinson College of Business/GSU, Atlanta, GA, [2]University of Georgia, Athens, Athens, GA, Contact: hxiao@gsu.edu

Recently, investors can obtain earnings forecast information through traditional venues, such as Wall Street, Institutional Brokers' Estimate System (IBES) as well as modern social

media platforms like Estimize which generates consensus estimates based on the forecasts from individuals with different backgrounds. As a result, this will inevitably lead to conflicts in earnings forecasts. This paper \hp{presents a novel and effective} optimization-based approach to resolve such conflicts in earnings forecast data and generate an accurate and robust earnings forecast consensus. Consistent with the wisdom-of-crowds effect, the new earnings forecast consensus is more accurate than the Wall Street consensus (67.5\%) and IBES consensus (67.4\%) of the time. The new earnings forecast consensus is incrementally useful in forecasting earnings.

6 Portfolio Optimization with Sentiment Trading Strategy

WenYi Lee, Yu-Hsuan Lin, National Taipei University of Business, Taipei, Taiwan. Contact: wy.lee@ntub.edu.tw

Portfolio optimization is widely used to adjust the stock weights. Since the unity of portfolio and trading strategy is popular to achieve better trading performance, little attention had paid to the consideration of sentiment analysis. Our study fills this gap by combining sentiment trading strategy and portfolio optimization. The conventional trading strategy, such as momentum and contrarian, allocates portfolio weights equally by selecting the pile of winners and losers according to stock capital. With sentiment analysis, these trading strategies could filter the winner and loser piles more appropriately. Portfolio optimization would adapt stock weights in a more detailed manner instead of equally allocating the weights. Thus, we extend portfolio optimization with a sentiment trading strategy to construct portfolios for achieving better trading performance.

Monday, 2 PM–3:15 PM

MD72

M - California

Impact of social media on individuals, organizations, or society

General Session

Session Chair

Cuibing Wu, UMass Lowell

1 The Effects of The FTC Policy and Affiliation Disclosures on Review Video Engagement: Evidence from Youtube

Jingwen Zhang[1], Stephanie Lee[2], [1]University of Washington, WA, [2]University of Washington, Seattle, WA

With affiliate marketing tactic, influencers can earn commission fees by posting affiliate links along with product reviews. However, concealing the affiliation can mislead consumers' product evaluation. The Federal Trade Commission published the Endorsement Guides, which requires influencers to disclose the affiliate relation along with product reviews. In this paper, we empirically examine the effectiveness of the Guides on product review videos that contain affiliate links. We mainly find that after the implementation of the Guides, consumers have significantly more engagements with review videos that disclose affiliation. Our findings have important implications for policymakers, content creators, and consumers in real practice.

2 Analyzing The First Year Students' Online Reviews to Formulate Strategies to Improve Low Retention Rate in Four-year Non-profit Historically Black Colleges and Universities

Tonghui Xu, UMass Lowell, Lowell, MA

This study aims to analyze the first-year full-time undergraduate student online reviews to improve the first-year retention rates of four-year non-profit historically black colleges and universities. Therefore, we first selected first-year students' online comments from 55 four-year non-profit HBCUs. These HBCUs have low first-year retention rates and high rates of black students. We used Latent Dirichlet Allocation topic modeling to construct topic clusters and then ran the bigrams model to determine the top word sequences from each topic cluster. Next, we integrated the sentiment analysis and neural network to analyze the different topic clusters to understand the first-year students' sentiment toward HBCUs. Finally, we formulate strategies to improve the first-year retention rates of four-year historically black colleges and universities.

3 Covid-19 and Socially Connected Music Listeners: Social Dynamics of Music Streaming Platforms

Mona Ghaffari[1], Gohar Khan[2], Shivendu Pratap Singh[1], Bruce Ferwerda[3], [1]The University of Waikato, Hamilton, New Zealand; [2]Zayed University, Abu Dhabi, United Arab Emirates; [3]Jönköping University, Jönköping, Sweden.

In this study, we investigated the impact of COVID-19 (outbreaks, restrictions, and Covid-19 cases) on quantity, novelty, and variety of music consumption. We empirically tested the online music listening behavior and social interactions of 37,328 Last.fm users in 45 countries before and after the first wave of confinement. We found that due to Covid-19, the play counts, variety, and novelty of online music consumption decreased, shifting toward mainstream artists, whereas individuals with more social networks and communication showed a reverse behavior. Our research shows that online social interactions significantly impact listeners' behavior and can be used as a guide to developing new design strategies for online platforms.

4 Influence of CEO's Facial Emotions in Interview Videos on Firm Market Value

Cuibing Wu[1], Julie Zhang[2], [1]UMass Lowell, Lowell, MA, [2]University of Massachusetts, Lowell, Lowell, MA, Contact: cuibing_wu@student.uml.edu

Facial expressions have been regarded as one of the most efficient and instinctive ways to telegraph feelings and intentions in the form of nonverbal communication. The CEO provides important facial information during the interview, which links to the firm's current market situation and future planning. This study explores how CEOs' facial emotions impact firm market value by analyzing the interview videos from the YouTube platform. We use the FER, a CNN algorithm-based method, to establish the facial emotions and build multiple regression models to predict the firm's market value. Our findings show that CEO's negative emotion has a significant negative impact on market value. Negative emotion swing has a negative impact on the stock price. The high CEO's emotion swing affects investors' confidence in the firm performance and reflects on the stock price.

Monday, 2 PM–3:15 PM

MD73

M - Colorado

Improving Social Welfare Using Operations Management Techniques

General Session

Session Chair

Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA

Session Chair

Arielle Elissa Anderer, 1</sup

1 Capacities of Inference in Regulation of Pharmaceutical Supply Chains

Eugene Wickett, Matthew Plumlee, Karen Smilowitz, Northwestern University, Evanston, IL, Contact: eugenewickett2022@u.northwestern.edu

Substandard and falsified pharmaceuticals are a crucial problem for global health. Regulators in low-resource settings combat this problem using post-market surveillance by testing samples where consumers buy products. Existing surveillance methodology focuses on locations of positive samples. Descriptive methodology has been developed that infers sources of substandard and falsified products within a supply chain by using available supply-chain information while accounting for multiple sources of uncertainty. We explore the predictive value of additional samples under this methodology for furthering regulator objectives. Establishing predictive value can help regulators decide when to discontinue surveillance activities or choose the locations for the next round of samples.

2 Bandits with Time-to-event Data: An Application to Clinical Trials

Arielle Elissa Anderer[1], Hamsa Sridhar Bastani[2], John M. Silberholz[3], [1]The Wharton School, University of Pennsylvania, Philadelphia, PA, [2]Wharton School, Philadelphia, PA, [3]University of Michigan Ross School of Business, Ann Arbor, MI, Contact: aanderer@wharton.upenn.edu

In many healthcare and marketing applications, decision makers are faced with data that is time-to-event. This project adapts online learning techniques to scenarios with this type of data, where there is a delay between choosing an arm and observing feedback that is endogenous to the quality of the arm. We posit a multi-armed bandit algorithm that uses a cox-proportional hazards estimator. We theoretically analyze and prove guarantees on the regret under this algorithm. We also focus on the gains that can be made by appropriately leveraging the granularity of time-to-event data against existing designs that simplify this data using methods such as binarization. Lastly, we examine its performance on a dataset of metastatic breast cancer clinical trials, and compare it to that of other adaptive allocation schemes.

3 Privately-owned Battery Storage - Re-shaping The Way We Do Electricity

Christian Kaps, Serguei Netessine, The Wharton School, Philadelphia, PA, Contact: ckaps@upenn.edu

In this paper, we use a proprietary, big-data-set of thousands of European households' storage and photovoltaic panel investments as well as their granular electricity demand and solar generation patterns to structurally estimate household-level preferences. In particular, we estimate each households' inherent utility to consume electricity for each hour of the day as well as their "greenness" valuation - a non-financial cost that households incur when purchasing energy from the grid, because they either want to avoid purchasing fossil-based energy or prefer to be autarkic. We then use these estimates to show that non-financial preferences are necessary to justify we investments in storage we observe and show how customers with storage behave differently as utility customers than if they had no storage.

4 **Estimating Variability in Surgery Times**

Cagla Keceli[1], Daniel Adelman[1], Josh Morris-Levenson[2], Kiran Turaga[2], Gulin Tuzcuoglu[1], Hunter Witmer[2], [1]University of Chicago, Booth School of Business, Chicago, IL, [2]University of Chicago, Chicago, IL, Contact: ckeceli@chicagobooth.edu

We show the need for standardizing the operative time of a surgical case, when one considers surgeries across the entire institution. We use different methods to standardize and compare how they perform against each other. We discuss applications where this standardized variable proves useful.

Monday, 2 PM–3:15 PM

MD74

M - Florida

Machine Learning for Quantitative Finance

General Session

Session Chair

Maxim Bichuch, Johns Hopkins University, Baltimore, MD

Session Chair

Nils-Christian Detering, University of California-Santa Barbara, Santa Barbara, CA

1 **Deep PDE Solution to BSDE**

Jiahao Hou, Maxim Bichuch, Johns Hopkins University, Baltimore, MD, Contact: jhou20@jhu.edu

We numerically solve a high dimensional BSDE by finding a classical solution of the corresponding semilinear PDE on unbounded domain. In order to have a good approximation of the gradient of the solution of the PDE, we numerically solve a coupled PDE, consisting of and the original PDE and the PDEs for the derivatives. We solve this coupled PDE using neural nets. We then prove existence and uniqueness of the classical solutions of this coupled PDE, and we show how to truncate the unbounded domain to a bounded one, so that the error between the original solution and that of the same coupled PDE but on the bounded domain, is small. This established a convergence of the numerical solution to the true solution. Finally, we test this on 100 dimensional Allen-Cahn and nonlinear Black-Scholes examples. We also compare our result to result of solving the BSDE directly.

2 **Latent Factors with Economic Restrictions**

Svetlana Bryzgalova[1], Victor DeMiguel[1], Sicong Li[1], Markus Pelger[2], [1]London Business School, London, United Kingdom; [2]Stanford University, Stanford, CA, Contact: ali@london.edu

We propose a new method for estimating latent asset pricing factors that incorporate economic information. Our estimator generalizes Principal Component Analysis (PCA) by including penalties for cross-sectional and time-series restrictions. Empirically, we show that cross-sectional shape and pricing error restrictions substantially help to span pricing kernels with higher Sharpe ratios and lower pricing errors than conventional PCA factors.

3 **Data-Driven Robust Optimal Execution with Unknown Price Impact**

Tao Chen, University of Michigan

In this project we study optimal execution of trades and focus on the analysis of book depth. We propose a foumulation of optimal execution that is adaptive and robust where the controller dynamically learns price impact parameters based on observations and adjusts the actions according to the worst case parameters to mitigate model risk.
This paper is a joint work with Michael Ludkovski and Moritz Voss.

Monday, 2 PM–3:15 PM

MD75

M - Illinois

Topics in Computational Actuarial Science and Risk Management

General Session

Session Chair

Daniel Bauer, University of Wisconsin-Madison, Madison, WI

1 **Dynamic Capital Allocation in General Insurance**

Qiheng (Steve) Guo[1], Daniel Bauer[2], George Zanjani[3], [1]Ball State University, Muncie, IN, [2]University of Wisconsin-Madison, Madison, WI, [3]University of Alabama, Tuscaloosa, AL, Contact: qguo@bsu.edu

This paper resolves the inconsistency between stochastic claims reserving and capital allocation models by integrating them in their canonical form for a value-maximizing insurance company. We demonstrate that this integration yields different guidance for the optimal portfolio choice. In particular, the integrated model attaches different valuation weights to cash flows with different tenors when determining risk-adjusted return ratios that characterize optimal exposures. Numerical results in a calibrated version of the model using common distributional assumptions showcase that these differences can be economically significant. A long time until final resolution as within so-called long-tailed business lines can be advantageous or disadvantageous, depending on the company's financial situation.

2 Metamodeling for Variable Annuity Valuation: What Works and What Does Not

Xiaochen Jing, University of Illinois Urbana-Champagne, IL

Variable Annuities are popular retirement products with complex design. Previous literature on the statistical learning and metamodeling approaches for Variable Annuity valuation all focus on specific techniques in the context of synthetic data. In this paper, I investigate the effectiveness of metamodeling approaches with different experimental designs and metamodels with real-world Variable Annuity contracts. I use textual analysis to extract value-related features and develop a flexible simulation-based scheme for valuation. I find that real-world variable annuity contracts are very complex and the intricate relations between their valuation and features are difficult to obtain. And the overall performance of a metamodeling method depends on the employed machine learning methods as well as the sample size—though not substantially on the sampling methods.

3 An Integrated Study of Cyber Security and Cyber Insurance

Yang Feng[1], Zhiwei Tong[2], [1]University of Science and Technology Beijing, Beijing, China; [2]The University of Iowa, Iowa City, IA, Contact: zhiwei-tong@uiowa.edu

Cyber risk is a top business concern nowadays and has been attracting increasing attention in recent years. We build a theoretical network model of companies subject to a cyber attack, where the companies can invest in cyber security to reduce its likelihood of being compromised and purchase cyber insurance to transfer losses to insurers. We provide a characterization of the Nash equilibrium and identify a sufficient condition for the Nash equilibrium to be unique. Considering a star network and assuming that the peripheral companies know the best response of the central company, we study the Stackelberg equilibrium and compare it with the Nash equilibrium. Finally, intensive numerical studies are performed to illustrate companies' decisions on security investment and insurance purchase.

4 A Least-squares Monte Carlo Approach to Calculating Risks; Regression-now or Later?

Hongjun Ha[1], Daniel Bauer[2], [1]St. Joseph's University, Philadelphia, PA, [2]University of Wisconsin-Madison, Madison, WI, Contact: hha@sju.edu

There has been substantial interest in estimating risk capital via Monte Carlo procedures. The difficulty arises from characterizing the distribution of a company's available capital. One prevalent approach, referred to as regression-now, projects the realized cash flows and regresses resulting discounted values against basis functions. Another approach, known as regression-later, approximates the cash-flows based on functions of processes and calculates the conditional expected functional combination. This paper makes two contributions. We show that the left and right singular functions of the valuation operator present robust basis functions for the two approaches. Secondly, we characterize situations in which either of the approaches results in superior performance. The regress-later approach performs better when theoretical conditions are met.

Monday, 2 PM–3:15 PM

MD76

M - Michigan

Supply Chain Optimization Flash Session

Flash Session

Session Chair

Gang Li, Bentley University, Waltham, MA

1 Assessing Product Availability in Retail Distribution Networks

Shahab Derhami, Binghamton University, Binghamton, NY

We present a model to assess product availability in a retail distribution network of high-value products under customer substitution, inventory transshipment, and uncertain demand.

2 Evaluating The Effect of Options and Other Strategies on Supplier Outcomes Under Supply Chain Disruptions and Demand Uncertainty

Michael Redmond[1], Mark Stephen Daskin[2], Abby Levin[2], [1]University of Nebraska, Lincoln, NE, [2]University of Michigan, Ann Arbor, MI, Contact: mredmond2@unl.edu

Supply chain disruptions and demand uncertainty can wreak havoc on producers' bottom lines and product availability. Since 2020, auto manufacturers have seen profits plummet due to a global chip shortage and an inability to meet bolstered demand. Our model seeks to mitigate these risks using strategies such as dual-sourcing and options contracts.

We examine the effect these strategies have in a multi-stage stochastic optimization model with unknown demand and supplier unreliability. We show that the number of options to purchase increases as uncertainty climbs and that increased supplier disruptions result in a more robust sourcing strategy.

3 Partner Trust Level in Collaborative Demand Forecast Sharing and Its Impact on Supply Chain Profitability

SEONG-HYUN NAM, University of North Dakota, Grand Forks, ND, Contact: snam@business.und.edu

Considering trust as a critical factor for successful collaborative demand forecast sharing, this paper studies the dynamic relationship between trust level-based forecasting capability and supply chain profitability. We develop a forecasting coordination model to examine how the enhanced partner trust level can influence the forecasting evolution to improve demand forecasts' accuracy. We estimate costs and profits from demand forecast sharing under varying trust levels between a buyer and a partner supplier and then determine the optimal level of trust for both parties to create the maximum economic value through collaborative demand forecast sharing.

4 Large-scale Production Line Changeover Planning for Multiple Model Years of High-tech Products

Candace Arai Yano, University of California-Berkeley, Berkeley, CA, Contact: yano@ieor.berkeley.edu

High-tech consumer products such as cell phones are typically sold for a few years and then discontinued. They are often produced in multi-product factories in which equipment on each production line must be replaced or reconfigured in order to produce a different product. The changeover costs and times are sequence-dependent and may include significant opportunity costs of lost production during the changeover. We present a model for optimizing changeovers, including their timing, at multiple factories, with the goal of minimizing changeover, backorder and inventory costs, taking into account constraints on the set of changeovers in progress at any point in time.

5 Coordination Between Multiple Vendors and a Buyer with Target Profits

Jose A. Ventura[1], Omar Abbaas[2], Marta J. Ventura[2], Sara F. Abu Aridah[1], [1]Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA 16802, PA, Contact: jav1@psu.edu

Several studies have focused on multi-vendor buyer coordination through quantity discounts. In this study, we propose a coordination mechanism where all parties divide the supply chain surplus fairly after satisfying their own profit targets. The proposed mechanism for division of surplus is illustrated through a numerical example and the impact of different parameter values on the results are examined.

6 Capacity Allocation and Pricing Decisions in Dual Channel with Dual Mismatch

Peeyush Mehta[1], Dhandabani S[2], R K Amit[2], [1]Indian Institute of Management Calcutta, Kolkata, India; [2]Indian Institute of Technology Madras, Chennai, India. Contact: pmehta@iimcal.ac.in

In this research we consider a dual distribution channel where a supplier with a fixed capacity sells directly to consumers and through the traditional retailer. The demand is price dependent with an additional uncertainty factor. Demand split to both the channels is realized with similar prices in both channels. The problem has a dual newsvendor structure. Any excess capacity allocated to the retailer results in opportunity loss to the supplier. The retailer also faces newsvendor trade-offs resulting in vertical capacity competition. We determine the pricing and capacity allocation decisions of the supplier and wholesale price of the retailer. Problem setting is found in many real-life contexts. We contribute to the literature of dual channel optimization with limited capacity. We provide managerial implications.

7 A Strategy of Reconfiguring Lean Operations for Supply Chain Coopetition

Gang Li[1], Yusen Xia[2], [1]Bentley University, Waltham, MA, [2]Georgia State University, Atlanta, GA, Contact: gli@bentley.edu

The Covid-19 pandemic is a wake-up call; waves of shortages from personal protective equipment to daily groceries to computer chips vindicate that the current global supply chain is too rigid to cope with disruptions. We propose a strategy that reconfigures some key components of lean operations so that competitors from different supply chains can cooperate without weakening their own competitiveness.

8 Supply Chain Operations Planning in a Carbon Cap-and-trade Market

Christopher M. Rump[1], Ibrahim Capar[1], Jessica Mysyk[2], Zubair Mohamed[3], William Sawaya[3], [1]Bowling Green State University, Bowling Green, OH, [2]Meijer, Grand Rapids, MI, [3]Bowling Green State University, Bowling Green, OH, Contact: cmrump@bgsu.edu

We model the multi-modal supply chain logistics of a major US retailer from their manufacture in China and Mexico to their distribution in the United States. Using a multi-objective, mixed-integer linear programming model, we optimize the choice of manufacturer, port, transportation mode, distribution center, and delivery timing to optimize the tradeoff in cost and environmental impact. We perform a sensitivity analysis on the market price of the carbon to be traded, which provides clarity on the degree to which the pricing of carbon credits in a carbon cap-and-trade system will drive organizational change.

Monday, 2 PM–3:15 PM

MD77

M - Texas

Behavioral Operations Management Best Working Paper Competition

Award Session

Session Chair

Anna Saez de Tejada Cuenca, IESE Business School, Barcelona, Spain.

Monday, 2 PM–3:15 PM

MD78

M - Utah

AI, Social Media and Digital Platforms

General Session

Session Chair

Yang Pan, Tulane University, New Orleans, LA

1 The Effects of Real-time Sale Data on Sales Performance: A Randomized Field Experiment in Livestream Selling

Yumei He[1], Lingli Wang[2], Ni Huang[3], Yili Kevin Hong[3], Yan Sun[4], [1]Tulane University, New Orleans, LA, [2]Beijing University of Posts and Telecommunications, Beijing, China; [3]University of Houston, Gilbert, AZ, [4]Alibaba Group, Hangzhou, China.

Livestream selling is a technology-enabled business model that transforms the landscape of the sales industry in the digital economy. However, there is limited understanding of how platforms can design systems to provide information that may help streamers improve their real-time decision-making and, more importantly, livestream selling performance.
In partnership with Alibaba, we collected data from a randomized field experiment that incorporated the real-time sales data into the sales dashboard for presale products. We find that the sales of presale products in the treatment group approximately increased by 20% compared with those of presale products in the control group. Second, the observed effect of providing real-time sales data is driven by the streamer' s optimization in time allocation and sales tactics.

2 Humans, AI Agents, and Reputational Considerations: Reciprocity to Kind and Unkind Actions

Akshat Lakhiwal[1], Chewei Liu[1], Hillol Bala[2], [1]Indiana University-Kelley School of Business, Bloomington, IN, [2]Indiana University, Bloomington, IN

Artificial intelligence (AI) agents are being deployed across diverse contexts, motivating researchers to examine changes in users' reactions. We assess changes in users' positive and negative reciprocity due to AI agents and discuss heterogeneity due to anthropomorphic and reputational aspects. In a 3x2 experiment, participants played a two-stage game with human, non-anthropomorphic chatbots, and highly anthropomorphic digital-humans. Without reputational consideration, AI agents weakened positive and negative reciprocity. Digital humans further weakened negative reciprocity as an asymmetry in positive and negative reciprocity emerged for chatbots. With reputation, both AI agents elicited weaker positive reciprocity with no effect on negative reciprocity. We discuss the growing agency of AI and emphasize awareness for informed deployment of AI agents.

3 Location Divide in Digital Platforms? Evidence from a Natural Experiment

Lanfei Shi[1], Raveesh K. Mayya[2], Ye Shun[3], [1]University of Virginia, Charlottesville, VA, [2]NYU Stern School of Business, New York, NY, [3]George Mason University, Fairfax, VA, Contact: ls4tj@comm.virginia.edu

With the rise of international e-commerce, geolocation boundaries seem to have become blurred and less relevant. Yet, emerging evidence has shown that consumers tend to exhibit location preferences when it comes to choosing sellers (e.g., U.S. consumers may prefer products that are domestically made). While researchers and practitioners have recognized the important role of salient information signals such as price and product ratings, our study seeks to examine a less investigated information signal - the seller's location. We ask whether and how the disclosure of seller location affects the product sales and pricing strategies of international sellers as compared to domestic sellers. Our findings shed light on the unintended consequences of information disclosure and provide valuable implications for designing and managing global e-commerce platforms.

4 The Value of Social Media Customer Support During The Pandemic

Huai-Tzu Cheng[1], Yang Pan[2], Rudy Hirschheim[1], [1]Louisiana State University, Baton Rouge, LA, [2]Tulane University, New Orleans, LA

Many companies are utilizing social media as the primary avenue for customer service during the pandemic. However, how customers' behaviors and interactions with customer service agents on social media are impacted by the lockdowns has not been well understood. In this study, we examine the impact of lockdowns and physical distancing on changes in customers' behaviors, such as emotional expressions in tweets and customers' satisfaction with social media customer service. Using a difference-in-differences research design, we find that with the lockdowns, customers expressed more negative emotions when tweeting the company they were having issues with. Surprisingly, compared to before the pandemic period, customers' emotional expressions became more positive and they were more likely to express their satisfaction after interacting with agents.

Monday, 2 PM–3:15 PM

MD79

JWM - Room 201

Technology, Innovation, and Data

General Session

2 Session Chair

John N. Angelis, University of Lynchburg, Lynchburg, VA

Session Chair

Juliana Hsuan, Copenhagen Business School, Frederiksberg, Denmark.

Optimal Cardinal Contests

Goutham Takasi, University of Texas-Dallas, Richardson, TX

We study the optimal design of a crowd-sourcing contest in settings where the output is quantifiable - e.g., a data science challenge. This setting is in contrast to settings where the output can only be assessed qualitatively - e.g., designing a logo. The rapidly growing literature on the design of crowd-sourcing contests focuses on ordinal contests - these are contests where contestants' outputs are ranked by the organizer and awards are based on these ranks. Such contests are ideally suited for the latter setting (where output is qualitative). For our setting (quantitative output), it is possible to design contests where awards are based on the actual outputs and not on their ranking alone - thus, our space of contest designs includes ordinal contests but is much larger. We derive an easy-to-implement contest design for this setting and prove its optimality.

1 Mental Models for Technology Adoption Among The Elderly

Charles Weber[1], Noshad Rahimi[2], Antonie J. Jetter[1], [1]Portland State University, Portland, OR, [2]Portland State University and Lewis & Clark College, Lake Oswego, OR

An empirically grounded collective mental model of 15 elderly women and their caregivers is expressed as a fuzzy cognitive map. The model provides insights into the adoption process for remote healthcare monitoring technology by the elderly.

3 Effect of Industry 4.0 Technologies Adoption on The Learning Process of Workers in a Quality Inspection Operation

Flavio S. Fogliatto[1], Guilherme L. Tortorella[2], Michel J. Anzanello[3], [1]Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil; [2]University of Melbourne, Melbourne, Australia; [3]Federal University of Rio Grande do Sul - UFRGS, Porto Alegre, Brazil. Contact: ffogliatto@producao.ufrgs.br

We examine the effect of Industry 4.0 (I4.0) technologies adoption on the learning process of operators modeled by learning curves. Data from the training of twenty new operators in a quality inspection workstation of an auto parts manufacturer was collected under two scenarios: before and after the adoption of I4.0 technologies to support the operation. A 2-parameter hyperbolic model was used to model the learning process. Results indicated that operators supported by I4.0 technologies had a significantly higher learning rate than those without I4.0 support. No significant difference was found in the final performance level between groups.

4 Increasing Commercialization Success Rates from University Research

Andrew L. Maxwell, York University

Increasing commercialization success rates from University Research Transforming university research into innovation outcomes is critical in driving regional economies & addressing pressing societal issues. Low success rates often due to misalignment between research outcomes & market needs. Our approach, deployed over 10 years, improves process understanding & facilitates graduate students pivoting research to increase percentage of research projects adopted by users. The process combines aspects of design thinking & behavioral economics through a "Stage-gate" process, enhancing commercialization outcomes, & better preparing graduating students for industry careers. In 2023, we launch our global classroom (open educational resource) to enhance project diversity, feedback & impact. We share our approach, insights, & an invitation to collaborate.

Monday, 2 PM–3:15 PM

MD80

JWM - Room 202

Methodological Improvements and Innovative Applications with FITradeoff Method

General Session

Session Chair

Caroline Mota, 1</sup

Session Chair

Danielle C. Costa Morais, Universidade Federal de Pernambuco - UFPE, Recife - PE, Brazil.

1 Analysis on The Structure and Properties of The Fitradeoff Method

Jonatas Almeida[1], Eduarda Asfora Frej[1], Adiel Teixeira De Almeida[2], [1]Universidade Federal de Pernambuco, Recife, Brazil; [2]Universidade Federal de Pernambuco, Recife PE, Brazil. Contact: jonatasaa@yahoo.com.br

The FITradeoff method, based on the tradeoff procedure and belonging to the MAVT method set, seeks to analyze how the weight subspace limited by partial information defines values and preference relationships between alternatives that will build the recommendation. Methodological improvements on FITradeoff and applications have been published in several journals and conferences. Thus, this study seeks to present some analytical aspects about the FITradeoff method and how the partial information obtained from the decision maker is used to build the recommendation. Aspects related to the method's mathematical structure are presented and discussed. It is expected that the analysis will help researchers and practitioners better understand how the method works and how it reduces the number of questions and speeds up the elicitation process.

2 A Decision-making Model to Prioritize Tasks: An Application in The Context of Criminal Investigations

Caroline Maria de Miranda Mota, Maria Carolina Pereira, Marco Aurelio Faveri, Universidade Federal de Pernambuco, Recife, Brazil. Contact: carolinemota@cdsid.org.br

This study aims to build an MCDA model to support tasks and processes prioritization that arrives at a high rate and that must be processed by the available team. The model is applied to the case of criminal investigations tasks that are conducted by the Brazilian Federal Police. The decision-making process involves a continuous analysis of criminal reports, starting from the arrival of criminal notice until the closing of the police inquiry. The model prioritizes these notices using two dimensions, of importance and urgency, to support the allocation of efforts and the evaluation of performance in the organization.

3 Multicriteria Model Decision for Remote Work Activities Performance Raking: Case Study in a Call Center Company in Brazil

Ricardo Pires de Souza, Aleson Belo da Silva, Thiago Allan Marques de Macêdo, Gisele de Souza Dantas, Amanda Braga Marques, Federal University of Rio Grande do Norte, Natal, Brazil. Contact: ricardo.pires@ufrn.br

Call center companies have employees as their main asset for customer service and often demand a large physical space. During the COVID-19 pandemic, many companies allocated their employees in remote work and some advantages and disadvantages of this type of work were noticed. The current study aims at developing a multicriteria decision model to rank employees' performance in remote work. The FITtradeoff ranking method was selected, for it uses the flexible and interactive elicitation procedure and enables holistic evaluations. The research was carried out in a call center company with more than 2,000 employees, located in Brazil. The model developed will allow the company to list the most apt employees to carry out their work activities in remote work, enabling increased productivity and employee satisfaction as well as cost reduction.

4 A Gis Based Multicriteria Model for Portfolio Selection with Fitradeoff to Support Natural Gas Network Expansion

Lucas Borges Leal da Silva[1], Carolina Lino Martins[2], João Batista Sarmento dos Santos[2], Eduarda Asfora Frej[1], Adiel Teixeira De Almeida[3], [1]Universidade Federal de Pernambuco, Recife, Brazil; [2]Universidade Federal de Mato Grosso do Sul, Campo Grande, Brazil; [3]Universidade Federal de Pernambuco, Recife PE, Brazil. Contact: borgesleal.lucas@gmail.com

The growth of natural gas consumption has led distribution companies to expand their networks of gas pipelines to meet multiple and conflicting demands of their stakeholders. Given this backdrop, this work proposes a multicriteria decision model for portfolio selection with FITradeoff method to aid decision-makers in expanding a natural gas distribution network of a Brazilian distribution company. This proposal uses the benefit to cost ratio concept, thereby requiring a smaller effort from the DM since he/she establishes partial information in the process of establishing attribute weights. Furthermore, the modeling proposal introduces the georeferencing information as important information to compose the portfolio of natural gas expansion for the next years.

Monday, 2 PM–3:15 PM

MD81

JWM - Room 203

Machine Learning and Optimization in Supply Chain Planning

General Session

Session Chair

Masoud Chitsaz, Kinaxis, Montreal, QC, Canada.

1 **Integrating Optimization into Kinaxis Rapidresponse**

Ingrid Bongartz[1], Carsten D. Jordan[2], [1]Kinaxis, Ottawa, ON, Canada; [2]Kinaxis, San Diego, CA, Contact: cjordan@kinaxis.com

Kinaxis offers an optimized solution to supply planning problems by solving a MILP model that incorporates most of the advanced features available in its heuristic solutions, including complex BOMs, part substitutions, and co-products. Results are presented in RapidResponse, permitting detailed analysis and visualization of multiple scenarios with different inputs, solved by either optimization or heuristics. We are developing methods for warm-starting our heuristics with optimal solutions, to respond quickly to data changes and to open new avenues in the co-existence of optimization and heuristics.

2 **Designing for Manufacturing in Semiconductors Using Hierarchical Optimization of Physical Parameters**

Zachary Eich, AMD, Austin, TX

Due to changes in the global semiconductor industry, package substrates have become a limiting component in manufacturing. Optimizing for substrate utilization independent of die dimensions can lead to issues in manufacturability such as supply, capacity, and fabrication costs. Our solution to this is hierarchical optimization of the affected domains to develop the most manufacturable product possible.

3 **Application of Machine Learning in Automatic Algorithm Selection for Supply Chain Planning**

Masoud Chitsaz, Kinaxis, Ottawa, ON, Canada. Contact: mchitsaz@kinaxis.com

Large-scale supply network optimization requires the solution of hundreds of product families. Each product family includes a set of final products that share some limited resources in the product structure and production process. The optimization model for these problems can include from hundreds to millions of variables and constraints. Traditionally, one algorithm is used to find quality solutions for all problem sizes. Our investigation shows different algorithms perform (time and quality) differently on different sizes of these problems. In this talk, we explain this computing challenge and highlight directions to automatically select the best algorithm to apply on each problem using a learning mechanism.

4 **Analytics Success---beyond The Numbers**

Prabha Thanikasalam, Flex, Austin, TX

This talk will focus on key ‘soft’ factors for the success of analytics and optimization projects in an industry and enterprise setting. These factors start with the formulation of the business problem statement, defining a data strategy, forming key partnerships with stakeholders and teams, and ends with selling the solution to the implementation teams leading to value creation. The intention is to provide key insights for success in an industry setting that is NOT taught in grad school!

Monday, 2 PM–3:15 PM

MD82

JWM - Room 204

New Frontiers in Multiple Criteria Decision Making

General Session

Session Chair

Salvatore Greco, University of Catania, Catania, Italy.

1 **How Can Decision Sciences and Mcdm Help Solve Challenging World Problems**

Jyrki Wallenius[1], Hannele Elina Wallenius[2], [1]Aalto University School of Business, Helsinki, Finland; [2]Aalto

University, Espoo, Finland. Contact: jyrki.wallenius@aalto.fi
The world is witnessing rapid changes, some positive, some negative. In this talk we overview several of the technology mega trends and other trends, which are of interest for the Decision Science/MCDM community. We discuss, what role our field could and should play in helping solve world problems.

2 Distance-based Value Functions for Interactive Approaches

Murat Mustafa Koksalan[1,2], Gulsah Karakaya[1], [1]Middle East Technical University, Ankara, Turkey; [2]University of Michigan, Ann Arbor, Ann Arbor, MI, Contact: koksalan@metu.edu.tr
Underlying value functions that are assumed to represent decision-maker preferences have been widely used in interactive multi-objective approaches. They typically aim to converge towards preferred solutions of a decision maker utilizing preference information and the characteristics of the assumed value functions. Linear, quasiconcave, and general monotone value functions have been commonly used. In this study, we consider a family of distance-based value functions that can represent a wide variety of preference structures. We discuss approaches that use such value functions for choice and design problems.

3 Preference Modeling with Binary Relation Optimization

Philip de Castro, Clemson University, Clemson, SC, Contact: pdecast@clemson.edu
We present a novel approach for modeling preference aggregation for group decision making when choosing from a set of alternatives. To do so, we develop a theory of a linear program on a convex polyhedral set of vectors of binary relations contained in a semimodule with the objective function mapping a vector of binary relations to a binary relation. The theory includes geometrical properties of the feasible set and optimality conditions. Ideas for extension to multiobjective linear programs are included.

4 Modelling Optimism and Pessimism in Stochastic Multicriteria Acceptability Analysis

Salvatore Greco[1], Sally Giuseppe Arcidiacono[1], Salvatore Corrente[2], [1]University of Catania, Catania, Italy; [2]University of Catania, Department of Economics and Business, Catania, Italy. Contact: salgreco@unict.it
We propose a methodology to take into account optimism and pessimism of a Decision Maker (DM) that, using Stochastic Multicriteria Acceptability Analysis, evaluates alternatives based on a plurality of weight vectors. With this aim we consider specific families of probability distributions in the space of the feasible weight vectors discussing the results they provide. We also propose a methodology to elicit the probability distributions. We discuss the results obtained through our methodology in the domain of composite indicators.

Monday, 2 PM–3:15 PM

MD83

JWM - Room 205

DEI Ambassador Program Session

Flash Session

Session Chair

Lisa Miller, University of Minnesota

Session Chair

Daniel Reich, Naval Postgraduate School, Monterey, CA

1 To My Younger Self (TMYS): A Mentoring Workshop for Women Ph.D. Students

Susan E. Martonosi[1], Banafsheh Behzad[2], [1]Harvey Mudd College, Claremont, CA, [2]California State University, Long Beach, Long Beach, CA, Contact: martonosi@g.hmc.edu
Our field suffers from a “leaky pipeline” in which women students are disproportionately more likely to leave academia than their male counterparts. The causes of this are complex and systemic; however, one possible solution is improved mentoring for these women students. Our mentoring program, TMYS, provided professional development and networking to women doctoral students through virtual workshops and paired mentoring with senior women in our profession.

2 Informal Reception for LGBTQIA+ Folks and Allies at 2022 INFORMS Annual Conference

Priyank Arora[1], Pritha Dutta[2], [1]University of Massachusetts Amherst, Amherst, MA, [2]Pace University, New York, NY, Contact: parora@isenberg.umass.edu
We propose to host an informal get-together of LGBTQIA+ and allies from among the INFORMS community at the annual conference in Indianapolis, IN. The main objective of the reception is to address the lack of a resource group for LGBTQIA+ folks and allies within the INFORMS community. This reception would provide more visibility of members identifying as LGBTQIA+ and allies, so that they can rely on each other for support, mentorship, and information exchange. Also, it will give an opportunity to gather feedback and suggestions from INFORMS members (especially,

LGBTQIA+ folks) on what additional activities, interventions, and actions can be taken to create a more equitable and inclusive environment.

3 Flash Paper: Diversity, Equity and Inclusion in Operations Research and Analytics University Programs

Michael P. Johnson[1], Tayo Fabusuyi[2], [1]University of Massachusetts Boston, Boston, MA, [2]University of Michigan, Ann Arbor, MI, Contact: michael.johnson@umb.edu

We present findings from a survey of over 100 OR/analytics university programs in the US to to better understand the level of diversity in OR/analytics education, in particular the presence of traditionally underrepresented groups among students, faculty and administrators, the presence of DEI themes in coursework, and the institutional orientation and commitment to DEI. To the best of our knowledge this is the first such study in our field and will support goal-setting within the profession to set goals regarding increased diversity and inclusion, as well as meaningful comparisons between OR/analytics and other disciplines regarding progress towards increased diversity and inclusion.

4 How Diverse is INFORMS, Really?

Max Liberatore-Resnick, Mary Leszczynski, Tracy Cahall, INFORMS, Catonsville, MD, Contact: mresnick@informs.org

INFORMS has a strategic goal to advance diversity, equity, and inclusion. To achieve this, we need current demographics from our members. We launched a campaign this year to collect member demographics so we can begin to answer: how diverse is INFORMS? The Ambassador project will showcase the diversity of INFORMS members in a recurring spread in *OR/MS Today*. An engaging visual narrative of member diversity will be displayed at the Annual Meeting to inspire more members to care about increasing diversity within our community. The artwork features hexagons divided into segments, filled with different colors, shapes, and patterns representing dimensions of each member's identity.

5 DAS Initiatives in DEI

Andrea Hupman[1], Jun Zhuang[2], Allison C. Reilly[3], Gul Okudan-Kremer[4], [1]University of Missouri - St. Louis, Saint Louis, MO, [2]University at Buffalo, Buffalo, NY, [3]University of Maryland, Washington, MD, [4]Iowa State University, Ames, IA

Effective promotion of diversity, equity, and inclusion (DEI) begins with well-articulated values, though, at present, it is unclear as a society how we might articulate our shared values and how we should evaluate any endeavor to promote them. In this work, we leverage value-focused thinking to articulate these shared DEI values. This, in turn, promotes the development and identification of metrics, decision opportunities, and alternatives in support of society DEI goals. The work also produces a 1-page reference sheet for letters of support for award nominations and promotion cases.

6 MIF Undergraduate Student Workshop

Trilce Encarnacion[1], Ruben Proano[2], [1]University of Missouri- St. Louis, Saint Louis, MO, [2]Rochester Institute of Technology, Rochester, NY, Contact: tencarnacion@umsl.edu

This workshop brings together sophomore URM undergraduate students with limited or no exposure to OR/MS to immerse them in our field's industrial, research, and educational opportunities. Through panels and presentations, industry, academic, and student speakers share their experiences. Participants also receive an invitation to attend the Annual Meeting and help to craft a personalized conference plan. We discuss the goals, mentoring material, feedback, and learnings from this experience.

7 An Exploration on the Unequal Effects of the Pandemic on the Research in Operations Research and Management Science

Yara Jubran[1], Riccardo Mogre[2], [1]Durham University, Durham, United Kingdom; [2]Durham University, Durham, United Kingdom. Contact: yara.n.jubran@durham.ac.uk

Since its emergence, Covid-19 has had an unequal impact on the research community. Some groups of researchers have been effectively marginalized by the pandemic, for example by experiencing a decrease in their productivity. This talk discusses the unequal impact of the pandemic on the researchers in Operations Research and Management Science. We identify measures to mitigate the impact on researchers marginalized by the pandemic, also providing guidelines to departments and research centers.

8 Initiate "INFORMS DEI Best Student Paper Award"

Weijun Xie[1], Grani Adiwena Hanasusanto[2], [1]Virginia Tech, Blacksburg, VA, [2]The University of Texas at Austin, Austin, TX, Contact: wxie@vt.edu

This DEI Ambassador project aims at promoting DEI-related research to the general INFORMS members, especially student members, by initiating the INFORMS DEI Best Student Paper Award. The award recognizes impactful research works by the student members that focus on improving diversity, equity, and inclusion among the broader INFORMS community using OR/MS methodologies.

Ultimately, this award will identify important DEI-related research topics in the braoder sense, engage future academics fully aware of DEI, and encourage them to address DEI and fairness issues.

9 Strategic Initiative: High School Outreach Flash Talk

Veronica M. White[1], Mary Ogidigben[2], Elizabeth Scaria[1], Carmen A. Haseltine[3], [1]University of Wisconsin-Madison, Madison, WI, [2]Pennsylvania State University, Lawrenceville, GA, [3]University of Wisconsin-Madison, Madison, WI, Contact: vmwhite@wisc.edu

This is a part of the larger 2022 DEI Ambassador Program - Strategic Initiative: High School Outreach Project. The project is tasked with creating High School Outreach materials. Each outreach activity aims to introduce, excite, and engage students to Operations Research and Management Science by having them complete an OR/MS activity. While part of the DEI initiative is to create some activities, we are hoping to reach out to the broader INFORMS to develop a larger number of examples that INFORMS members can select from in the future when implementing outreach near their local chapters.

10 Implementing an Accessible INFORMS

Kezban Yagci Sokat[1], Kayse Lee Maass[2], [1]San Jose State University, San Jose, CA, [2]Northeastern University, Boston, MA, Contact: k.maass@northeastern.edu

This project builds upon the learnings from DEI Project titled: Creating an Accessible ORMS Community for Disabled People" which was focused on identifying barriers to access at INFORMS conferences and developing a checklist of conference accessibility best practices. The objective of this the proposed project is to create a more accessible and inclusive INFORMS community for disabled people by providing implementation implementing these strategies for a selected INFORMS conference in collaboration with INFORMS and a selected conference committee. We expect this project to increase the participation of disabled students, academics, researchers, and practitioners in the ORMS community.

Monday, 2 PM–3:15 PM

MD84

JWM - Room 206

Simulation in Industry Applications

Contributed Session

Session Chair

Thomas Maxner, University of Washington, Seattle, WA

1 Prognostic-based Active Battery Degradation Management in Wireless Sensor Network

Lang Wu[1], Qiang Zhou[2], Hongki Jo[2], [1]University of Arizona, Tucson, AZ, [2]University of Arizona, Tucson, AZ, Contact: langwu@email.arizona.edu

We propose to develop an active battery degradation management framework such that batteries in a wireless sensor network will achieve similar end-of-life times. The battery degradation process will be managed by adjusting sensor node workload while ensuring certain performance metrics at the network level. The proposed idea has two major advantages that lead to substantially reduced maintenance cost: (1) it can significantly simplify the maintenance scheduling and operations, effectively converting a complex multi-unit system group maintenance decision-making problem into a single-unit maintenance problem; (2) it will extend the lifetime of the battery group, as it avoids early failures of battery individuals that can cripple the sensor network and lead to a battery group replacement request.

2 Airport Checkpoint Optimization Using a Simio-MATLAB Evolutionary Optimization

Oswaldo Aguirre[1], Jose Espiritu[1], Kelvin Cheu[2], [1]Texas A&M University - Kingsville., Kingsville, TX, [2]University of Texas at El Paso, El Paso, TX

Airport check points represent the first line of defense for a port of entry of any country. Therefore, allocating resources that provides a good level of security and customer satisfaction without using too many resources is an area of interest in literature. In order to obtain the optimal allocation of resources at a terminal level. The airport terminal is replicated into a simulation software that captures the behavior of the system. To find the allocation strategy that optimizes the terminal, a genetic algorithm is used to communicate with the simulation software in order to test a large amount of possible solutions in order to obtain and optimal allocation of resources to be applied in the field

3 Virtual Factory - Simulation Platform for Facilities at Bayer Crop Science

Shrikant Jarugumilli[1], Jennifer Becker[2], Anirudha P. Kulkarni[1], Tzai-Shuen Chen[3], Terrence Druggan[4], Chun Hsuan Huang[1], [1]Bayer, Saint Louis, MO, [2]Bayer, Muscatine, IA, [3]Bayer, St. Louis, MO, [4]Bayer, Lexington, KY

This case study presents an overview of the Virtual Factory Platform developed for Facilities at Bayer Crop Sciences. In this talk, we will cover: process complexity in agriculture, the platform needs for the facilities and an overview of various business scenarios. We will conclude our talk byproviding our perspectives on the various challenges and opportunities from a practitioner's viewpoint.

4 **Microsimulation-based Analysis of The Performance of Curbs Across Differing Space Type Allocations**

Thomas Maxner[1], Andisheh Ranjbari[2], Chase Dowling[3], [1]University of Washington, Seattle, WA, [2]Pennsylvania State University, State College, PA, [3]Pacific Northwest National Laboratory, Seattle, WA

Curbspace is a limited resource in urban areas. Delivery, ridehailing and passenger vehicles must compete for parking spaces. Cities are considering adjusting curb rules and dedicating curbspace for uses other than short-term paid parking. In this research three metrics are developed to evaluate the performance of the curb, covering productivity, accessibility, and CO2 emissions. Six scenarios representing differing allocations of curbspace uses, including bus stops, paid parking, passenger loading zones, and commercial vehicle loading zones, are simulated. The metrics are calculated for each scenario across a range of input parameters and compared to each other and against a baseline scenario. This work can inform public policy decisions by city agencies responsible for managing the curb, and can be useful to industry players seeking to optimize route planning.

Monday, 2 PM–3:15 PM

MD85

JWM - Room 207

Incorporating Equity and Inclusion in Analytics Education

General Session

Session Chair

Amanda G. Smith, University of Wisconsin-Madison, Madison, WI

1 **Creating An Inclusive Classroom Learning Experience**

Dawn Strickland, ISyE Georgia Tech, Atlanta, GA

We all want to be inclusive in our teaching - and we may believe we are doing so, particularly since many of our classes are quantitative in nature. But how can we be sure we are succeeding, and that all students in our courses are being given the greatest chance to succeed? In this session, we will present best practices and invite discussion on how to make the classroom a more-inclusive learning environment.

2 **Supporting Diverse Pathways to Statistical Learning**

Jill Hardin Wilson, Northwestern University, Evanston, IL

The Statistical Learning course taught by Industrial Engineering serves students from the IE major as well as from other related majors. Students in these related majors come to the course from a number of feeder statistics courses with varying perspectives and objectives. We discuss our approach to incorporating students from various pathways, the resources we have developed to support their success in the course, and the benefits of such resources for all enrolled students.

3 **Integrating Diversity and Inclusion Topics in An Introductory Statistics Course**

Amanda G. Smith, University of Wisconsin-Madison, Madison, WI

An overview of innovative methods to incorporate considerations of diversity, equity, and inclusion in an introductory statistics course through creative use ofcase studies, examples, and hands-on team activities that demonstrate how statistics can be used to support environmental, socioeconomic, and public health initiatives in addition to more traditional application areas. Further support of DEI efforts is accomplished through providing resources and training to support diverse, inclusive teams.

Monday, 2 PM–3:15 PM

MD86

JWM - Room 208

Future Technologies in Air Mobility

General Session

Session Chair

Ang Li, University of California-Berkeley, Emeryville, CA

1 **Hierarchical Vertiport Network Design for On-demand Multi-modal Urban Air Mobility: A Case Study of San Francisco Bay Area**

Xin Peng[1], Vishwanath Bulusu[2], Raja Sengupta[3], [1]University of California Berkeley, Berkeley, CA, [2]Crown Consulting Inc., Berkeley, CA, [3]University of California-Berkeley, Berkeley, CA, Contact: xin-peng@berkeley.edu

The autonomous urban "flying taxi" concept has attracted attention as a potential safe, fast, and on-demand transportation mode. It must however carry a significant portion of urban traffic to serve urban mobility and justify public investment. We therefore explore the addressable market for UAM as a multi-mode alternative. Accessibility and time savings depend on vertiport location and connectivity. We propose a hierarchical two stage k-median network design method to serve maximum demand with time savings from the multi-modal alternative, considering the passenger waiting time and the vertiport capacity constraint.

2 Bi-objective Optimization Model for Urban Cargo Delivery Using EVTOL Aircrafts

Nahid Parvez Farazi[1], Bo Zou[2], [1]Univerisity of Illinois at Chicago, Chicago, IL, [2]University of Illinois, Chicago, IL, Contact: nfaraz2@uic.edu

This research focuses on an urban cargo delivery system where eVTOL aircrafts can be used as a substitute for traditional truck-based delivery to carry freight from distant warehouses to the close proximity to urban households. An optimization model is developed to minimize community noise exposure and shipping cost of such a delivery system by considering the tradeoff between these two objectives. Community noise annoyance is one of the pressing issues that need to be resolved before the widespread adoption of urban air mobility. We develop a novel methodology to estimate the community noise impact using demographic information that can be generic enough for any eVTOL type. We integrate this estimated community noise impact into a mixed-integer linear programming model to optimize the usages of eVTOLs and vertiports for various demands of cargo delivery in an urban area.

3 Graph Neural Network Applications for UAM Commute Flow Prediction

Namwoo Kim[1], Yoonjin Yoon[2], [1]Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of; [2]KAIST, Daejon, Korea, Republic of.

Transportation of persons or goods via flying vehicles over urban areas has garnered great interest. Accordingly, studies to estimate the demand using UAM as a means of transportation are being actively conducted.
In this study, we estimated commute flow for urban air mobility based on the surface urban mobility dataset, and predict the commuting flow through region representation learning. Recent studies demonstrated that learning the representation of urban regions can be an effective strategy to understand urban dynamics and to make cities smarter. We applied graph attention network to encode intrinsic characteristics of urban regions by utilizing attention mechanism, and a simple regression layer is trained for predicting commute flows based on learned region embeddings.

4 Multimodal Strategies for Mitigating Congestion from Urban Parcel Delivery Integrating Drones, Non-motorized Vehicles and Trucks

Ang Li, University of California-Berkeley, Emeryville, CA

The explosive growth in e-commerce, the increasing urgency of de-carbonization, the rapid advances in UAV technology, and the continuous disruptive development of the gig economy create needs and opportunities for dramatic improvements in urban package delivery. To mitigate the congestion impact from truck and van traffic, as well as reduce costs and travel times, last-mile delivery should in many cases be shifted toward non-motorized modes and UAV. In this research, we propose a suite of multimodal, congestion-sensitive strategies for urban delivery, by integrating traditional motorized vehicles, non-motorized modes, and UAV. We first conceptualize and optimize the integrated delivery strategy combining different types of vehicles, then incorporate congestion effects into the integrated delivery strategy.

Monday, 2 PM–3:15 PM

MD87

JWM - Room 209

Dynamic Programming and Control

Contributed Session

Session Chair

Michael Rotkowitz, Instacart, San Francisco, CA

1 Approximate Dynamic Programming for Decomposable Problems

Rayner Rebello[1], Andrew E.B. Lim[2], [1]National University of Singapore, Singapore, Singapore; [2]National University of Singapore, Singapore, Singapore. Contact: r.rebello@u.nus.edu

Approximate Dynamic Programming (ADP) provides a framework to approximate the solution of a dynamic program. ADP methods approximate the value function by using basis functions sidestepping the need to solve the DP for every state. Often the choice of basis function is independent of the problem which can lead to a large number of basis functions and thereby increasing its computational burden. We investigate using the value functions of simpler but related DPs as the basis functions for a larger DP. We present approximations for dynamic pricing and inventory control problems. The performance is compared against bounds constructed by using information relaxations.

2 Optimizing Batch Recipe for An Industrial Case Study

Lingxun Kong[1], You Peng[1], Ivan Castillo[1], Zhenyu Wang[1], Ricardo Rendall[2], Daniel Trahan[1], [1]The Dow Chemical Company, Lake Jackson, TX, [2]The Dow Chemical Company, Terneuzen, TX, Contact: ypeng4@dow.com

Dow has a batch process that produces multiple products. In this process, the product yield decreases after a certain time from the start of the batch. From an economic perspective, it is desired to stop and reset the process after some time so that the average profit gained per time (profit rate) remains high. We introduced a batch recipe optimization model that maximizes the average profit rate. The batch length, reactant feed rate, and reaction temperature profile are decision variables to be optimized. The dynamic optimization model describes the process as a differential algebraic equations (DAE) system, and includes constraints that describe the operation rules. The model is transformed into a continuous nonlinear program (NLP) and solved by optimizers. We showed that significant economic values can be generated via batch recipe optimization.

3 Robust Feature-based Learning in Risk-averse Markov Decision Processes

Shangzhe Yang[1], Andrzej Ruszczynski[2], [1]Rutgers University, Piscataway, NJ, [2]Rutgers University, Piscataway, NJ, Contact: shangzhe.yang@rutgers.edu

We consider a control problem for a finite-state Markov system whose performance is evaluated by a coherent Markov risk measure. For each policy, the risk of a state is approximated by a function of its features, thus leading to a lower-dimensional policy evaluation problem, which involves non-differentiable stochastic operators. We propose a robust learning algorithm for Markov policy evaluation and study its convergence. Then we introduce a suited sample-based risk forms as a special class of transition risk mappings. Finally, we discuss structured policy improvement in the feature-based risk-averse setting. The considerations are illustrated with a robot navigation problem. We identify the relevant features, test the simulation-based learning method, and optimize a structured policy in a hyperspace containing all possibly located problems.

4 Optimization of Order Statistics

Michael C. Rotkowitz, Instacart, San Francisco, CA

We consider the problem of optimizing order statistics, such as that of a vector variable or a particular singular value of a matrix variable. This simply stated but unstudied problem arises in control theory, where it serves as the main obstacle to computing metrics for stabilizability, controllability, and robustness. Prior work found fast methods for obtaining upper bounds, but scalable lower bounds remained elusive until recently. We consider optimizing this objective subject to convex constraints and binary constraints, and show how to achieve convex upper and lower bounds for this problem, beginning with using a Difference of Convex (DC) formulation.

Monday, 3:30 PM–4:30 PM

MK01

CC - Sagamore 1

Keynote: From the Battlefield to the Gig Economy: How Hybrid Optimization can Guide Decision Making in Highly Dynamic and Unpredictable Settings

Keynote Session

Session Chair

Shima Mohebbi, George Mason University, Fairfax, VA

1 From the Battlefield to the Gig Economy: How Hybrid Optimization can Guide Decision Making in Highly Dynamic and Unpredictable Settings

Karla L. Hoffman, George Mason University, Fairfax, VA

This talk describes the use of optimization to assist in real-time decision-making where solutions must be available almost instantaneously. We highlight the success of these methods in two very different settings: (a) the routing and scheduling of deliveries in gig-economy applications; and (b) the problem of sustaining communications in a highly dynamic battlefield environment. In the first of these applications, we present the problem of assigning drivers to service requests and presenting the drivers with an efficient routing of all request locations. The decision framework for these assignment problems often has competing objectives (e.g., minimizing cost to the company, providing assignments that are profitable to the drivers, and assuring that customers receive their orders in a timely fashion). The process may include predicting whether a driver will accept a given assignment and the notification to both the customer and the supplier (e.g., the restaurant providing the food to be delivered). If the drivers are not hired on a schedule, then the driver might refuse an offer and It might, therefore, take multiple "offers' to alternative drivers before the assignment is finalized. The entire process of allocating of assignments to drivers, notifying customers of expected delivery time and alerting suppliers to new demands must be done in under a minute. In our second application, there is the need to reassign wireless channels to a military unit (or units) that lose communication capabilities due to enemy jamming or other interference issues. The need to recover quickly while assuring that reassignments do not harm other units is essential to overall battlefield success. Our approach uses hybrid algorithms designed with problem structure in mind to help satisfy challenging time requirements. In both applications, we work to generate multiple feasible solutions quickly, update prior solutions with new information, and bound the solution space. This hybrid approach obtains near-optimal solutions within the tight timeframe that these applications demand. These fast hybrid algorithms use standard optimization solvers in conjunction with feasibility checkers, constraint programming, and/or decision diagrams. These techniques are likely to be applicable in many other settings.

Monday, 3:30 PM–4:30 PM

MK02

CC - Sagamore 2

Keynote: Omega Rho Distinguished Lecturer - Artificial Intelligence and the Future of Universities

Keynote Session

Session Chair

Chun-An Chou, Northeastern University, Boston, MA

1 Artificial Intelligence and the Future of Universities

Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA

Artificial intelligence (AI) leveraging multiple data sources and input modalities (tabular data, computer vision, and natural language) is poised to become a viable method to deliver more accurate results and deployable pipelines across various applications. This work proposes and evaluates a unified Holistic AI in Medicine (HAIM), Agriculture, Meteorology, and Law. We show that our proposed framework can consistently and robustly produce models that outperform similar single-source approaches across all these applications. Throughout their entire history, universities have been organized along distinct departments. I outline what I expect will be the impact of these developments on how universities will be organized in the following decades and how OR/MS can play a leading role.

Monday, 3:30 PM–4:30 PM

MK06

CC - Sagamore 6

Keynote: Jane Snowdon

Keynote Session

Session Chair

Enver Yucesan, INSEAD, Singapore, NA, Singapore.

1 The Era of Accelerated Discovery in Healthcare and Life Sciences

Jane L. Snowdon, IBM, Cos Cob, CT

Technology has tremendous potential to be a primary catalyst for transformation in the healthcare and life sciences industry. Today a convergence of computing revolutions is taking place that will help accelerate the rate of scientific discovery. The era of accelerated discovery is fueled by significant advances across artificial intelligence (AI), hybrid cloud, and quantum computing combined with massive amounts of data from heterogeneous sources. In this talk, I present an overview of these information technology trends and some results obtained from applying AI and advanced analytics to provide insights for population health and precision medicine.

Monday, 3:30 PM–4:30 PM

MK07

CC - Sagamore 7

Keynote: UPS Smith Winner Reprise - Learning by Doing at the Eindhoven University of Technology

Keynote Session

1 Learning by Doing at the Eindhoven University of Technology

Maria Vlasiou, Eindhoven University of Technology, Eindhoven, Netherlands.

The Eindhoven University of Technology (TU/e) was founded in 1956 in the spirit of collaboration with society and industry. This spirit is still at the heart of the university community. TU/e has ranked consistently as one of the top performing universities worldwide in collaboration and scientific output in cooperation with industry. The Industrial and Applied Mathematics (IAM) Master's program of TU/e embodies this principle. The program offers academic education that is driven by fundamental and applied research in close collaboration with industry. Our educational philosophy is based on personal attention and room for individual ambitions and talents and supports a fully individualized study program. Our program combines scientific curiosity with a hands-on mentality. Fundamental knowledge enables us to design solutions for the highly complex problems of today and tomorrow. We understand things by making them and we make things by understanding them. For more than 50 years, the Mathematics and Computer Science Department has partnered with industry, produced impactful research, and influenced the teaching of operations research. In this presentation, we provide an overview of the historical and current innovative activities undertaken by IAM that culminated in its receiving the 2022 INFORMS UPS George D. Smith Prize.

Monday, 5 PM–6:15 PM

MD57

M - Marriott 4

ML/AI for Fairness, Transparency, and Interpretability

General Session

Session Chair

Arman Sabbaghi, Purdue University, West Lafayette, IN

1 The Causal View on Fairness Violations from Spurious Associations

Victor Veitch, University of Chicago / Google Research, Chicago, IL, Contact: victorveitch@gmail.com

There are many notions of fairness in machine learning, yet it is often unclear which is right for a given situation. In this talk, I consider fairness violations due to spurious (non-causal) associations in training data---e.g., selection effects that arise if some patient groups are more likely to be treated. Here, the natural notion of fairness is counterfactual: changing the protected attribute (and the input features in turn) should not change model decisions. However, counterfactual fairness relies on never-unobserved counterfactual pairs. I show that observable notions of fairness---demographic parity, equalized odds, and predictive parity---all arise as implications of counterfactual fairness in this context. In particular, the correct observable notion depends on the true causal structure of the problem (e.g., does label cause features or vice versa).

2 Generalized Predictive Comparisons for Complex Model Interpretation

Raquel de Souza Borges Ferreira, Intel, Ocala, FL

Machine learning algorithms and models constitute the dominant set of predictive methods for a wide range of complex, real-world processes and domains. However, in general, it is difficult to interpret and validate the patterns and insights inferred by the models. We propose a methodology based on generalized predictive comparisons to interpret multiple inputs and interesting functional forms of them to learn and interpret underlying relationships between inputs and the outcome that are inferred by complex models. We demonstrate the broad scope and significance of our generalized predictive comparison methodology by illustrative simulations and case studies.

3 Achieving Fairness Via Post-processing in Web-scale Recommender Systems

Brian Hsu, LinkedIn, Sunnyvale, CA

We present a scalable post-processing methodology for achieving fairness in recommendation systems at web-scale while accounting for position bias. Our methodology focuses on two commonly accepted notions of fairness, equality of opportunity and equalized odds. We propose methods for achieving these fairness criteria in rankings in the presence of position bias, which commonly plagues data generated from recommendation systems. Importantly, our algorithms are model agnostic and depend only on the final scores provided by a model, making them applicable to virtually all web-scale recommender systems.

4 Adaptive Data Debiasing Through Bounded Exploration and Fairness

Yifan Yang[1], Yang Liu[2], Parinaz Naghizadeh[3], [1]The Ohio State University, Columbus, OH, [2]UC Santa Cruz, Santa Cruz, CA, [3]Ohio State University, Columbus, OH, Contact: yang.5483@osu.edu

Biases in existing datasets used to train algorithmic decision rules can raise ethical, societal, and economic concerns due to the resulting disparate treatment of different groups. We propose an algorithm for sequentially debiasing such datasets through adaptive and bounded exploration. Exploration means the decision maker deviates from its loss-minimizing rule, and accepts individuals that would otherwise be rejected, so as to reduce statistical data biases. Our proposed algorithm can be used to balance between the ultimate goal of removing data biases, which will in turn lead to more accurate and fair decisions, and the incurred exploration risks. We show both analytically and numerically how such exploration can help debias data in certain distributions. We further investigate how fairness measures can work in conjunction with such data debiasing efforts.

Monday, 5 PM–6:15 PM

ME01

CC - Room 101

Data Mining on Health Data

General Session

Session Chair

Zhuqi Miao, Oklahoma State University, Stillwater, OK

1 Multi-branching Neural Network for Myocardial Infarction Prediction

Zekai Wang[1], Bing Yao[2], Chenang Liu[2], [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Stillwater, OK

Myocardial infarction (MI), also known as heart attack, is the leading cause of death in the United States. In this paper, we propose a Multi-Branching Neural Network (MB-NN) framework for robust and reliable MI prediction. First, we implement the weighted K-Nearest Neighbors (wKNN) method to estimate the missing values. Second, we develop a Hierarchical Clustering (HC)-based under-sampling approach to create multiple balanced sub-datasets to eliminate the potential bias caused by imbalanced data distribution in model training. Third, we adapt the multi-branching architecture and combine it with multi-layer perceptron (MLP) to further handle the imbalanced issue for robust MI prediction. Experimental results show that the theMB-NN method achieves better performance in MI prediction compared with existing widely used machine learning methods.

2 Error Analysis of Two Models for Extracting Patient History Information from Clinical Notes

Suhao Chen[1], Tuan-Dung Le[1], Thanh Thieu[2], Andrew Gin[1], Phuong D. Nguyen[1], Tieming Liu[1], Zhuqi Miao[1], [1]Oklahoma State University, Stillwater, OK, [2]University of South Florida, Tampa, FL, Contact: suhao.chen@okstate.edu

Patient history information is essential for medical billing. In this study, we evaluate the performances of two systems developed to extract patient history information directly from clinical notes and perform an error analysis of the two models. Association analysis is also conducted to identify note features highly correlated with errors. The findings of the analyses will be useful to upgrade the model architectures.

3 Balancing The Scale and The Accuracy of a Risk Index: An Enhanced Automatic Risk Score Generator for Health Condition Prediction

Yajun Lu[1], Thanh Duong[2], Thanh Thieu[3], Zhuqi Miao[2], [1]Jacksonville State University, Jacksonville, AL, [2]Oklahoma State University, Stillwater, OK, [3]Moffitt Cancer Center, Tampa, FL, Contact: ylu@jsu.edu

Machine learning-based predictive models are widely used to predict patients' health conditions, but they are "black box" in nature and thus typically difficult for physicians to interpret obtained results. A risk index is a point-based model simplifying the estimation of the risk, which can be developed by selecting essential predictors and converting their associated risks to integer-type scores. Though some basic algorithms were recently developed to automatically select super-parameters, the selection is not sufficiently sophisticated, leading to unoptimized accuracies and unnecessarily large scales for the risk scores. In this study, we developed a new generator with smarter parameter selection procedures to overcome the issue. The obtained risk scores are simpler but maintaining high accuracies, thus easier to be used for risk stratification.

4 Us Covid-19 County-level Outbreak Prediction

Qi Li[1], Ai Ren[2], xiaodong li[3], [1]SUNY New Paltz, NEW PALTZ, NY, [2]SUNY New Paltz, New, NY, [3]Anhui Polytechnic University, Wuhu, China. Contact: liq11@newpaltz.edu

This work aims to provide empirical evidence on the effectiveness of the governments' policy, vaccines, and socioeconomic measures in response to the COVID-19 pandemic in US. We considered three categories of factors: policies (including lockdowns, social distancing, travel ban, and masks), vaccines (vaccines rates of all, first dose, full dose, and boosters), socioeconomics (including public health measures and population profiles). We found that our model can predict the COVID-19 county-level outbreak by consider those three factors.

Monday, 5 PM–6:15 PM

ME03

CC - Room 103

Advances in Deep Learning Methods and Applications II

General Session

Session Chair

Imtiaz Ahmed, West Virginia University, Morgantown, WV

Session Chair

Shouyi Wang, University of Texas at Arlington, Arlington, TX

Session Chair

Linh Ho Manh, 1</sup

1 Predicting Transactional Fraud on The Ethereum Blockchain with Graph Neural Networks

Charity Mwanza, University of Alabama in Huntsville, Huntsville, AL, Contact: cm0260@uah.edu

Blockchain-based currencies have gained popularity in recent years. This is evident by the increased creation of alt-tokens and the advent of decentralized finance. However, the increased adoption also leads to unethical behaviors among individuals looking to thwart the open nature of the blockchain. This work explores the use of graph neural networks to detect fraudulent transactions on the Ethereum blockchain. We hope that we can design an interpretable, systematic approach to identifying such transactions for the well-being of the blockchain.

2 Optimal Genotype Selection for Different Weather Conditions Using Deep Learning

Zahra Khalilzadeh, Lizhi Wang, Iowa State University, Ames, IA, Contact: zahrakh@iastate.edu

Accurate prediction of crop yield can improve agricultural breeding and provide monitoring across diverse climatic conditions. This can protect crop production from climatic challenges. To predict crop yield, it is important to capture the complexity of biological interactions and more site-specific weather variable complexities. This paper presents a deep learning framework using convolutional neural networks (CNNs) and long short-term memory networks (LSTM) for crop yield prediction based on weather and genotype data. Then this model is used to identify the optimal genotypes with the highest potential yield for different locations based on the given weather data. The proposed model demonstrated the capability to generalize the yield prediction to untested genotypes without significant drop in the prediction accuracy.

3 Prediction of Ship Traffic on Waterways for Optimized Usage of Harbours with Graph Neural Networks and The Transformer

Amadou Ba, Christopher Lohse, Ben Schaper, Fabio Lorenzi, Joern Ploennigs, IBM Research Europe, Dublin, Ireland. Contact: amadouba@ie.ibm.com

Ports generate myriad of data making them an appealing infrastructure to automate. However, ports face significant operational challenges due to siloed operations and complex dynamics. To overcome this limitation, we develop an AI prediction method for ship traffic on ports' waterways. Our approach is based on the combination of Graph Neural Networks (GNN) and the Transformer. We start by building the graph representation of the port, where we consider that the nodes are the waterways and the edges are the connections between them. Data processed with GNN at the nodes level are then fed to the Transformer for causal prediction of ship traffic. We demonstrate with extensive experiments that our approach outperforms competitive techniques, while providing explainable and reliable 12-hour prediction of ship traffic on waterways and optimized usage of harbours.

4 Hydrogen Liquefaction Process Specific Energy Consumption Prediction Framework Using Quantum Mechanics-Based Deep Learning

Eunseo Oh, Hyunsoo Lee, Kumoh National Institute of Technology, Gumi, Korea, Republic of. Contact: chss014@kumoh.ac.kr

Energy supply methods are being diversified due to competition for resources. Hydrogen energy, one of the renewable energies, has the advantage of low carbon dioxide emission. However, gaseous hydrogen has low stability and requires a liquefaction process. Therefore, the hydrogen liquefaction process is important. Various studies have been proposed to reduce the Specific Energy Consumption (SEC), which is the sum of energy consumed in the entire process to liquefy 1kg of hydrogen, but the uncertainty of the attribute values in the hydrogen liquefaction process are not considered. Therefore, in this study, a framework for predicting SEC according to attribute value using quantum mechanics-based deep learning is proposed. The attribute values corrected through quantum mechanics contribute to improving the prediction accuracy by reflecting the attribute of the data.

Monday, 5 PM–6:15 PM

ME04

CC - Room 104

Value Creation in Social Media Platforms

General Session

Session Chair

Ta-Wei Kao, University of Michigan - Dearborn, Dearborn, MI

1 Developing Mobile App Design from User Feedback Using Deep Unsupervised Learning

Chengfei Wang[1], Ashish Gupta[2], Qin Xiao[1], [1]Auburn University, Auburn, AL, [2]Auburn University, Auburn, AL, Contact: czw0078@auburn.edu

The mobile app market, a multi-billion-dollar industry, is highly competitive. Online consumer feedback can provide good insights into product strengths and weaknesses. In this study, we utilize deep unsupervised learning models to build a framework for harnessing potential customer feedback. The first part of the framework uses Bidirectional Encoder Representations from Transformers (BERT)-based topic modeling approach to identify topics and key themes that emerge from user reviews of mobile apps belonging to the health and fitness genre. The second part, sentiment analytics, integrates the accompanying ratings to reveal the market acceptance of various aspects of the product design. The findings provide strong guidance for improving the design and development of such apps. The study has important implications for creating an AI-driven app design framework.

2 Consumers Online Search Pattern and Distribution Channel Selection

WonJung Joey Ryu, Chris K. Anderson, Cornell University, Ithaca, NY, Contact: wr226@cornell.edu

While the advent of the online market provides additional channel of distribution to product and service providers, it has also led to the increase of competition with a vast number of online intermediaries (e.g., retailers, agents, distributors etc.). In this research, we study the heterogeneity of the customers performing different search patterns when purchasing directly or through an intermediary. We analyze the clickstreams; a subset of 50,000 consumers is randomly selected from a broader panel, and how it led to different booking channel selection. This disaggregated approach enables us to observe the consumer's browsing behaviors across domains capturing a detailed level of consumer's online search. We subsequently, discuss the managerial implications of our findings for firms to better allocate their marketing spendings and minimizing on commission.

3 Social Media Analytics for Product Feature Analysis

Alex Rudniy, Drew University, Madison, NJ

Social media analytics is a powerful instrument for analysis of public sentiment and identifying trends. Natural language processing as applied to online social media data is a cost-efficient approach for mining information of customer sentiment towards upcoming or existing products. This study presents an approach for identifying product features with customer positive or negative sentiment that could facilitate decision making in manufacturing and marketing.

Monday, 5 PM–6:15 PM

ME05

CC - Room 105

Novel Data Mining Methodologies for COVID-19 Data Prediction Incorporating Spatial and Socioeconomic Information

General Session

Session Chair

Qingpeng Zhang, City University of Hong Kong, Kowloon, Hong Kong.

Session Chair

Jin Wang, 1</sup

1 The Impact of Socio-economic Factors and Commuter Pattern Between New York and New Jersey on The Spread of Covid-19 Cases and Deaths

Wenting Wang, Rutgers University, New Brunswick, NJ, Contact: wwt8966@gmail.com

Socio-economic factors impact how epidemics spread. We investigated the possible effect of several local socio-economic factors on the case count and time course of confirmed Covid-19 cases and deaths across all New Jersey counties, and the effect of commuter pattern, which was provided by smartphone-derived location-based services data, between New York and New Jersey on the spread of disease. Multiple predictive models were applied to study the effect of various socio-economic factors and commuter patterns on the time course of Covid-19 cases and deaths. Our study found that the evolution of the epidemic was influenced by certain socio-economic factors, which could be helpful for the formulation of public health policies.

In addition, we will discuss the patterns of commuting and how they relate to the pandemic transmission from New York to New Jersey.

2 **Mining The Time-dependent Relationship Between Covid19 Cases and Deaths Series and Modeling with Time Series Model**

Chun Pang Lin, Rutgers University, New Brunswich, NJ

COVID19 cases and deaths data are related time series. Their relationship can be complicated and time-dependent especially when the studied time range includes multiple variants. In this talk, we present a modeling framework utilizing a time series model with segments to forecast the deaths. The motivation comes from the observations that different cross correlations were seen between cases and deaths at different waves or variants. It is also expected that the time series characteristics are different at different phases of the pandemic or with different virus variants. This modeling framework improves the forecasting of COVID19 deaths.

3 **Using Arima Forecasting Methods to Estimate Excess COVID Deaths in the US**

Nuria Diaz-Tena, Rutgers University, NJ

Causes of death incidence in America fluctuates year by year. COVID-19 has brought further uncertainties given the additional COVID test necessary to achieve the correct cause of death of the deassed Americans. The COVID deaths data don't catch everyone whose life was shortened by the pandemic and add other people whose primary reason for dying was not COVID. This paper shows how to detect excess deaths using confidence interval of the projected number of deaths with arima models and comparing it with the actual number of deaths. We consider the fluctuations of the data from previous years and the main drivers for the excess COVID deaths.

4 **Social Mixing Indicators from Smartphone Geolocation Data and The Disparity of Covid-19 Spread**

Michalis Xyntarakis[1], Javier Cabrera[2], Michael N. Katehakis[2], [1]Rutgers University, Newark, NJ, [2]Rutgers University, Piscataway, NJ, Contact: mx77@business.rutgers.edu

We apply spatiotemporal pattern mining to smartphone GPS trajectories to assess contact frequency using smartphone geolocation data from 2019 to 2021, covering more than 15 million unique users in the states of NY, NJ, and FL. First, we calculate aggregate neighborhood-level social mixing indicators based on the contact frequency of the devices residing in a neighborhood. Second, we analyze differences in social distancing by identifying neighborhood social mixing patterns for the different phases of the pandemic. Third, we study how government-mandated social distancing policies, sociodemographics, and infection rates are related to social mixing across neighborhoods and states.

Monday, 5 PM–6:15 PM

ME07

CC - Room 107

Physics-guided Machine Learning for Materials and Manufacturing Systems

General Session

Session Chair

Imtiaz Ahmed, West Virginia University, Morgantown, WV

1 **Predicting Operator Trust in Automated Decision Aids Using Gaze Data and Machine Learning Techniques**

Ali Farahani, Mary Fendley, Louisiana Tech University, Ruston, LA, Contact: afa011@latech.edu

User trust is conventionally measured through subjective rating scales, which have inherent bias, and limitations on when they can be used without interrupting task performance. We investigated the use of machine learning techniques and gaze data to predict user trust in automation. In this study, participants performed bone defect detection with the help of an automated decision aid. Participant's subjective ratings at the end of each trial were used as class labels. Applying five machine learning techniques, SVM performed the best in predicting the level of trust with an accuracy of 77%. This indicates that gaze data can be a promising real-time, non-intrusive measure of operator trust.

2 **Hybrid Modeling for Energy Efficient Cnc Grinding**

Sathish Kasilingam[1], Thorsten Wuest[1], Ruoyu Yang[2], Shubhendu Kumar Singh[3], Rahul Rai[2], [1]West Virginia University, Morgantown, WV, [2]Clemson University, Greenville, SC, [3]Clemson University, Greenvile, SC, Contact: sk00036@mix.wvu.edu

Grinding is a subtractive manufacturing process that exhibits a very high specific energy consumption (SEC) among machining processes. We use hybrid analytics to capture inherited knowledge of the defined physics relationships and data-driven methods to fill remaining gaps of the physics model. We aim to address the pressing problem that today's complex CNC grinding operations are not holistically optimized for energy efficiency when taking grinding, dressing, and sharpening into consideration. The overall goal is to holistically reduce the high SEC of gear grinding processes by at least 15%. The inputs include time series machine tool data (MT Connect) alongside simulated data & uncertainty quantification from the physics model.

3 Incorporating Physics Based Knowledge in Manufacturing Decision Making Via Transfer Reinforcement Learning

Md Ferdous Alam[1], Max Shtein[2], Kira Barton[3], David Hoelzle[4], [1]The Ohio State University, Columbus, OH, [2]University of Michigan, Ann Arbor, MI, [3]University of Michigan, Ann Arbror, MI, [4]The Ohio State University, Columbus, OH, Contact: alam.92@buckeyemail.osu.edu

Machine learning driven systems often lack the principles of physics based knowledge and suffer from data inefficiency to be deployed in real-world applications. These challenges are even more crucial for online sequential decision making in manufacturing systems due to the online data collection strategy and high expense of data collection. To this end, we present ideas to incorporate physics based knowledge via transfer learning in the context of reinforcement learning (RL), a formal framework for sequential decision making under uncertainty. Our approach solves some major limitations in deploying machine learning driven online decision making in manufacturing systems including designing transfer RL algorithm as well as developing software and hardware design principles. We demonstrate these ideas on a custom built autonomous manufacturing research bot.

4 Physics-guided Long Short-term Memory Networks for Emission Prediction in Powder Bed Fusion

Rong Lei[1], Yuebin Guo[1], Weihong Guo[2], [1]Rutgers University-New Brunswick, Piscataway, NJ, [2]Rutgers, The State University of New Jersey, Piscataway, NJ, Contact: yuebin.guo@rutgers.edu

Powder Bed Fusion (PBF) experiences a unique thermal cycle characterized by rapid heating, fast solidification, and melt-back. During this process, the melting pool causes thermal emission which may be used as a process signature for the melt pool stability. This paper predicts heat emissivity in the melt pool by harnessing the recurrent neural networks. Long Short-Term Memory (LSTM) networks are developed to learn from sequential data (emission readings), while the learning is guided by process physics. Results provide the new knowledge on how raw pyrometer data should be processed to work best with LSTM, which physics features are more informative of overheating, and the effectiveness of physics-guided LSTM in emissivity prediction.

Monday, 5 PM–6:15 PM

ME08

CC - Room 108

Learning and Inference of Preferences

Contributed Session

Session Chair

Taeyoung Kee, Aalto University, Helsinki, Finland.

1 Learning Stochastically Revealed Preference

John R. Birge[1], Xiaocheng Li[2], Chunlin Sun[3], [1]University of Chicago, Chicago, IL, [2]Imperial College Business School, London, United Kingdom; [3]Stanford University, Stanford, CA, Contact: chunlin@stanford.edu

We study the learning problem of revealed preference in a stochastic setting: a learner observes the utility-maximizing actions of a set of agents whose utility function follows some unknown distribution. The learner aims to infer the distribution through the observations of actions. Existing works assume there exists one utility vector that is consistent with all the observations which may be violated under practical contexts. In this paper, we consider two settings for the stochastically revealed preference problem: a Gaussian setting where the utility follows the von Mises-Fisher distribution and a ⍰-corruption setting where the utility distribution concentrates on one vector with high probability and is corrupted otherwise. We devise Bayesian algorithms for parameter estimation and develop theoretical guarantees for the recovery of the true parameter.

2 On a Mallows-type Model for (Ranked) Choices

Yifan Feng[1], Yuxuan Tang[2], [1]NUS Business School, Singapore, Singapore; [2]National University of Singpore, Singapore, Singapore.

We consider a preference learning setting where every participant chooses an ordered list of *k* most preferred items among a displayed set of candidates. (The set can be different for every participant.) We identify a distance-based ranking model for the population's preferences and their (ranked) choice behavior. The ranking model resembles the Mallows model but uses a new distance function called Reverse Major Index (RMJ). We find that despite the need to sum over all permutations, the RMJ-based ranking distribution aggregates into (ranked) choice probabilities with simple closed-form expression. We develop effective methods to estimate the model parameters and showcase their generalization power using real data, especially when there is a limited variety of display sets.

3 Dynamic Learning of User Preference Based on Path-level Feedback for Knowledge Graph-based Recommender Systems

Solha Kim, Yeonbin Son, Sunghoon Kim, Hyewon Seo, Yewon Kang, Yerim Choi, Seoul Women's University, Seoul, Korea, Republic of.

With the rapid development of recommender systems, several attempts were made to utilize user feedback to improve performances. Even though the state-of-the-art framework showed significant performance improvements by learning user preference based on like/dislike feedback for items, the learning process is naive, since the only binary signal is imposed as a constraint. Therefore, we propose a recommender system that utilizes user feedback on a path which is a causal inference obtained through a path reasoning on a knowledge graph. Moreover, as the degree of user preference on each relation constituting a path is diverse, the feedback is refined by using the weights on relations computed during a path reasoning. Experimental results demonstrate the effectiveness of utilizing feedback for a path and calculating different degrees of preference for each relation.

4 Post-decision Surprises and Poor Choices - The Impact of Evaluation Uncertainties in Multiattribute Decision-making

Taeyoung Kee[1], Eeva Vilkkumaa[2], Juuso Ilari Liesio[3], Pekka Malo[2], [1]Aalto university, Helsinki, Finland; [2]Aalto University School of Business, Helsinki, Finland; [3]Aalto University School of Business, Espoo, Finland.

Decisions that involve multiple attributes are supported by decision analysis methods deploying a multi-attribute utility function, which captures decision makers' preferences on the attributes and risk attitude. Often, there are uncertainties in evaluating the performances of these attributes, causing the decision maker to experience *post-decision disappointment*. In this paper, we study the impact of attribute-specific estimation uncertainties and non-linear utility functions on *post-decision disappointment* and the quality of decision making in a multi-attribute setting. We study the performance of several choice heuristics and examine whether they lead to the optimal choice that maximizes the expected multi-attribute utility and whether these choices correspond to truly optimal choices that maximize *ex ante* true multi-attribute utility.

Monday, 5 PM–6:15 PM

ME09

CC - Room 109
Semiconductor Industry
Contributed Session

Session Chair
Young-Mok Bae, SK hynix, Pohang-si, Korea, Republic of.

1 Multiclass Defect Detection of Printed Circuit Boards Using Deep Learning Based Object Detection Networks

Chun-Hsiang Chang[1], Hao-Wei Chen[1], Chun-Cheng Lin[2], [1]National Yang Ming Chiao Tung University, Hsinchu, Taiwan; [2]National Yang Ming Chiao Tung University, Hsinchu, Taiwan. Contact: sean963852.mg08@nycu.edu.tw

Printed circuit boards (PCBs) are crucial components of electronic products, and automated optical inspection (AOI) has been used for detecting defects through optical equipment when manufacturing PCBs. However, the false alarm rate of AOI is still far from acceptable. Therefore, this work proposes an improved multiclass fault detection method for PCBs based on deep learning object detection networks. From a real PCB plant, 10,000 images were suspected to be faulty by AOI. The testing results on the collected images shows that the proposed model can successfully reaches an accuracy of 83.75%, leading to a substantial decrease in false alarm rate and inspection time, as compared to the practical procedure using an AOI machine with manual reexamination. In addition, the results demonstrate that the proposed model has the potential to identify various classes of defects.

2 Deterioration Feature Extraction with The Covariate Filtering and Autoencoder-based Health Indicator: Applications to The Coal-fired Power Plant Heat Exchanger Fouling

Geunseop Lee, Seongjoon Kim, Chosun University, Gwangju, Korea, Republic of. Contact: chzhffpt704@chosun.kr

The power plant's operating data are strongly affected by various covariates such as generating output (MW), Airflow, and Fuel type. Therefore, it is essential to separate those factors from the target of interest when performing feature extraction for health monitoring. In this study, we focused on the heat exchanger's deterioration due to fouling, which is defined as the undesirable formation of material on the heat exchanger tube. A data-driven deterioration feature extraction method is developed using

covariate filtering and autoencoder-based feature extraction methods. The proposed framework is demonstrated using numerical examples and the multi-variate power plant's boiler sensor data.

3 Profiling Failure Modes Using a Mixed Membership Weibull Model

Youngmin Lee, Hyung-Seok Kang, Samsung Electronics, Hwaseong-si, Korea, Republic of.

We propose a mixed membership Weibull model (mmWeibull) for analyzing reliability of semiconductor products. Because of heavily censored rates and short observation periods, it is difficult to estimate the reliability distribution of semiconductor products accurately. The mmWeibull, a generalization of a mixed Weibull model, allows product group specific mixing weights but shares failure mode profiles between products groups. The use of a mixed membership structure enables incorporating heterogeneity in sub-populations and robust life distribution inference by using data from multiple group data jointly. Simulation results shows that mmWeibull outperformed than mixed Weibull if the mixed membership assumption holds.

4 An Approach for Detecting Abnormal Equipment Using Event Log Data in Semiconductor Wafer Test

Young-Mok Bae[1,2], Young-Gwan Kim[1], Kwang-Jae Kim[1], Jeong-Woo Seo[2], Hyun-A Kim[2], Chang-Ho Shin[2], [1]Pohang University of Science and Technology, Pohang, Korea, Republic of; [2]SK hynix, Icheon, Korea, Republic of. Contact: ymbae@postech.ac.kr

A wafer test performed in the back-end semiconductor production evaluates the quality, reliability, and computational speed of chips. Advanced approaches to detect abnormal wafer test equipment are fundamental for equipment maintenance purposes in this context. However, existing studies show a low level of detectability of abnormal equipment since the approaches mainly focus on indirect information such as wafer yields or probe cards in wafer test equipment. This study proposes a new approach for detecting abnormalities by analyzing event log data, which contain the detailed operation records of wafer test equipment. The proposed approach helps select critical events using feature selection and detect unusual event patterns in each wafer test equipment. The proposed approach is validated using a newly collected event log dataset from actual wafer test equipment.

Monday, 5 PM–6:15 PM

ME10

CC - Room 110

How Artificial Intelligence is Improving Ecosystem Efficiency

General Session

Session Chair

Ziru Li, Arizona State University WP Carey School of Business, Chandler, AZ

1 Unbox The Blackbox: Predict and Interpret Youtube Viewership Using Deep Learning

Jiaheng Xie, University of Delaware, Newark, DE, Contact: jxie@udel.edu

As video-sharing shapes an emerging social media landscape, content creators and businesses urge to prioritize video viewership prediction to optimize influence and marketing outreach with minimum budgets. Although deep learning champions viewership prediction, it lacks interpretability, which is required by regulators and is fundamental to guiding video production and accepting predictive models. Existing interpretable predictive models face the challenges of imprecise interpretation and negligence of unstructured data. Following the design-science paradigm, we propose a novel information system, PrecWD, that accurately predicts viewership leveraging unstructured raw videos and well-established features while precisely interpreting feature effects. PrecWD outperforms benchmarks and achieves superior interpretability in a user study.

2 Presenter

Stan Shi, 1</sup

3 Presenter

Jiaqi Yan, Nanjing, China.

Monday, 5 PM–6:15 PM

ME11

CC - Room 111

Machine Learning Applications in Healthcare

General Session

Session Chair

Nick Street, University of Iowa, Iowa City, IA

1 **Peer Adaptive Ensemble Learning: An asynchronous and decentralized collaborative learning approach for medical imaging**
Brianna Mueller, University of Iowa, Iowa City, IA
Progress towards implementation of reliable AI tools in clinical practice is hindered by regulatory restrictions on patient data sharing. Many institutions do not have access to comprehensive datasets needed to develop trustworthy models that generalize well to diverse patient populations. In recent years, federated learning (FL) has been proposed to overcome the hurdles of sharing private data. While FL has shown promising results, there are still various limitations. This study proposes peer adaptive ensemble learning, a new collaborative learning approach that circumvents patient data sharing while also addressing limitations of traditional FL. Experiments performed on the NIH chest x-ray dataset confirm the promise of this new method.

2 **Optimal Policy Trees for Numeric Treatments or Survival Outcomes**
Ying Zhuo, Jack W. Dunn, Interpretable AI, Boston, MA, Contact: zhuo@mit.edu
Previously we have developed Optimal Policy Trees that learns optimal policies from observational data with categorical treatments and numeric/binary outcomes. We have since expanded the framework to work with numeric treatments (both single and multiple) as well as survival outcomes with proper counterfactual estimation and policy learning under the new data settings. The methodology has been applied to real-world problems such as diabetes management (multiple continuous treatments) and HIV clinical trial data (survival outcomes), where it demonstrated the superiority in both the interpretability and the performance of the approach compared to other state-of-the-art methods.

3 **Multistage Post-surgical Readmission Prediction: A Machine Learning Approach with Bayesian Updating**
Xinyu Yao[1], George Huaien Chen[1], Karmel S. Shehadeh[2], Rema Padman[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Lehigh University, Bethlehem, PA, Contact: xinyuyao@andrew.cmu.edu
The challenge of unplanned hospital readmissions after surgical procedures is a significant burden on patients as well as the healthcare system. This paper aims to develop an interpretable prediction model for the readmission probability at different stages of patients' care pathways when undergoing a surgical procedure. We propose a timestep prediction framework with Bayesian updating to predict whether the patient will be readmitted based on data available at discrete points in time such as at the preoperative stage, the surgery completion stage, and the hospital discharge stage. Using cardiac surgery data from a major health system, the framework provides better prediction performance, generalizability, and temporally appropriate updates for clinical decision-making as more conditions and data are revealed over time compared to existing conventional models.

4 **Prediction of Patient Punctuality in a Psychiatry Clinic Based on The Machine-Learning Algorithms**
Alireza Kasaie, Suchithra Rajendran, University of Missouri, Columbia, MO, Contact: skdx2@umsystem.edu
Patient lateness is a major concern in the healthcare system, which makes schedule disruption, ineffective doctor utilization, and longer waiting time for subsequent patients who may have arrived on time. Since each ML algorithm's training approach may differ, the study's goals are to compare the predictive performance, computational time, and interpretability of four ML models (multinomial logistic regression, decision tree, random forest, and artificial neural network) and develop a Shapley Additive Explanation (SHAP) model to comprehend and trust the results and outputs created by ML models. Results indicate that patients are more inclined to be late for their appointments when the lead time decreases. However, when the lead time is zero, it has no impact on patient lateness. Moreover, the results show that travel distance has no impact on patient lateness.

Monday, 5 PM–6:15 PM

ME12

CC - Room 113
Military and Security (MAS) Society Awards
Award Session

Session Chair
Brian J. Lunday, Air Force Institute of Technology, Beavercreek, OH

1 **MAS President Welcome & Remarks**
Brian J. Lunday, Air Force Institute of Technology, Beavercreek, OH
This session is made possible by the efforts of MAS Past-president Dr. Natalie Scala, who orchestrated the MAS Annual Awards for 2023, as well as the chairs of the respective committees: Dr. Nate Bastian for the Bonder

Scholarship; Dr. William Caballero for the Koopman Prize; and Mr. Jeffrey Kline (CAPT, USN Ret.) for the J. Steinhardt Prize.

2 Seth Bonder Scholarship for Applied Operations Research in Military and Security Applications

Nathaniel D. Bastian, Army Cyber Institute, U.S. Military Academy, West Point, NY, Contact: nathaniel.bastian@fulbrightmail.org

Award session for the winner of the 2022 INFORMS Seth Bonder Scholarship for Applied Operations Research in Military and Security Applications. The purpose of this award is to promote the development and application of process modeling and operations research (OR) analyses to defense-related applications, including military and national security issues.

3 Koopman Prize

William Caballero, AFIT

The Koopman Award recognizes the most outstanding publication in military operations research of the previous year. This prize is named in honor of Bernard Koopman, one of the founding fathers of military operations research. Please join the MAS council as we recognize the next winner of this most prestigious award.

4 J. Steinhardt Prize

Jeffrey Kline, Naval Postgraduate School, Salinas, CA

The J. Steinhardt Prize is sponsored by the CNA Corporation. The prize is awarded for outstanding contributions to Military Operations Research and is awarded for life work rather than for any particular contribution. A founding member of the Operations Research Society of America, Jacinto (Jay) Steinhardt served on the original Council and Publications Committee of the Society in 1952-53. He was elected Vice President of ORSA the following year and acceded to the Presidency in the Society's third year. He contributed greatly over the years to the operations research community through his work in military OR and his thoughts on the philosophy of the discipline.

Monday, 5 PM–6:15 PM

ME13

CC - Room 114

Network Analysis

General Session

Session Chair

Samuel Kroger, 1</sup

1 A Two-Stage Network Interdiction-Monitoring Game

Di H. Nguyen[1], Yongjia Song[2], Cole Smith[3], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, [3]Syracuse University, Syracuse, NY

We study a network interdiction problem involving two agents: a defender and an evader. The evader seeks to traverse a path from a source node to a sink node in a directed network without being detected. The game takes place in two stages. In the first stage, the defender removes a set of arcs in the network. In the second stage, the defender and the evader play a simultaneous game (employing mixed-strategy solutions). The defender monitors a set of arcs, thus increasing the probability that the evader will be detected on that arc. The evader selects a source-sink path. We propose a solution approach that utilizes Benders decomposition and constraint-and-column generation. Since both the constraint-generation and column-generation problems are NP-hard, we also prescribe approximate versions of these problems.

2 On Fractional Clique Relaxations

Yehor Blokhin[1], Sergiy Butenko[1], Oleg A. Prokopyev[2], [1]Texas A&M University, College Station, TX, [2]University of Pittsburgh, Pittsburgh, PA, Contact: e.blokhin23@gmail.com

Originally motivated by social network analysis clique relaxations were introduced to describe cohesive clusters. In this talk, we consider clique relaxation models with single-ratio fractional objectives: the maximum ratio s-plex problem and the maximum ratio s-defective clique problem. We discuss several reformulations of the aforementioned models and present alternative approaches. The comparison of different approaches is also presented.

3 A Bilevel Network Interdiction Problem with Applications in Human-trafficking Disruption

Daniel Bruno Lopes da Silva[1], Thomas Sharkey[2], Yongjia Song[2], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, Contact: dlopesd@clemson.edu

Motivated by applications in human-trafficking (HT) network interdiction problems, we study a special case of a bilevel network interdiction problem where the network operator's objective is to maximize the flow through the network after interdiction, but the attacker's objective is to minimize the number of arcs from a critical set with flow on them. For the optimistic problem, we develop a single-level reformulation, perform a complexity analysis, and run a set of computational experiments for an special case of HT networks as well as to general network structures. We also investigate a single-level reformulation for the pessimistic problem based on a tight-relaxation scheme, as well as its complexity and implementation.

4 Differentially Private Network Data Collection for Influence Maximization

Fang-Yi Yu[1], M. Amin Rahimian[2], [1]Harvard University, Cambridge, MA, [2]University of Pittsburgh, Pittsburgh, PA, Contact: rahimian@pitt.edu

Public health professionals rely on social network data to target their interventions with maximum impact. Developing new methods that are privacy-preserving for network data collection and targeted interventions is critical for designing sustainable public health and development interventions on social networks. We study privacy guarantees for influence maximization algorithms when the social network is unknown, and the inputs are samples of prior influence cascades that are collected at random. Our results build on recent work about seeding with costly network information by introducing randomization in the collected data or the algorithm output to bound each node's privacy loss in deciding whether their data should be included in the algorithm input.

Monday, 5 PM–6:15 PM

ME14

CC - Room 115

Fusing Physics and Data for Connected and Automated Vehicles Modeling

General Session

Session Chair

Zhiwei Chen, FL

Session Chair

Xiaopeng Li, FL

1 Physics-informed Deep Learning for Traffic State Estimation

Zhaobin Mo, New York, NY

This paper introduces a physics-informed deep learning (PIDL) framework to the Traffic state estimation (TSE) problem. PIDL contains both model-driven and data-driven components, making possible the integration of both approaches. This paper focuses on highway TSE with observed data from loop detectors and probe vehicles, using both density and average velocity as the traffic variables. With numerical examples, we show the use of PIDL to solve a popular second-order traffic flow model, i.e., a Greenshields-based Aw-Rascle-Zhang (ARZ) model, and discover the model parameters. We then evaluate the PIDL-based TSE method using the Next Generation SIMulation (NGSIM) dataset. Experimental results demonstrate the proposed PIDL-based approach to outperform advanced baseline methods in terms of estimation accuracy and data efficiency

2 Network-wide Traffic State Prediction by Coupling Physics-based Traffic Models and Graph Neural Networks

Yufei Xu[1], Zhiwei Chen[2], Srinivas Peeta[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, atlanta, GA, [3]ISyE Georgia Tech, Atlanta, GA

Accurate traffic state (i.e., flow, density, and speed) prediction is crucial for traffic planning, management, and control. Various deep learning techniques have been applied to predict traffic state. However, complex spatial-temporal correlations in traffic networks challenge these deep learning techniques, especially when the training data available is small. Learning methods also lack interpretability. We propose to combine physics-based traffic models and Graph Convolution Neural Network to increase prediction accuracy and model interpretability. Numerical experiments show the effectiveness of the proposed approach.

3 Vehicle Trajectory Prediction with a Physics-aware Learning-based Model Considering Shockwaves in a Connected Vehicle Environment

Handong Yao, Xiaopeng Li, Ke Ma, University of South Florida, Tampa, FL, Contact: kema13@usf.edu

The physics of shockwaves is a fundamental traffic flow characteristic that is useful for traffic state estimation and prediction. Recently, learning-based trajectory prediction models have been proposed to improve the model predictability. Yet, these models are usually purely data-driven without explicit inclusion of fundamental physics, thus lacking interpretability and physical insights, or even missing opportunities for further improving model predictability. This study proposes a physics-aware learning-based hybrid model for trajectory prediction. The proposed model explicitly incorporates the physics of shockwaves in a deep learning framework. A real-world trajectory dataset is adopted for training and validation. Experiments show that the inclusion of shockwaves in learning-based models can significantly improve the model predictability.

4 An Online Shockwave Detection Approach Based on Real-time Vehicle Trajectory Data

Chenlu Pu, Lili Du, Universtiy of Florida, Gainesville, FL,

Contact: cpu1@ufl.edu
Monitoring traffic shockwave propagation direction and speed online will facilitate real-time traffic control. This paper aims to develop a data-driven approach to detect the shockwave and propagation adaptively based on real-time trajectory data collection. The methodology will integrate shockwave theories, optimization, clustering, and computational geometry approaches to recognize breakpoints, detect shockwave speed, and then estimate shockwave starts and ends. The numerical experiments conducted on the Next Generation Simulation (NGSIM) dataset validated the accuracy and efficiency of our approach.

Monday, 5 PM–6:15 PM

ME15

CC - Room 120

Hospital Operations

General Session

Session Chair
Sukriye Nilay Argon, University of North Carolina, Chapel Hill, NC

Session Chair
Qian Cheng, University of North Carolina at Chapel Hill, Carrboro, NC

1 Data-driven Hospital Admission Control: A Contextual Learning Approach
Mohammad Zhalechian[1], Esmaeil Keyvanshokooh[2,3], Cong Shi[1], Mark P. Van Oyen[4], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, Bryan, TX, [3]Texas A&M University, Bryan, TX, [4]University of Michigan, Ann Arbor, MI, Contact: mzhale@umich.edu
The choice of care unit upon admission to the hospital is a challenging task due to the wide variety of patient characteristics, uncertain needs of patients, and the limited number of beds in intensive and intermediate care units. We design a new personalized and dynamic care unit placement model when the patient outcomes are uncertain and there are limited reusable hospital beds. Our policy adaptively learns patient outcomes and chooses the best care unit allocation for sequentially arriving patients based on the observed contextual information and the occupancy level of care units. We prove that our policy admits a Bayesian regret bound. We also investigate and assess its effectiveness using hospital system data.

2 Prediction-driven Surge Planning with Application in The Emergency Department
Yue Hu[1], Carri Chan[2], Jing Dong[1], [1]Columbia University, New York, NY, [2]Columbia Business School, New York, NY
Optimizing emergency department (ED) nurse staffing decisions to balance the quality of service and staffing cost can be extremely challenging, especially when there is a high level of uncertainty in patient-demand. Increasing data availability and continuing advancements in predictive analytics provide an opportunity to mitigate demand-rate uncertainty by utilizing demand forecasts. In this work, we study a two-stage prediction framework that is synchronized with the base (made months in advance) and surge (made nearly real-time) staffing decisions in the ED. We quantify the benefit of the more expensive surge staffing. We also propose a near-optimal two-stage staffing policy that is straightforward to interpret and implement. Lastly, we develop a unified framework that combines parameter estimation, real-time demand forecasts, and staffing in the ED.

3 Aggregate Early Bed Requests for Admitted Patients in An Emergency Department
Qian Cheng[1], Nilay Tanik Argon[2], Serhan Ziya[2], [1]University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC
Long emergency department (ED) boarding is associated with adverse patient health outcomes and leads to ED crowding. The current practice is to request hospital beds for admitted patients only after their ED service has ended, and the transfer preparation process (TPP) starts only after a suitable hospital bed has been located. One possible way to shorten the boarding times is to predict patient admissions and make early bed requests for patients who are highly likely to be admitted, and thereby parallelize the ED service and TPP. In this work, we use stochastic modeling to propose a framework to make aggregate early bed request decisions based on the state of ED patients and hospital beds. Proposed policies are evaluated and compared by means of a simulation model populated with data from an academic hospital in US.

Monday, 5 PM–6:15 PM

ME16

CC - Room 121

Healthcare Decision Learning

General Session

Session Chair
Kimia Ghobadi, Johns Hopkins University, Baltimore, MD

1 **A Geometric Approach to Beam Angle Selection in Radiation Therapy Treatment Planning**
Danielle A. Ripsman, Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada. Contact: daripsman@uwaterloo.ca
Beam angle optimization (BAO) is a difficult but essential component of intensity-modulated radiation therapy treatment planning. Despite a wealth of proposed methodologies for BAO in the literature, with significant treatment quality gains, clinicians often opt for the selection of a fixed number of equidistant beams, or manual iterative planning in practice. This is due, in part, to the resource-intensive calculations needed to formally validate any BAO selections. In this talk, a method for geometrically abstracting the BAO problem into a simple set covering problem is proposed, with a goal of pivoting away from sophisticated and iterative calculations at the early stages of the planning process.

2 **A Data-driven Framework to Recommend Improved Radiation Therapy Treatment Plans**
Farzin Ahmadi, Kimia Ghobadi, Todd McNutt, Johns Hopkins University, Baltimore, MD, Contact: fahmadi1@jhu.edu
Clinically acceptable radiation therapy plans are not always optimal and improvements in target coverage or organs-at-risk sparing are often possible. Manually optimizing the plans during the initial steps can result in delays in arriving at acceptable plans. We develop a data-driven optimization framework to improve clinical objectives for future patients. We propose an inverse learning model to personalize radiation therapy treatment plans by adding new dose-volume objective terms to the optimization model. Our results indicate improved plans in terms of organ-at-risk sparing while maintaining target coverage for prostate cancer patients. By learning these new objectives, our framework is capable of automatically maintaining a set of objective recommendations for future patients with similar attributes.

3 **Learning from Good and Bad Decisions Using Inverse Optimization**
Houra Mahmoudzadeh[1], Kimia Ghobadi[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]Johns Hopkins University, Baltimore, MD, Contact: houra.mahmoudzadeh@uwaterloo.ca
Traditional inverse optimization inputs an optimal observation and finds the problem parameters such that optimality conditions in linear programming are enforced for the given observations. In this talk, we propose an inverse optimization framework that can input any number of both acceptable (good) and unacceptable (bad) observations and find problem parameters that respect the classification of good/bad decisions as feasible/infeasible solutions and make the preferred solution optimal. We provide bounds on the number of constraints that need to be inferred depending on the structure of the input data. We demonstrate the methodology in the context of radiotherapy treatment planning.

4 **Learning Diet Recommendations**
Kimia Ghobadi, Johns Hopkins University, Baltimore, MD
We focus on Inverse Optimization techniques to recover underlying optimization models that lead to the observed decisions. We present a data-driven inverse optimization framework (Inverse Learning) to recover the parameters of underlying optimization models and their optimal solutions. We discuss hybrid inverse optimization and machine learning techniques to utilize the strengths of both approaches. Finally, we demonstrate our approach using examples in the context of precision nutrition and personalized daily diet recommendations.

Monday, 5 PM–6:15 PM

ME17

CC - Room 122
Funding Opportunities in Health Care
Panel Session

Session Chair
Esma S. Gel, University of Nebraska-Lincoln, Lincoln, NE

Session Chair
Jennifer Ryan, University of Nebraska–Lincoln

1 **Moderator**
Esma S. Gel, University of Nebraska-Lincoln, Lincoln, NE
This panel discussion is sponsored by the INFORMS Health Applications Society and aims to provide useful insights to researchers interested in health applications, particularly junior faculty. Our panelists will discuss various important issues when pursuing healthcare research funding, such

as identifying the right funding source, strategies for writing successful proposals, and how funding processes differ across agencies.

2 **Panelist**
Alexandra Medina-Borja, US National Science Foundation, Falls Church, VA

3 **Panelist**
Kalyan Pasupathy, University of Illinois at Chicago, Chicago, IL

4 **Panelist**
Yuehwern Yih, Purdue University, West Lafayette, IN

5 **Panelist**
Sanjay Mehrotra, Northwestern University, Evanston, IL

Monday, 5 PM–6:15 PM

ME18

CC - Room 123
Sanjay and Panna Mehrotra Research Excellence Award Session
Award Session

Session Chair
Paul Griffin, Purdue, West Lafayette, IN

1 **Informing Hepatitis C Elimination Policy: Working with the White House, CDC, and World Health Organization**
Jagpreet Chhatwal, Harvard Medical School, Mass General Hospital, Boston, MA
In this talk, I will describe my work on hepatitis C virus modeling that directly informed hepatitis C elimination policies in the United States and globally. Over the course of 8 years, my group developed multiple mathematical models and tools to inform health policy decision-making for hepatitis C, which were utilized by the White House, the Centers for Disease Control and Prevention (CDC), and the World Health Organization. I will discuss how such collaborations were initiated, progressed, and lessons learned that could help INFORMS community increase the impact of their work.

2 **Managing Patients with Chronic Conditions**
Mariel Sofia Lavieri, University of Michigan, Ann Arbor, MI
Chronic disease management often involves sequential decisions that have long-term implications. Those decisions are based on high dimensional information, which pose a problem for traditional modeling paradigms. I describe some of my ongoing research modeling medical decisions of patients with chronic conditions. Model conception and validation is described, as well as the role of multidisciplinary collaborations in ensuring practical impact of my work.

3 **Recent Advancement in Healthcare Scheduling: Theory and Practice**
Nan Liu, Boston College, Chestnut Hill, MA
Scheduling is the core function of healthcare operations to match provider service capacity and patient demand in a safe, efficient and equitable way. Scheduling (of patients and providers) is a classic operations problem that has been studied for decades. In recent years, the topic has gained renewed interest due to advancement in clinical practice, data availability and analytics methodologies. In this talk, I will discuss some recent developments in this domain and potential future research directions, and share my experience of translating research to practice.

Monday, 5 PM–6:15 PM

ME19

CC - Room 124
Data-driven Healthcare Analytics
General Session

Session Chair
Yichuan Ding, McGill University, Montreal, QC, Canada.

Session Chair
Yiwen Jin, UBC, Sauder School of Business, Vancouver, BC, Canada.

1 **Automated Data-driven Modeling and Simulation of a Large Hospital Emergency Department**
Opher Baron[1], Dmitry Krass[2], Arik Senderovich[1], Nancy Li[1], [1]University of Toronto, Toronto, ON, Canada; [2]Rotman School of Management, University of Toronto, Toronto, ON, Canada. Contact: opher.baron@rotman.utoronto.ca
The goal of this project is to develop an automated data-driven simulation model using event log data, process mining, queue mining, and machine learning techniques. We apply these tools to model wait times of an Emergency Department (ED) in a large city hospital in Toronto, Canada.

We deal with missing data by using a state dependent M/G/infinity, where patients' length of stay depends on their medical characteristics and congestion at the ED. We are particularly interested in evaluating the impact of consults on wait times and their 90 percentile. We find that while the direct effects of consults are relatively minor, their indirect effects are much stronger. We explain how similar simulation models can be automatically implemented in other settings.

2 The Cost of Task Switching: Evidence from Emergency Departments

Yiwen Jin[1], Yige Duan[2], Mahesh Nagarajan[2], Yichuan Ding[3], Garth Hunte[4], [1]University of British Columbia, Vancouver, BC, Canada; [2]University of British Columbia, Vancouver, BC, Canada; [3]McGill University, Montreal, QC, Canada; [4]University of British Columbia, Vancouver, BC, Canada. Contact: daniel.ding@mcgill.ca

Emergency department (ED) physicians treat patients with different symptoms and constantly switch between tasks. Using a comprehensive patient visit dataset and a unique lab test dataset from two EDs, we investigate the impact of task switching on physician productivity, quality of care, patient routing, and patient waiting time. To address estimation bias due to measurement errors and endogenous patient routing, we construct an instrumental variable that exploits the exogenous composition of waiting patients. Our estimates indicate that, at different EDs, switching between different types of patients reduces patient throughput rates. Task switching also affects how physicians route patients, though we find little impact on healthcare quality. We further propose patient clustering method to improve ED efficiency.

3 Patient Preference and Quality Trade-offs: An Exploration of Safety-net Hospital Utilization in Massachusetts

Ankita Shirahatti, Boston University, Boston, MA, Contact: ashiraha@bu.edu

Medicaid expansion has dramatically altered the healthcare landscape in MA where healthcare access has been historically marked by residential segregation, lack of sufficient insurance coverage, and variation in service experiences. Usage of safety-net hospitals after the 2008 MA Health Reform has been of interest to providers and policy-makers, as prior studies demonstrate that demand for safety-net hospital services has not decreased in response to expanded access to healthcare for populations that were previously disproportionally affected by lack of insurance. Using a dataset of MA inpatient discharges ten years following the MA Health Reform, we explore the hypothesis that safety-net hospital operations are better designed to meet the needs of these patient populations, who are willing to make quality trade-offs for safety-net hospital experiences.

Monday, 5 PM–6:15 PM

ME20

CC - Room 125
DAS Award Session
Award Session

Session Chair

Emanuele Borgonovo, Bocconi University, Milano, Italy.

DAS Best Student Paper Award

Mehmet Ayvaci[1], Sasa Zorc[2], [1]Stanford University, Stanford, CA, [2]Stanford University, Charlottesville, VA

The Student Paper Award is given annually to the best decision analysis paper by a student author, as judged by a panel of the Decision Analysis Society of INFORMS. The winner and finalists will be recognized and the winner will give a condensed presentation of their paper.

DAS Publication Award

Aurelien Baillon[1], Jay Simon[2], [1]Erasmus University Rotterdam, Rotterdam, Netherlands; [2]American University, Washington, DC, Contact: baillon@ese.eur.nl

DAS Practice Award

Gilberto Montibeller[1], Nadia Papamichail[2], [1]Loughborough University, Loughborough, United Kingdom; [2]University of Manchester, Greater Manchester, United Kingdom.

The Decision Analysis Practice Award is awarded jointly by DAS and the Society of Decision Professionals to the best example of decision analysis practice as judged by the Decision Analysis Practice Award Committee. The purpose of the award is to publicize and encourage outstanding applications of decision analysis practice. We will present the finalists and this year's winner.

DAS Ramsey Award

Karen Jenni, U.S. Geological Survey, Denver, CO

The Ramsey Medal of the Decision Analysis Society is awarded for distinguished contributions in decision analysis. Distinguished contributions can be internal, such as theoretical and procedural advances in decision analysis, or external, such as developing or spreading decision analysis in new fields. We will introduce the Ramsey Medal winner, followed by a presentation by the winner.

Monday, 5 PM–6:15 PM

ME21

CC - Room 126
Machine Learning and Optimization for Healthcare
General Session

Session Chair
Holly Mika Wiberg, MIT, Somerville, MA

1 **HAIM: Integrated Multimodal Artificial Intelligence Framework for Healthcare Applications**
Luis R. Soenksen[1,2], Yu Ma[3], Cynthia Zeng[4], Leonard Boussioux[3], Kimberly M. Villalobos Carballo[3], Liangyuan Na[5], Holly Mika Wiberg[4], Michael Lingzhi Li[4], Ignacio Fuentes[1], Dimitris Bertsimas[4], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Harvard University, Cambridge, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, [4]Massachusetts Institute of Technology, Cambridge, MA, [5]Massachusetts Institute of Technolgy, Cambridge, MA, Contact: midsumer@mit.edu
We propose a Holistic AI in Medicine (HAIM) framework to leverage the use of multiple data sources in AI systems. We evaluate our HAIM framework by training 14,324 independent models based on MIMIC-IV-MM, a multimodal clinical database spanning 4 data modalities (i.e., tabular, time-series, text and images). We show that this framework can robustly produce models that outperform similar single-source approaches by 6-33% in tasks including chest pathology diagnoses, length-of-stay and 48-hour mortality predictions. We also quantify the contribution of each modality using Shapley values and demonstrate the heterogeneity in data type importance. The generalizable properties and flexibility of our Holistic AI in Medicine (HAIM) framework could offer a promising pathway for future multimodal predictive systems in clinical and operational healthcare settings.

2 **Optimizing Virtual Care for Chronic Disease Patients: A Case Study in Diabetes**
Holly Mika Wiberg, Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, Contact: hwiberg@mit.edu
We study the effectiveness of virtual and in-person care for diabetic patients. The COVID-19 pandemic significantly accelerated telehealth adoption. Policymakers and hospital systems must now determine how to best utilize telehealth in patient care moving forward. We tackle this question from a causal machine learning and optimization approach. We consider the visit modality, virtual vs. in-person, as a treatment and use causal inference methods to estimate individual treatment effects. These effects inform a scheduling model that optimizes a provider's virtual/in-person mix. We vary the prioritization of operational vs. clinical outcomes and overall virtual visit limits. Our findings suggest a benefit to increasing virtual care and motivate further policy investigations.

3 **Distributionally Robust Learning over Wasserstein Uncertainty Sets and Applications in Hypertension Control**
Ioannis (Yannis) Paschalidis, Boston University, Boston, MA, Contact: yannisp@bu.edu
We will present a framework we have introduced for solving a distributionally robust version of the standard expected risk minimization problem used to learn either a regression or a classification model. We will cover applications in hypertension control, predicting who suffers from poor hypertension control and prescribing the best type of medication for controlling their blood pressure.
(joint work with Ruidi Chen and Yang Hu)

4 **Predicting Elderly Abuse Victims in The Emergency Department Using Electronic Health Records Data**
Yiye Zhang, Weill Cornell Medicine, New York, NY
This study describes a machine learning approach to predict patients at risk of bring a victim for elderly abuse victims at the emergency department. We used electronic health records data at NewYork-Presbyterian Hospital.

Monday, 5 PM–6:15 PM

ME22

CC - Room 127
Game Theory
Contributed Session

Session Chair
Reza Maihami, East Tennessee State University, Johnson City, TN

1 **Computing Pareto-optimal and Almost Envy-free Allocations of Indivisible Goods**
Jugal Garg[1], Aniket Murhekar[2], [1]University of Illinois,

Urbana-Champaign, Champaign, IL, [2]University of Illinois, Urbana-Champaign, CHAMPAIGN, IL, Contact: aniket2@illinois.edu

We study the problem of allocating a set of indivisible goods to agents with additive valuations while satisfying the popular fairness notion of envy-freeness up to one good (EF1) in conjunction with Pareto-optimality (PO). We present a pseudo-polynomial time algorithm to compute an allocation that is EF1 and fPO, which is a stronger notion than PO, thereby improving earlier known results. We also present polynomial time algorithms for two interesting sub-classes: (i) k-ary instances where k is a constant, i.e., each agent has at most k different values for the goods, and (ii) when the number of agents is constant. These results significantly extend the polynomial-time computability beyond the known cases of binary or identical valuations.

2 Fair and Efficient Allocations of Chores Under Bivalued Preferences

Jugal Garg[1], Aniket Murhekar[2], John Qin[2], [1]UNIV OF ILLINOIS AT URBANA CHAMPAIGN, Urbana, IL, [2]University of Illinois - Urbana Champaign, Champaign, IL

We study the problem of fair and efficient allocation of a set of indivisible *chores* to agents with additive cost functions. We consider the popular notion of envy-freeness up to one good (EF1) with the efficiency notion of Pareto-optimality (PO). While it is known than EF1+PO allocation exists and can be computed in pseudo-polynomial time in the case of goods, the same problem is open for chores.

Our first result is a strongly polynomial-time algorithm for computing an EF1+PO allocation for *bivalued instances*, where agents have (at most) two disutility values for the chores. To the best of our knowledge, this is the first non-trivial class of chores to admit an EF1+PO allocation and an efficient algorithm for its computation.

Our second result shows that for bivalued instances of divisible chores, an envy-free (EF) and PO allocation can be computed in strongly polynomial-time.

3 Deep Learning The Equilibrium of Multi-stage Bayesian Games

Nabiha Nasir Orpa, Lichun Li, FAMU-FSU College of Engineering, Tallahassee, FL, Contact: no18k@fsu.edu

The existence of Nash equilibrium in discounted two-player zero-sum Bayesian games is proven, but computing it is another story. As the information sets' size in multi-stage games grows exponentially in the number of stages, the computation load increases correspondingly and restricts us in small games because of the memory shortage. We introduce an algorithm that combines dynamic programming (DP) and deep learning to compute the equilibria of discounted Bayesian games efficiently. In the n^{th} iteration, we first train an n-stage neural network (NN) *value* model using the game value data computed from the previous step and then construct an n+1-stage NN *equilibrium* model based on DP to compute the game value and equilibrium. The process is continued until the game value converges whereas LP can only compute up to 4 stages in the provided example due to memory shortage.

4 The Effect of Government Policies on The Pricing Problem in Green Supply Chains

Reza Maihami[1], Mojtaba Nowurozi[2], Anwar Mahmoodi[2], [1]East Tennessee State University, Johnson City, TN, [2]University of Kordestan, Sanandaj, Iran, Islamic Republic of. Contact: maihami@etsu.edu

In this study, we examine the pricing of two green products that are interchangeable and are produced by separate supply chains. We study how supply chains and their members interact using Nash and Stackelberg Game models. There are two supply chains competing with equal power in the Nash model, but within each supply chain, there is a Stackelberg type of competition between retailers and manufacturers. The Stackelberg model assumes that one of the supply chains is the market leader. The mathematical model is formulated and closed-form analytical solutions are provided for each game structure. In conclusion, regardless of Nash or Stackelberg structures, with increasing government intervention (government's adjustment factor and green level floor for subsidies), the green level of the product will increase while wholesale and retail prices will decrease.

Monday, 5 PM–6:15 PM

ME23

CC - Room 128

Disrupting Human Trafficking

General Session

Session Chair

Kayse Lee Maass, Northeastern University, Charlton, MA

1 Disrupting Sex Trafficking Recruitment Using Community Based Resource Allocation Models

Baris Tezcan[1], Kayse Lee Maass[1], Thomas Sharkey[2], Yongjia Song[2], Lauren Martin[3], Kelle Barrick[4], Amy Farrell[1], [1]Northeastern University, Boston, MA, [2]Clemson University, Clemson, SC, [3]University of Minnesota, Minneapolis, MN, [4]RTI International, Longmont, CO, Contact: tezcan.b@northeastern.edu

A person's risk of being trafficked is greatly influenced by their (lack of) access to community support structures. We model a trafficker's process of recruiting sex trafficking victims using a network where states represent a potential victim's fluctuating likelihood of being trafficked, various trafficking recruitment strategies, and chances of being re-trafficked after leaving their trafficker. Potential victims transition from one state to another probabilistically. We aim to allocate resources throughout this network in a way that changes the state transition probabilities with the objective of minimizing the exploitation a victim experiences. We design and validate the network space with a human trafficking survivor advisory board. Finally, we collect or generate data for our model by conducting stakeholder interviews and from the relevant literature.

2 Sex Trafficking and Its Intersections with Other Forced Illicit Labor Markets: Modeling Disruptions

Michael Clark[1], Thomas Sharkey[1], Lauren Martin[2], [1]Clemson University, Clemson, SC, [2]University of Minneosta, Minneapolis, MN, Contact: tcshark@clemson.edu

Victims of sex trafficking networks are often forced to work in both commercial sex markets and perform other illicit activities (e.g., drug dealing, theft, and fraud). We present a network model that captures the operations of trafficking networks that force their victims to participate in multiple illicit activities and an interdiction problem that seeks to disrupt such trafficking networks. Our interdiction problem allows us to capture the impacts of market-level disruptions, such as decreasing the demand for commercial sex, on the trafficking networks as well as traditional disruptions that focus on removing victims or traffickers from the network. We discuss how we gathered data to populate our model through working with our survivor-centered advisory group and insights obtained through our interdiction problem.

3 Labor Violation Trends Among Employers of Agricultural Workers on H-2A Visas: What We Can Learn to Improve Inspection Strategies

Arezoo Jafari[1], Priscila De Azevedo Drummond[1], Dominic Nishigaya[2], Shawn Bhimani[2], Amy Farrell[2], Kayse Lee Maass[2], [1]Northeastern University, Boston, MA, [2]Northeastern University, Boston, MA, Contact: Jafari.a@northeastern.edu

Labor trafficking has been documented within U.S. agricultural supply chains with workers on H2-A visas being particularly vulnerable to exploitation. Given the limited resources to inspect worksites, this study helps identify unsafe working conditions by analyzing public data regarding employer wage and hour violations and H2-A certification applications. Using a mixed linear regression model, we assess the relationship of a set of factors, such as investigation time and number of H-2A workers certified on the number of H-2A violations reported.

4 Optimizing The Benefit-to-Cost Ratio for Effective Capacity Deployment for New York City's Homeless Youth Shelter System

Frederick I. Miller[1], Yaren Bilge Kaya[2], Geri Dimas[1], Renata Alexandra Konrad[1], Kayse Lee Maass[3], Andrew C. Trapp[1], [1]Worcester Polytechnic Institute, Worcester, MA, [2]Northeastern University, Jamaica Plain/Boston, MA, [3]Northeastern University, Boston, MA, Contact: fimiller@wpi.edu

Runaway and homeless youth (RHY) face a high risk of being trafficked. While an existing shelter system provides necessary RHY services such as shelter, mental health and financial support, there is a great need for system-wide, yet costly, shelter capacity expansion. We undertake an RHY and service provider-informed, systematic, and data-driven approach that considers the benefits to society obtained from rolling out new capacity against associated costs.
We propose a mixed integer linear fractional program (MILFP) that maximizes the benefit to cost ratio of capacity expansion for the New York City shelter system. We employ Dinkelbach's algorithm to convert the MILFP to a series of linearized versions, improving tractability. Our results provide data-informed recommendations for NYC shelter expansion opportunities to better serve RHY.

Monday, 5 PM–6:15 PM

ME24

CC - Wabash 1
JMP, A SAS Company / SAS
Technology Tutorial

1 No-Code Text Mining with JMP Pro

Ross Metusalem, JMP Stastistical Discovery, Tampa, FL, Contact: ross.metusalem@jmp.com

Unstructured text can be a rich information source, provided the right tools to transform it into structured data for further analysis. JMP Pro is powerful, no-code data analysis software, and this tutorial will demonstrate JMP Pro's text mining tool, Text Explorer. We will apply Text Explorer to real-world data to perform sentiment analysis, topic analysis, and text regression. We also will see how to use outputs from text mining as inputs to further analyses.

2 **Building and Solving Optimization Models with SAS**

Robert Pratt, SAS Institute, Inc., Cary, NC, Contact: rob.pratt@sas.com

SAS offers extensive analytic capabilities, including machine learning, deep learning, natural language processing, statistical analysis, optimization, and simulation. SAS analytic functionality is also available through the open, cloud-enabled design of SAS® Viya®. You can program in SAS or in other languages - Python, Lua, Java, and R. SAS Analytics is also equipped with AI-enabled automations and modern low-code or no-code user interfaces that democratize data science usage in your organization and offer unparalleled speed to value.
OPTMODEL from SAS provides a powerful and intuitive algebraic optimization modeling language and unified support for building and solving LP, MILP, QP, conic, NLP, constraint programming, network-oriented, and black-box models. This tutorial will include an overview of the optimization capabilities and demonstrate recently added features.

Monday, 5 PM–6:15 PM

ME25

CC - Wabash 2

Using Simple Games to Teach Supply Chain Management

Tutorial Session

Session Chair

Mabel Chou, National University of Singapore, SG, SG, Singapore.

1 **Using Simple Games to Teach Supply Chain Management**

Elena Katok, University of Texas at Dallas, Richardson, TX

Classroom simulation, or games, are often used in operations and supply chain management courses. Popular games are often quite complicated because their goal is to create realistic scenarios. But there is value to using simple games to quickly illustrate simple points and motivate material. In this article I discuss games that I use in the classroom, drawn almost directly from my research, for three topics: inventory and contracting, competitive bidding, and trust and collaboration. For each topic, I explain the specific goals the games are designed to accomplish, the game setup and how to modify games designed for research for classroom use, and my typical experience with student reactions and feedback.

Monday, 5 PM–6:15 PM

ME26

CC - Wabash 3

Location Modeling

General Session

Session Chair

Sibel Alumur Alev, University of Waterloo, Waterloo, ON, Canada.

1 **Dynamic Location of Test Centers for Clinical Trials Under Resource Constraints**

Dmitry Krass[1], Zhili Tian[2], [1]Rotman School of Management, University of Toronto, Toronto, ON, Canada; [2]Florida International University, Weston, FL, Contact: krass@rotman.utoronto.ca

Gaining approval for a new drug requires the manufacturer to undergo Randomized Controlled Trials (RCTs). Optimizing this process is crucial: should the drug gain approval, the time spent in RCT counts against the patent protection period, thus it is desirable to recruit the needed number of patients as soon as possible. The RCT is typically conducted across a large number of test centers, operating them incurs both fixed and variable costs. The patient recruitment processes at different centers are highly stochastic; many centers fail to recruit a single patient. We formulate the problem as a stochastic dynamic location problem and present initial theoretical and experimental results.

2 **Socially Optimal Public Service Network Design**

Robert Aboolian[1], Majid Karimi[2], [1]California State University-San Marcos, San Diego, CA, [2]California State University San Marcos, San Marcos, CA, Contact: raboolia@csusm.edu

Governments are involved in providing essential services, such as healthcare, transportation, education and utilities. In contrast with the private sectors' mission to maximize profit, governments' mandate is to maximize the societal benefit by acting as *public agents*. When designing service systems, many models in public sector focus on maximizing accessibility to public services to increase societal benefit. The idea is to (re)design the public service to maximize the number of people who will benefit from the program given a limited budget, thus using accessibility as a proxy for benefit. Such models fail to capture the *marginal benefits* -- savings in costs to taxpayers by adding or reducing a unit of service capacity. We study the problem of determining the optimal number, locations, and capacities of a network of facilities to maximize the public's *overall benefit*.

3 Multi-objective Covering Location Problems with Advanced Connectivity Features and Zonal Requirements: Exact and Matheuristic Approaches

Serena Fugaro[1], Antonino Sgalambro[2,2], [1]National Research Council of Italy, Rome, Italy; [2]University of Sheffield, Sheffield, United Kingdom. Contact: a.sgalambro@sheffield.ac.uk

We explore the integration of the Maximal Covering Location Problem with spatial-related requirements and advanced connectivity features. A broad modeling perspective is adopted, accounting for structural and economic aspects of connectivity features in facility location, while allowing the choice of one or more facilities to serve the facility networks as depots, and containing the maximal distance between any located facility and such depot(s). A novel class of Multi-objective Covering Location problems are introduced and modeled, and the arising Pareto Sets are explored by adopting the robust version of the AUGMEnted �-CONstraint method. We also make use of the mathematical properties of the introduced problems to design Matheuristic algorithms, integrated within the solution scheme, to tackle instances with increasing size and multiple depots.

4 Determining Optimal Covid-19 Testing Center Locations and Capacities

Esma Akgun, Sibel Alumur Alev, F. Safa Erenay, University of Waterloo, Waterloo, ON, Canada. Contact: eakgun@uwaterloo.ca

Early isolation of the positive cases through testing is one of the key methods to control the COVID-19 pandemic. However, this intervention relies on fast access to testing, which has become a global challenge due to the recent variants and surge in testing demand. We propose a multi-period location and capacity allocation model that determines the locations and capacities of COVID-19 testing centers under budget and capacity constraints. We apply our model to the case of locating COVID-19 testing centres in the Region of Waterloo, Canada. The results of our numerical analyses provide practical insights to the public health decision-makers on the locations and timing of testing capacity expansions.

Monday, 5 PM–6:15 PM

ME27

CC - Room 138

Information in Sustainable Management and Service Operations

General Session

Session Chair

Yunlong Peng, Tsinghua University, Beijing

Session Chair

Chong Zhang, Tilburg University, Tilburg, Netherlands.

1 Green Disposable Packaging and Communication: The Implications of Bring-your-own-container

Yunlong Peng[1], Fei Gao[2], Jian Chen[1], [1]Tsinghua University, Beijing, China; [2]Indiana University Bloomington, Bloomington, IN, Contact: pengyl.17@sem.tsinghua.edu.cn

A growing eco-trend among eco-conscious consumers is "Bring-Your-Own-Container" (BYOC), where consumers take their own reusable packaging to buy and consume products to reduce the waste of single-use packaging. In this paper, we study the impacts of BYOC on a firm's disposable packaging and communication decisions.

2 Traceability and Product Recalls in a Vertically-Integrated Food Supply Chain

Beyza Celik[1], Milind Dawande[2], Ganesh Janakiraman[3], [1]University of Texas at Dallas, Richardson, TX, [2]The University of Texas at Dallas, Richardson, TX, [3]University of Texas- Dallas, Richardson, TX, Contact: Beyza.Celik@utdallas.edu

Traceability can help reduce the cost of food recalls. However, it does not eliminate the probability of food safety crises. By considering the optimal traceability level and the contamination mitigation efforts of a vertically-integrated firm, we examine the impact of traceability on the interaction between a firm and its consumers.

3 Signaling Demand Via Queue Visibility

Chenguang Wu[1], Chong Zhang[2], Qiuyi YAN[1], Ying-Ju Chen[3], [1]Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [2]Tilburg University, Tilburg, Netherlands; [3]Hong Kong University of Science and Technology, Kowloon, Hong Kong. Contact: c.zhang@tilburguniversity.edu

We consider a queuing system in which customers' arrival rate is uncertain and the realized arrival rate is the server's private information. The server utilizes queue disclosure strategies to signal the arrival rate to new customers, shape their beliefs, and influence their joining behaviors. We develop a signaling game to capture the server-customer interaction, provide a complete characterization of the server's optimal queue disclosure strategies that maximize the steady-state throughput, and demonstrate how they differ from those under classic complete information. Our analysis identifies a new equilibrium that can only exist under asymmetric information: making the queue unobservable when the demand is high and observable when the demand is low.

4 Wait Time Dependent Payment Mechanism for Queueing Systems with Heterogeneous Customers

Chen-An Lin, Kevin Shang, Peng Sun, Duke University, Durham, NC, Contact: peng.sun@duke.edu

This paper studies a mechanism design problem for a single-server queue where customers arrive according to a Poisson process. Arriving customers have private information about their wait-time sensitivity. For each arriving customer, the service provider announces the system wait time and offers a menu in which each option consists of an admission probability and a payment. In response, the customer either selects an option in the menu or balks from the system. The objective is to maximize the long-run average revenue. We show that a wait-time dependent, type-threshold menu is optimal. We conduct a numerical study to assess the value of the mechanism.

Monday, 5 PM–6:15 PM

ME28

CC - Room 139

Marketing/OM Interface

General Session

Session Chair

Shuya Yin, University of California-Irvine, Irvine, CA

Session Chair

Rachel Rong Chen, University of California-Davis, Davis, CA

1 Pricing and Stocking Planning: Official Vs Third-party Channels

Ning Ma, Yimin Wang, Rui Yin, Arizona State University, Tempe, AZ, Contact: ningma7@asu.edu

Rapid advances in information technology in recent years have enabled the manufacturers to operate multiple internet channels, especially operating both their own official website and contracting with a third-party marketplace. In this work, we study how such manufacturers should make centralized decisions by deciding production quantity, allocation quantity across channels, and selling price of the official channel. This model allows us to study the utilization of three types of consumers with different channel loyalties and endogenous demand functions. We propose the "channel price matching strategy" and the "spillover strategy". In addition, we generalize our model to an asymmetric competition setting in which the manufacturer competes with other retailers or suppliers in the third-party marketplace.

2 The Role of Product Quality in Marketplaces

Leela Aarthy Nageswaran[1], Aditya Jain[2], Haresh B. Gurnani[3], [1]University of Washington, Seattle, WA, [2]Baruch College, Zicklin School of Business, New York, NY, [3]Wake Forest University, Winston Salem, NC, Contact: aditya.jain@baruch.cuny.edu

Traditional retailers have started to offer marketplaces, wherein suppliers may sell directly to customers. We study which mode of operation - marketplace, wholesale, or a combination - will prevail when the product quality is uncertain. In contrast to marketplace's dominance when quality is certain, we show that there may be a separating equilibrium wherein only a low-quality product is offered via marketplace.

3 Promotion Incentives for Customer Retention: Field Experiment with a Subscription Meal Kit Service

Aysun Mutlu[1], Sanjith Gopalakrishnan[2], Mehmet Gumus[3], Saibal Ray[3], [1]McGill University, Montreal, QC, Canada; [2]McGill University, Burnaby, BC, Canada; [3]McGill University, Montreal, QC, Canada. Contact: aysun.mutlu@mail.mcgill.ca

Customer retention is a challenging problem in retail management. Companies employ a variety of incentives to retain or re-acquire customers. However, their effectiveness is not well understood. Via field experiments carried out with a subscription meal-kit service, we estimate the impacts of various incentives on customer retention and lifetime value.

4 Partial Centralization in a Durable-Good Supply Chain

Jin Li[1], Xiaodong Yang[2], Gangshu Cai[3], Chunming Victor Shi[4], [1]Zhejiang Gongshang University, Hangzhou, China;

[2]Shanghai University of International Business and Economics, Shanghai, China; [3]Santa Clara University, Santa Clara, CA, [4]Wilfrid Laurier University, Waterloo, ON, Canada. Contact: cshi@wlu.ca

There has been extensive research on the strategic choice between supply chain centralization or decentralization. However, most research omits the commonly adopted supply chain structure of partial centralization, where a firm owns a portion but not all, of its partner. To help fill this research gap, in this paper, we make a major contribution by analyzing partial centralization in a supply chain where a durable-good manufacturer owns a portion of its downstream retailer. We find that partial centralization can become the equilibrium structure for a durable-good supply chain. Also, the manufacturer's optimal ownership share in the retailer decreases in the product durability and decision horizon length, implying that complete decentralization is more likely to be the supply chain structure in equilibrium for higher product durability and longer decision horizon.

Monday, 5 PM–6:15 PM

ME29

CC - Room 140

Emerging Operations Models and New Insights

General Session

Session Chair

Xun Xu, California State University-Stanislaus, Turlock, CA

1 An Empirical Analysis of Sequential Diagnostic Decisions for Bike Returns

Hailong Cui[1], Jingxuan Geng[2], Guangwen Kong[3], Guo Li[4], Sampath Rajagopalan[5], [1]University of Minnesota, Minneapolis, MN, [2]Temple University, Philadelphia, PA, [3]Temple University, Philadephia, PA, [4]Beijing Institute of Technology, Beijing, China; [5]University of Southern California, Los Angeles, CA, Contact: raj@marshall.usc.edu

We study diagnostic decisions for bike maintenance in which a triage worker and a worker sequentially decide whether to replace or repair a part of a bike. We examine the impact of decisions on repair or replacement of parts on bike return and find factors that impact repair or replacement choice.

2 Hiding in Plain Sight: Surge Pricing and Strategic Providers

Jiaru Bai[1], Manish Tripathy[2], H. Sebastian Heese[3], [1]Stoney Brook University, Stoney Brook, NY, [2]UBC, Vancouver, BC, Canada; [3]NC State University, Raleigh, NC

There is increasing evidence that service providers strategically collude to induce artificial supply shortages by reducing the number of providers showing as available on the app. Our work establishes some first structural insights into the problem of collusion by strategic providers in an on-demand service platform context.

3 Can On-demand Ride-hailing Platforms Coexist with Traditional Taxi Services?

Liling LU[1], Xin Fang[2], Guiyun Feng[3], Sergei Savin[4], [1]NULL, singapore, Singapore; [2]Singapore Management University, Singapore, Singapore; [3]SMU, singapore, Singapore; [4]Wharton School, Philadelphia, PA, Contact: xfang@smu.edu.sg

We consider an on-demand ride hailing platform who can potentially collaborate with taxi companies to gain access to taxi drivers in addition to its own private car drivers. We investigate the government regulation to such collaboration and its implications. In our model, taxi drivers and private car drivers differ in service quality. The platform sets ride fee for riders requesting ride hailing services and provides wage compensation for participating drivers who serve the requests. The government decides the maximum amount of time that taxi drivers are allowed to serve the requests on the platform. By comparing with the benchmark without the collaboration or regulation, we find that the collaboration between the platform and taxi companies may not always benefit riders or drivers, and the government regulation is needed for larger welfare.

Monday, 5 PM–6:15 PM

ME30

CC - Room 141

MSOM/iForm and Supply Chain Flash Session

Flash Session

Session Chair

Retsef Levi, MIT, Cambridge, MA

1 Financing Platforms with Cryptocurrency

Jingxing (Rowena) Gan[1], Gerry Tsoukalas[2], Serguei Netessine[3], [1]Cox School of Business, Southern Methodist University, Dallas, TX, [2]Boston University, Boston, MA, [3]The Wharton School, Philadelphia, PA, Contact: jingxingg@smu.edu

Initial coin offerings are a highly customizable form of crowdfunding for blockchain-based startups. The startup controls the token price, the sales cap, the function of the token, the allocation of funds raised, sources of post-ICO income, etc. We study how various design elements interact and how startups with different visions may utilize these tools.

2 Blockchain Adoption in a Supply Chain with Market Power

Garud N. Iyengar[1], Fahad Saleh[2], Jay Sethuraman[1], Wenjun Wang[3], [1]Columbia University, New York, NY, [2]Wake Forest University, Sugar Land, TX, [3]Susquehanna International Group, Bala Cynwyd, PA, Contact: salehf@wfu.edu

We model a supply chain with a risk-averse manufacturer. Blockchain plays two roles. First, blockchain enables efficient tracing of defective items, enabling selective recalls of defective items in place of full recalls. This traceability reduces the risk of buying from multiple vendors and thus leads to endogenous diversification across vendors. The diversification enhances manufacturer welfare due to her risk aversion. Second, blockchain reduces information asymmetry regarding manufacturer type, which leads to improved consumer decision-making and enhanced consumer welfare. The manufacturer extracts some consumer welfare by optimally raising consumer prices.

3 Supply Chain Transparency and Blockchain Design

Yao Cui[1], Vishal Gaur[1], Jingchen Liu[2], [1]Cornell University, Ithaca, NY, [2]Nanjing University, Nanjing, China. Contact: yao.cui@cornell.edu

In this paper, we consider two ways that blockchain can enhance supply chain transparency: (1) making the manufacturer's sourcing cost credibly transparent to the buyers (i.e., vertical cost transparency) and enabling the manufacturer to charge dynamic wholesale prices; and (2) making the ordering status of buyers transparent to each other (i.e., horizontal order transparency) and changing the ordering policies of buyers. We study when blockchain should be adopted, who should be the initiator of the blockchain, and how firms should design the functionality of blockchain.

4 Supply Chain Analytics: From Problem Solving to Problem Discovery

Yao Zhao, Rutgers, The State University NJ, Newark, NJ, Contact: yaozhao@business.rutgers.edu

Supply chain management is primarily model driven problem solving. I will showcase descriptive and diagnostic analytics for data driven problem discovery in supply chain and risk management.

5 Consumer Privacy in Online Retail Supply Chains

Xiaoyu Wang[1], Fasheng Xu[2], Fuqiang Zhang[1], [1]Washington University in St. Louis, St. Louis, MO, [2]Syracuse University, Syracuse, NY, Contact: xiaoyuwang@wustl.edu

Exploitation of consumer data allows online retailers to provide tailored services to consumers, but at the risk of causing unintended privacy issues. This paper studies the implications of newly adopted privacy policies such as the GDPR in online retail supply chains consisting of a retailer and a supplier. We find that, although the GDPR is designed to protect consumer privacy, it may actually hurt consumer surplus. In fact, the GDPR may even lead to a triple-lose situation for the retailer, supplier, and consumers. We further explore two coordinated supply chain arrangements, i.e., agency selling and vertical integration. We show that the GDPR still may decrease the consumer surplus.

6 Selling Agri-tech Products: Firm Strategy, Farmer Incentives, and Government Subsidy

Xiao Tan[1], Duo Shi[2], Fuqiang Zhang[1], [1]Washington University in St. Louis, St. Louis, MO, [2]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China. Contact: xtan@wustl.edu

With the development of technology, many emerging agri-technology products can help with improving output. However, new products may be expensive or hard to use. We study the impact of agri-tech product adoption, like agricultural drones, on the traditional agriculture supply chain. Farmers' purchasing strategies, the firm's pricing decisions, and government subsidy schemes are considered. Apart from selling agri-tech products, the firm may also sell professional services to help farmers. We find the best pricing strategy for the firm is to achieve either complete bundle selling or no bundle selling at all. In addition, four subsidy schemes are considered.

7 Predicting The Spread of SARS-COV-2 Variants: An Ai Enabled Early Detection

Retsef Levi, El Ghali Ahmed Zerhouni, MIT, Cambridge, MA, Contact: retsef@mit.edu

This study analyzes 9.0 Million SARS-COV-2 genetic sequences in 30 countries, and describes the diversity of variants over time, particularly of those that caused significant waves. It designs new features to uncover the characteristics of the infectious variants likely to spread and cause new infection waves. Then, a Machine Learning risk assessment model is developed to detect the variants likely to cause a new wave of infections in each country as early as 1 week after their first detection. The out of sample AUC is 85.6% after one week, and 88.0% after two weeks. Such methodology could be used to quantitatively and continuously monitor new variants for a proactive management of SARS-COV-2.

8 Coordination of The Supply Chain with Quality Improvement and Customer Returns

Xinghao Yan, University of Toledo, Toledo, OH, Contact: yanxinghao@gmail.com

Customer returns are commonly observed in reality and significantly influence firms' profits, which may or may not be caused by low product quality. This paper is the first to study supply chain performance with both quality improvement and customer returns. We also study coordinating contract design for the supply chain.

Monday, 5 PM–6:15 PM

ME31

CC - Room 142

Platform Economics

General Session

Session Chair

Xuying Zhao, University of Notre Dame, Notre Dame, IN

Session Chair

Duc Vu, The University of Texas at Dallas, Richardson, TX

1 Search Neutrality and Competition Between First-party and Third-party Sellers

Tianxin Zou[1], Bo Zhou[2], [1]University of Florida Warrington College of Business Administration, Gainesville, FL, [2]University of Maryland, College Park, MD, Contact: tianxin.zou@warrington.ufl.edu

Major economies are discussing search neutrality regulations that ban dominant platforms from self-preferentially boost their own products' search rankings over the third-party competitors'. We analyze how search neutrality affects consumer search and the competition between a platform (first-party seller) and a third-party seller. Importantly, we find that with personalized search rankings on the platform, search neutrality will generally weaken sellers' price competition and may possibly deter third-party seller entry. Against its good intention, search neutrality may hurt consumers and third-party sellers.

2 Selling Vs Subscription for Information Goods Under Valuation Uncertainty

Duc Vu, The University of Texas at Dallas, Richardson, TX

The media market is growing fast and playing important role in the global economy. When a new product is released, the publisher needs to consider whether to sell this product separately or to include the product in a subscription service. In addition, customers have some valuation uncertainties about the value of this new product. We derive the optimal strategy and provide managerial insights for the publisher.

3 Cancellation Policy on Rental Sharing Platforms

Xing Hu[1], Lifei Sheng[2], Zhixi Wan[3], Hao Zhang[4], Xuying Zhao[5], [1]University of Hong Kong, Hong Kong, China; [2]University of Houston Clear Lake, Houston, TX, [3]University of Hong Kong, Hong Kong, Hong Kong; [4]University of British Columbia, Vancouver, BC, Canada; [5]University of Notre Dame, Notre Dame, IN, Contact: sheng@uhcl.edu

We study the cancellation policies on C2C platforms such as Airbnb. Three parties are considered: the platform, hosts, and consumers. Two representative policies are considered: a strict cancellation policy (full refund only if guests cancel their bookings certain days before check-in) and a flexible cancellation policy (full refund as long as guests cancel their bookings before check-in). We identify the market conditions where hosts and the platform have misaligned preferences on cancellation policies. In addition, we find that a strict cancellation policy can generate even higher social welfare than a flexible cancellation policy under certain market conditions.

4 Does Everyone Do What I Think They Do? a Behavioral Investigation of Fulfilled Expectations in Network Product Adoption

Yifan Dou[1], Ang Gao[2], Yinghao Zhang[3], Yuanyuan Zhou[4], [1]Fudan University, Shanghai, China; [2]Beijing Institute of Technology, Beijing, China; [3]University of Cincinnati, Cincinnati, OH, [4]Beijing Foreign Studies University, Beijing, China. Contact: yfdou@fudan.edu.cn

The fulfilled expectation equilibrium (FEE) is the standard approach in literature for characterizing customer expectations under network effects. It assumes that all potential customers, given substantial information, will be fully rational to form a homogeneous expectation, which is self-fulfilling when the network reaches the equilibrium. By relaxing these assumptions, this paper offers a fresh, behavioral perspective on the way customers form their expectations about the network size. We first develop a behavioral model that incorporates two well-established behavioral phenomena---the cognitive hierarchy (CH) and the anchoring-and-adjustment heuristic. We then verify

these findings with a laboratory experiment and calibrate the magnitude of the behavioral tendencies through structural model estimations.

Monday, 5 PM–6:15 PM

ME32

CC - Room 143

Emerging Issues in Nonprofit and Public Sector Operations

General Session

Session Chair

Can Zhang, Duke University, Durham, NC

1 Unmasking Human Trafficking Risk in Commercial Sex Supply Chains with Machine Learning

Pia Ramchandani[1], Hamsa Sridhar Bastani[1], Emily Wyatt[2], [1]Wharton School, Philadelphia, PA, [2]Tellfinder Alliance, Toronto, ON, Canada.

The covert nature of sex trafficking provides a significant barrier to generating large-scale, data-driven insights to inform law enforcement, policy and social work. We leverage massive deep web data (collected from leading commercial sex websites) in tandem with a novel machine learning framework to unmask suspicious recruitment-to-sales pathways, thereby providing a global network view of trafficking risk in commercial sex supply chains. This allows us to infer likely recruitment-to-sales trafficking routes of criminal entities, deceptive approaches used to recruit victims, and regional variations in recruitment vs. sales pressure. These insights can help law enforcement better coordinate efforts, and target local interventions.

2 Group-level Fairness in Dynamic Refugee Matching

Daniel Freund[1], Thodoris Lykouris[2], Elisabeth Paulson[3], Bradley Sturt[4], Wentao Weng[5], [1]MIT, Charlestown, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]HBS, Cambridge, MA, [4]University of Illinois at Chicago, Chicago, IL, [5]MIT, Cambridge, MA

This study develops a new algorithm that dynamically assigns refugees and asylum seekers to localities within a host country with the goal of maximizing a chosen outcome (e.g., employment) subject to group-level fairness constraints. For example, the groups could be defined by religion, country of origin, or other covariates. The group-level fairness constraint seeks to ensure that each group's average outcome is at least as large as it would have been under a "random allocation benchmark." We prove that the proposed online algorithm is able meet this fairness constraint with high probability in many settings, while achieving a high probability regret bound on the overall efficiency of the algorithm. The performance of the algorithm is demonstrated on real refugee resettlement data from one of the largest resettlement organizations in the US.

3 Audit and Remediation Strategies in The Presence of Evasion

Shouqiang Wang[1], Francis de Vericourt[2], Peng Sun[3], [1]The University of Texas at Dallas, Richardson, TX, [2]ESMT, Berlin, Germany; [3]Duke University, Durham, NC, Contact: shouqiang.wang@utdallas.edu

Using a dynamic mechanism design framework, we study how to uncover an adverse issue that may occur at a random point in time in organizations with the capability to evade detection. We reformulate the problem as the optimal stochastic control of a piecewise deterministic Markov process. As a key finding, the optimal policy is a dynamic cyclic auditing and remedial cost-sharing mechanism, which we characterize in closed form. Importantly, we find that the principle should randomly audit the agent when the evasion capability is highly effective, but resort to pre-determined audit schedules otherwise. Our numerical study further reveals that the total audit costs can in fact decrease in the effectiveness of the evasion capability.

4 Two-sided Subsidies for Electric Vehicles: The Impact of Operational Considerations

Saed Alizamir[1], Michael Blair[1], Troy Tang[2], [1]Yale University, New Haven, CT, [2]Xi'an Jiaotong University, Shaanxi, China.

Electric Vehicles (EVs) are touted as the future of urban transportation and a solution to climate change.We analyze a government's problem of designing subsidy policies for EVs and investigate the benefits of implementing a hybrid policy. Our model captures the complementarity between EVs and charging stations, which creates a positive network effect, as well as the competition between investors. We characterize the optimal subsidy mechanism for both sides of the market and specify conditions under which incentivizing only EV-buyers is suboptimal. We examine the impact of different technology and market characteristics on the government's policy in the presence of operational considerations. government's policy.

Monday, 5 PM–6:15 PM

ME33

CC - Room 144

Optimization and Learning in Mathematical Finance

General Session

Session Chair

Zhengyuan Zhou, Stern School of Business, New York University, New York, NY

Session Chair

Wenpin Tang, Columbia University

1 **Data Driven Continuous-Time Markowitz Strategies**

Yilie Huang, Xunyu Zhou, Yanwei Jia, Columbia University, New York, NY, Contact: yh2971@columbia.edu

We propose an efficient implementation of the continuous-time actor-critic reinforcement learning algorithms in a dynamic Markowitz strategy setting, and compare it with widely used strategies, including the 1/N strategy and many variants to the static mean-variance models. To make it more stable and practical, we adopt an offline pre-training stage, use off-policy learning for online decision making, and incorporate constraints in terms of leverage and rebalancing frequency. Using S&P 500 data from 2000 to 2019, we show that our online algorithm with the modifications outperforms the others, in terms of criteria such as Sharpe ratio, for various periods under consideration, including the period of financial crisis. In addition, the gross returns of the unconstrained portfolios can reach the pre-specified target returns and remain competitive under all criteria.

2 **Presenter**

Jianbo Chen, Citadel Securities

We will address challenges we face in the application of machine learning to problems in quantitafive finance, including insufficient data, interpretability and robustness. We compare such problems to well-studied problems in other areas and discuss potential solutions inspired by them.

3 **Presenter**

Ni Ma, Bloomberg, NY

4 **"i Just like The Stock": The Role of Reddit Sentiment in Gamestop**

Suwan Cheng Long[1,2], Brian Lucey[1], Larisa Yarovaya[3], Ying Xie[4], [1]Trinity College Dublin, Dublin, Ireland; [2]University of Cambridge, Cambridge, United Kingdom; [3]University of Southampton, Southampton, United Kingdom; [4]Anglia Ruskin University, Cambridge, United Kingdom. Contact: sapienssuwan@gmail.com

This paper investigates the role, if any, played by the social media platform Reddit in the events around the GameStop(GME) share rally in early 2021. In particular, we analyse the impact of discussions on the r/WallStreetBets subreddit on the price dynamics of the American online retailer GameStop. We customise a sentiment analysis dictionary for Reddit platform users based on the VADER sentiment analysis package and perform textual analysis on 10.8 million comments. The analysis of the relationships between Reddit sentiments and 1-minute, 5-minute, 10-minute, and 30-minute GameStop returns to contribute to the growing body of literature on 'meme stocks' and the role of the discussions on investment forums on intraday stock price movements

Monday, 5 PM–6:15 PM

ME34

CC - Room 145

Sustainable Supply Chains

Contributed Session

Session Chair

Hannan Sadjady Naeeni, Longwood University, Farmville, VA

1 **Enterprise Scope 1 and Scope 2 Emission Estimation Using Crowd Source Data**

Manikandan Padmanaban[1], Ayush Jain[2], Jagabondhu Hazra[1], Kommy Weldemariam[3], [1]IBM Research, Bangalore, India; [2]IBM Research, Delhi, India; [3]IBM Research, Nairobi, Kenya. Contact: manipadm@in.ibm.com

Globally, GHG emissions have grown by 50% from 1990 to 2018. Even though Enterprises are under significant pressure from investors, consumers, and policymakers to disclose their GHG emissions, only 20% of publicly listed U.S. companies voluntarily disclose emissions data as of now. The major challenge in reporting enterprise emission lies in process/asset level data collection overhead from multiple business units across multiple geographies. To address this challenge, we proposed a Natural language processing (NLP) based framework to estimate Scope1 (S1) and Scope2 (S2) emissions of an Enterprise by learning an emission model from publicly disclosed S1, S2 emissions, and other contextual data such as Environmental, Social and Governance reports. This AI based tool will help small and medium enterprises to estimate their S1 and S2 emissions without any primary data.

3 Optimal Ordering Policy for Storage and Delivery of Forest Residues and Willow Biomass for Continuous Industrial Supply

Md Abu Helal[1,2], Nathaniel M. Anderson[3], Yu Wei[1], Matthew Thompson[4], [1]Colorado State University, Fort Collins, CO, [2]United States Department of Agriculture, Fort Collins, CO, [3]U.S. Forest Service, Missoula, MT, [4]U.S. Forest Service, Fort Collins, CO, Contact: abu.helal@colostate.edu

The development of biomass energy projects and other bio-based businesses depends on effective and efficient biomass logistics and supply from forestry and agricultural operations. Improved inventory management practices can contribute to increased competitive advantage and improved organizational performance in every industrial sector. Despite the potential direct and favorable influence of optimized inventory management on biomass supply chain efficiency, inventory management methods are often disregarded in the literature in this area. In this study we proposed an optimal inventory ordering policy for sustainable biomass supply chain management in the Mid-Atlantic region of the United States in order to improve biomass logistics to meet demand at the lowest possible cost and reduce risk to investment.

4 Corporate Social Responsibility and Consumer Reaction to Different Product Types

Hannan Sadjady Naeeni, Hua (Meg) Meng, Longwood University, Farmville, VA, Contact: naeenihs@longwood.edu

We investigate the impact of corporate social responsibility (CSR) on consumer's purchase intention of different product types, i.e. service vs. good. In line with the existing literature, our findings suggest that the low CSR of a business negatively affects consumer's purchase intention. However, our studies show that such negative impact is more intense when the business is a service provider, as compared to when it is a good manufacturer. This is because when consumers imagine a service setting, as compared to a good manufacturing site, they experience a lower level of psychological distance (i.e., feel more present at the service environment), and a subsequent higher level of emotional intensity (e.g. more upset, sorrowful, etc.), resulting in a lower purchase intention.

Monday, 5 PM–6:15 PM

ME35

CC - Sagamore 1

Networks in Health Care

General Session

Session Chair

Md Morshedul Alam, University of Louisville, Louisville, KY

1 Algorithms Using Local Graph Features to Predict Epidemics

Yeganeh Alimohammadi[1], Christian Borgs[2], Amin Saberi[3], [1]Stanford University, Stanford, CA, [2]UC Berkeley, Berkeley, CA, [3]Stanford University, San Francisco, CA, Contact: yeganeh@stanford.edu

We study a simple model of epidemics: each node infects its neighbors independently with probability p. The size of an outbreak in this model is studied for configuration model and preferential attachment. However, these models only consider locally tree-like graphs.

Here, we ask a different question: what information is needed for general networks to predict the size of an outbreak? Is it possible to make predictions by accessing small subgraphs? We answer the question in the affirmative for large-set expanders with Benjamini-Schramm limits. We show that there is an algorithm that gives a (1–[illegible]) approximation of the probability and the size of an outbreak by sampling a constant-size neighborhood of a constant number of nodes chosen uniformly at random. We also present corollaries for the preferential attachment and study generalizations with household structure.

2 Performance Analysis of a Blood Bank Merger in The Covid-19 Pandemic

Amir H. Masoumi[1], Min Yu[2], Jan Hoffmann[3], Dong "Michelle" Li[4], [1]Manhattan College, New York, NY, [2]University of Portland, Portland, OR, [3]Universität Siegen, North Rhine-Westphalia, Germany; [4]Babson College, Babson Park, MA, Contact: amir.masoumi@manhattan.edu

In this research we analyze a successfully completed real-world case of merger between two blood banks in California in 2015. As part of the merger analysis, we present a supply chain network optimization model which can capture capacity overflows and outsourcing options. We then consider multiple supply/demand scenarios corresponding to pre-COVID conditions, early weeks of the pandemic, as well as a return to normal scenario, utilizing our developed framework to compare the performance measures of the merged organization with those of the two individual blood banks in the pre-merger problem. Our results suggest that adjacent blood banks can notably benefit from a merger during these unprecedented times, both in terms of operational cost savings and stability of blood supplies.

3 Multimorbidities Network Analysis for Neurodegenerative Diseases

Mostafa Amini[1], Ali Bagheri[2], Dursun Delen[3], [1]Oklahoma State University, Oklahoma city, OK, [2]Oklahoma State University, Stillwater, OK, [3]Oklahoma State University, Tulsa, OK, Contact: moamini@okstate.edu

Millions of people suffer from neurodegenerative diseases (NDDs) with Alzheimer's alone being the sixth leading cause of death in the US. We study the multimorbidities (i.e., co-occurring diseases) network of NDDs to enhance descriptive and predictive models. Multimorbidities co-occur independently or from a common biological, social, or environmental antecedent. We use the Cerner data warehouse to study over 25 million encounters of more than 800 thousand patients diagnosed with NDDs. We transform the data into two networks, where the nodes are the diseases, and the edges show the existence of a patient diagnosed with both disorders. We build one network based on the data before a patient is diagnosed with NDDs (pre-d) and one on the post-diagnosis data (post-d). The analysis of the pre-d network indicates the onset of NDDs, whereas the post-d infers future comorbidities.

4 An Optimization Approach to Evaluate Accessibility of Community Pharmacy with Social Determinants of Health

Md Morshedul Alam, Lihui Bai, Sara Abedi, University of Louisville, Louisville, KY

Pharmacies are most accessible and trusted partner of U.S. healthcare systems and patients routinely encounter at their community pharmacy. A risk-adjusted optimization model is developed to measure the accessibility for community pharmacies by considering factors regarding patients, pharmacies and community builds. Pharmacy desert - a community with limited access to pharmacy is identified. Social determinant of health is analyzed for desert and non-desert area, so that the policy maker can better plan their limited resources to improve public health.

Monday, 5 PM–6:15 PM

ME36

CC - Sagamore 2

Disaster OM

General Session

Session Chair

Christopher W. Zobel, Virginia Tech, Blacksburg, VA

Session Chair

Andrew N. Arnette, University of Wyoming, Laramie, WY

1 On The Effects of a Global Pandemic on The Population's Stockpiling: An Empirical Study from Germany

Markus Lüttenberg[1], Miriam Klein[1], Florian Diehlmann[1], Marcus Wiens[2], Frank Schultmann[3], [1]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany; [2]Technical University Bergakademie Freiberg, Freiberg, Germany; [3]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany. Contact: markus.luettenberg@kit.edu

Public authorities recommend that the population stockpiles food, drinking water, and medicines on its responsibility in order to be prepared for a supply failure. As a scientifically sound database is indispensable for disaster planning, we surveyed the populations' stockpiling behaviour based on recommendations of the Federal Office for Civil Protection and Disaster Assistance (BBK). The first survey round with 330 participants took place before the COVID-19 pandemic in early 2020. We conducted a second round in summer 2021 with 402 participants to measure the effects of a pandemic. Among others, we find that respondents do not stockpile sufficiently and that COVID-19 has only shown short-term effects in stockpiling behaviour. The quantitative data obtained is valid for decision-makers in public authorities for the initiation and control of appropriate measures.

2 Wildfire Response Operations: Operational Information Management for Disaster Response

Patricia L. Moravec[1], Lu (Lucy) Yan[2], Alfonso J. Pedraza-Martinez[2], Sebastian Villa Betancur[3], [1]Indiana University, Bloomington, IN, [2]Indiana University, Bloomington, IN, [3]University of New Mexico, Albuquerque, NM

There has been an increase in severity and spread of wildfires, suggesting a need for strategies to enable appropriate response by victims. We examine whether operational transparency on social media could help reduce public fear through two studies. Through an exploratory study on wildfires in California, we find that increased operational transparency negatively influences fear, such that fear decreases when information is posted by the premier authority on wildfire fighting. Second, results from an online experiment suggest that highlighting expertise in social media posts reduces fear and increases user intention to heed warnings from this authority.
This intervention requires little or no additional cost to organizations, making it a feasible solution for agencies that face budget shortages while they struggle to fight the consequences of climate change.

3 **Workforce Management in Charity Setting**
Chao Wu[1], Mahyar Eftekhar[2], Joline Uichanco[3], [1]Arizona State University, Phoenix, AZ, [2]Arizona State University, Tempe, AZ, [3]University of Michigan, Ross School of Business, Ann Arbor, MI
We study the problem of workforce management in a charity setting and develop an optimization model to enhance the volunteer management policy. In particular, our model incorporates the heterogeneity of volunteers, balances understaffing and overstaffing costs, and explicitly connects individuals' time and monetary donations.

4 **Two-stage Stochastic Program for Multi-period Environmental Displacement Planning Under Demand Uncertainty**
Buket Cilali[1], Kash Barker[2], Andres David Gonzalez[2], [1]University of Oklahoma, Norman, OK, [2]University of Oklahoma, Norman, OK, Contact: buket.cilali@ou.edu
Forced displacement is a global problem that requires planning for the relocation and integration of displaced people. Most studies focus on short-term planning assuming that demand within the fixed time interval is known. However, forced displacement is an ongoing and long-term process with dynamic parameters. We are interested in the long-term displacement problem, especially for climate-driven cases in which people will be forced to leave uninhabitable regions to escape slow-onset climate change impacts such as water stress, crop failure, and sea-level rise. To reflect the long-term planning requirements of the climate-driven displacement problem, we present a two-stage stochastic program where demand uncertainty is represented with scenarios, capacity is managed dynamically, and integration outcomes and related costs are optimized.

Monday, 5 PM–6:15 PM

ME37

CC - Sagamore 6

Recent Studies in Robust, Distributionally Robust and Data-driven Optimization

General Session

Session Chair

Chennan Zhou, Ohio State University, Columbus, OH

Session Chair

Guzin Bayraksan, The Ohio State University, Columbus, OH

1 **On Novel Primal and Dual Bounding Techniques for Multistage Adaptive Robust Optimization**
Maryam Daryalal[1], Ayse Nur Arslan[2], Merve Bodur[3], [1]HEC Montreal, Ottawa, ON, Canada; [2]IRMAR, INSA de Rennes, Rennes, France; [3]University of Toronto, Toronto, ON, Canada. Contact: bodur@mie.utoronto.ca
We adapt some recent decision rules, such as two-stage linear and Lagrangian dual decision rules, introduced in the stochastic programming literature to robust optimization both from the primal and the dual perspective. The resulting problems are challenging and require advanced techniques for their solution which we present. We The illustrate potential benefits of our methodologies with results on production planning and transportation problems.

2 **Effective Scenarios in Two-stage Dro: Properties and Acceleration of Decomposition Algorithms**
Chennan Zhou, Ohio State University, Columbus, OH
Effective scenarios are critical to Distributionally Robust Optimization (DRO) in the sense that, if removed, the optimal value will be changed. Earlier, effective scenarios were examined for convex DRO with Total Variation distance. In this work, we study them for a class of DRO with Wasserstein distance and phi-divergences. We present several properties and discuss how they can be used to accelerate Benders' decomposition algorithms to solve this class of problems.

3 **An Adaptive Subsampled Hessian-free Optimization Method for Statistical Learning**
Fabian Bastin, Jérémy Rieussec, Jean Laprés-Chartrand, Université de Montréal, Montréal, QC, Canada. Contact: bastin@iro.umontreal.ca
We consider nonconvex statistical learning problems and propose a variable sample-path method, where the sample size is dynamically updated to ensure a decrease in the true objective function with high probability. We integrate this strategy in a subsampled Hessian-free trust-region method with truncated conjugate gradient, relying on outer product approximations. The approach is compared to various adaptive sample approximation algorithms and stochastic approximation methods proposed in stochastic optimization and machine learning. The efficiency of the approach is illustrated on various large size datasets and different regression models.

4 **Distributed Optimization with Differential Privacy**
Kibaek Kim, Argonne National Laboratory, Lemont, IL

We present a collection of our recent work in distributed optimization and learning with data privacy concern. Examples include distributed control of power systems and federated learning on distributed private data such as biomedical datasets. We develop Lagrangian-based algorithms for the distributed optimization problems. In order to achieve the data privacy, we apply differential privacy techniques that systematically add random noise to the distributed algorithms. We show the convergence of the algorithms with the probabilistic guarantee of data privacy. We also demonstrate the numerical experiments for the applications of interest.

Monday, 5 PM–6:15 PM

ME38

CC - Sagamore 7

Decision-making under Endogenous Uncertainty

General Session

Session Chair

Phebe Vayanos, University of Southern California, Los Angeles, CA

Session Chair

Qing Jin, USC University of Southern California, LA, CA

1 A Preliminary Study on Converting a Decision-Independent Uncertainty Set to a Decision-Dependent One in Robust Optimization

Bo Zeng[1], Tarik Bilgic[1], Wei Wang[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, Contact: bzeng@pitt.edu

In this talk, we present results of an initial investigation on converting a decision-independent uncertainty set to a decision-dependent one in robust optimization. Our study involves both the methodological part to achieve this conversion and the numerical part showing the computational benefits from this conversion.

2 Classes of Predictive Stochastic Programming (PSP) Models

Suvrajeet Sen, Shuotao (Sonny) Diao, University of Southern California, Los Angeles, CA, Contact: suvrajes@usc.edu

Predictive Stochastic Programming (PSP) refers to a class of Stochastic Programs (SP) in which data is available in the form of correlated tuples of Predictor (Independent) Variables, and Response (Dependent) Variables. Such SP models have the potential to integrate both data and decision sciences via one composite model. We will cover three alternative model types within PSP: LEO (Learning Enabled Optimization), CLEO (Coupled LEO) and LEON (Learning Enabled Optimization with Non-Parametric) models. The last two should be looked upon as being decision-dependent SP models. The computational challenges of these models arise from non-convexity, as well as streaming data and online applications with strict time barriers for decision-making. These models lead to the possibility of a common mathematical setting to study the interplay between Big Data and Big Decisions.

3 Distributionally Robust Optimization with Decision-dependent Information Discovery

Qing Jin[1], Angelos Georghiou[2], Phebe Vayanos[3], Grani Adiwena Hanasusanto[4], [1]USC University of Southern California, LA, CA, [2]University of Cyprus, Nicosia, Cyprus; [3]University of Southern California, Los Angeles, CA, [4]The University of Texas at Austin, Austin, TX, Contact: qingjin@usc.edu

We study a two-stage distributionally robust optimization problem with decision-dependent information discovery (DRO-DDID), where the revelation of the uncertain parameters is not free and depends on the decision maker's actions. We propose a novel framework of DRO-DDID and adopt the popular K-adaptability scheme, which chooses K candidate policies here and now and implements the best policy after the selected uncertain parameters have been observed. We then present a decomposition algorithm that solves the K-adaptable formulation exactly. Finally, we showcase the effectiveness of our model framework and algorithm on the R&D project portfolio optimization problem and the best box problem.

Monday, 5 PM–6:15 PM

ME39

CC - Room 201

Optimization Methods for Statistical Learning

General Session

Session Chair

Yuxin Chen, University of Pennsylvania, Princeton, NJ

Session Chair

Yuling Yan, Princeton University, Princeton, NJ

1 Best (worst-case) Linear Predictors Using The Projected Robust Wasserstein Metric

Cynthia Rush, Columbia University, New York, NY, Contact: cgr2130@columbia.edu

In learning, one often models data with latent variables and estimates with empirical risk minimization (ERM). We study distributionally robust optimization (DRO), an alternative to ERM, for learning when latent variables are estimated by linear projections of covariates. DRO is a minimax framework that can robustify against, e.g., covariate shifts or adversarial attacks. We provide data-dependent generalization bounds using the projected robust Wasserstein (PRW) metric (Paty & Cuturi '19) within the DRO framework. The PRW metric exploits the one-dimensional projections, meaning our bounds do not suffer from the curse of dimensionality, as do known bounds using standard Wasserstein and DRO. Hence, we provide efficient procedures with rigorous robustness guarantees and similar convergence rates as non-robust methods. Joint with J. Montiel, J. Wiesel, & A. Velez.

2 Leave-one-out Singular Subspace Perturbation Analysis for Spectral Clustering

Anderson Ye Zhang, University of Pennsylvania, Philadelphia, PA, Contact: ayz@wharton.upenn.edu

The singular subspaces perturbation theory is of fundamental importance in probability and statistics. It has various applications across different fields. We consider two arbitrary matrices where one is a leave-one-column-out submatrix of the other one and establish a novel perturbation upper bound for the distance between two corresponding singular subspaces. It is well-suited for mixture models and results in a sharper and finer statistical analysis than classical perturbation bounds such as Wedin's Theorem. Powered by this leave-one-out perturbation theory, we provide a deterministic entrywise analysis for the performance of the spectral clustering under mixture models. Our analysis leads to an explicit exponential error rate for the clustering of sub-Gaussian mixture models.

3 Inference for Heteroskedastic PCa with Missing Data

Yuling Yan, Princeton University, Princeton, NJ, Contact: yulingy@princeton.edu

This talk studies how to construct confidence regions for principal component analysis in high dimension. While computing measures of uncertainty for nonlinear/nonconvex estimators is in general difficult in high dimension, the challenge is further compounded by the prevalent presence of missing data and heteroskedastic noise. We propose a novel approach to performing valid inference on the principal subspace, on the basis of an estimator called HeteroPCA (Zhang et al., 2018). We develop non-asymptotic distributional guarantees for HeteroPCA, and demonstrate how these can be invoked to compute both confidence regions for the principal subspace and entrywise confidence intervals for the spiked covariance matrix. Our inference procedures are fully data-driven and adaptive to heteroskedastic random noise, without requiring prior knowledge about the noise levels.

4 Robust Learning Overparameterized Models Without Overfitting

Qing Qu, 1</sup

Overparameterization has been shown to be beneficial to the dominating performance of many machine learning tasks. However, overparameterization can lead to overfitting, especially when corruption presents. In this talk, I introduce an effective method for dealing with overfitting: double overparameterization. As illustrative examples, we will introduce the ideas on robust recovery of low-rank matrices from linear measurements, with no prior knowledge on the intrinsic rank. Moreover, empirically we show that the proposed approaches can also effectively learn robust deep image prior (DIP), that we can robustly recover natural images by over-parameterizing images with deep networks without overfitting. Finally, I will discuss the generality of these methods for dealing with label noise in classification problems.

Monday, 5 PM–6:15 PM

ME40

CC - Room 202

Algebraic Methods in Semidefinite and Polynomial Optimization

General Session

Session Chair

Ali Mohammad Nezhad, Carnegie Mellon University, Pittsburgh, PA

1 Locating The Closest Singularity in a Polynomial Homotopy

Kylash Viswanathan, University of Illinois at Chicago, IL

A polynomial homotopy is a family of polynomial systems, where the systems in the family depend on one parameter. If for one parameter we know a regular solution, then what is the nearest value of the parameter for which the solution in the polynomial homotopy is singular? Applying the ratio theorem of Fabry on the solution paths defined by the homotopy, extrapolation methods can accurately locate the nearest singularity. Once the radius of convergence is known, then via a transformation of the continuation parameter, the series expansions of the solution curves will have convergence radius equal to one. To compute all coefficients of the series we propose the quaternion Fourier transform.

2 Applications of Real Algebraic Geometry in Optimization

Saugata Basu[1], Ali Mohammad Nezhad[2], [1]Purdue University, IN, [2]Lehigh University, Bethlehem, PA

In this talk I will explain how quantitative results from real algebraic geometry lead to interesting bounds in optimization, for example on the degree of the central path in semi-definite programming.

3 Fewnomial Optimization and The Number of Connected Components

Weixun Deng, Texas A&M University, College Station, TX

Let f be an n-variate real polynomial of degree d with exactly n+k monomial terms. We give a new upper bound for the number of connected components of the positive zero set of f, which is polynomial in n for fixed k. Furthermore, our bound is linear in n if k=3. Such bounds are useful for optimization, since they determine the complexity of the underlying level set and thus the number of possible local extrema. In this way, we derive an efficient algorithm for optimizing certain fewnomials. This is joint work with Jens Forsgard, Mounir Nisse, and J. Maurice Rojas.

4 Cubic Polynomials and Semidefinite Programming

Jeffrey Zhang, Carnegie Mellon University, Pittsburgh, PA

In this work we explore the connection between cubic polynomials and semidefinite programming, and use this connection to develop algorithms for optimization. Every spectrahedron can be expressed as the local minima of a cubic polynomial with a particular structure, so algorithms that find local minima of these polynomials can be used to solve semidefinite feasibility problems. We present algorithms that use this connection, as well as draw relationships and connections between these algorithms and existing algorithms.

Monday, 5 PM–6:15 PM

ME41

CC - Room 203

Recent Advances in Continuous Optimization

General Session

Session Chair

Cesar A. A. Uribe, Rice University, Houston, TX

Session Chair

Mateo Diaz, CalTech, Pasadena, CA

1 Asynchronous Parallelized Nonconvex Gradient Descent with Locally Chosen Stepsizes

Matthew Ubl, Matthew Hale, University of Florida, Gainesville, FL, Contact: matthewhale@ufl.edu

Distributed nonconvex optimization problems underlie many applications in learning and autonomy, and such problems commonly face asynchrony in agents' computations and communications. In this talk, I will present an uncoordinated stepsize selection rule for partially asynchronous gradient descent that leads to faster convergence for a class of nonconvex problems than existing stepsize rules. This stepsize rule requires less information to be available to each agent than existing approaches, typically allows for agents to use much larger
stepsizes, and alleviates the impact of stragglers while still guaranteeing convergence to a stationary point. I will also present simulation results that provide comparisons and illustrate the faster convergence attained by the stepsize rule we develop.

2 Trajectory of Batch Momentum: Batch Size Saturation and Convergence in High-dimensions

Kiwon Lee, Andrew Cheng, Elliot Paquette, Courtney Paquette, McGill University, Montreal, QC, Canada. Contact: andrew.cheng@mail.mcgill.ca

We analyze the dynamics of large batch stochastic gradient descent with momentum (SGD+M) on the least squares problem when both the number of samples and dimensions are large. In this setting, we show that the dynamics of SGD+M converge to a deterministic discrete Volterra equation as dimension increases. We identify a stability measurement, the implicit conditioning ratio (ICR), which regulates the ability of SGD+M to accelerate the algorithm. When the batch size exceeds this ICR, SGD+M converges linearly at a rate of $\mathcal{O}(1/\sqrt{\kappa})$, matching optimal full-batch momentum. For batch sizes smaller than the ICR, in contrast, SGD+M has rates comparable to single batch SGD (measured in epochs). We give explicit choices for the learning rate and momentum parameter in terms of the Hessian spectra that achieve this performance.

3 **Nearly Optimal Linear Convergence of Stochastic Primal-dual Methods for Linear Programming**

Jinwen Yang, The University of Chicago, Chicago, IL

There is a recent interest on first-order methods for linear programming (LP). In this paper,we propose a stochastic algorithm using variance reduction and restarts for solving sharp primal-dual problems such as LP. We show that the proposed stochastic method exhibits a linear convergence rate for solving sharp instances with a high probability. In addition, we propose an efficient coordinate-based stochastic oracle for unconstrained bilinear problems, which has $\mathcal O(1)$ per iteration cost and improves the complexity of the existing deterministic and stochastic algorithms. Finally, we show that the obtained linear convergence rate is nearly optimal (upto $\log$ terms) for a wide class of stochastic primal dual methods.

Monday, 5 PM–6:15 PM

ME42

CC - Room 204

Optimization Under Uncertainty

Contributed Session

Session Chair

Bing Zhang, IBM, San Jose, CA

1 **Wasserstein Barycentric Distributionally Robust Optimization and Its Entropic-Regularized Variants**

Tim Tsz-Kit Lau[1], Han Liu[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: timlautk@u.northwestern.edu

In many applications in statistics and machine learning, the availability of data samples from multiple possibly heterogeneous sources has become increasingly prevalent. On the other hand, in distributionally robust optimization, we seek data-driven decisions which perform well under the most adverse distribution from a nominal distribution constructed from data samples within a certain discrepancy of probability distributions. However, it remains unclear how to achieve such distributional robustness in model learning and estimation when data samples from multiple sources are available. In this work, we propose constructing the nominal distribution in optimal transport-based distributionally robust optimization problems through the notion of Wasserstein barycenter as an aggregation of data samples from multiple sources. Under specific choices of the loss function, the proposed formulation admits a tractable reformulation as a finite convex program, with powerful finite-sample and asymptotic guarantees. As an illustrative example, we demonstrate with the problem of distributionally robust sparse inverse covariance matrix estimation for zero-mean Gaussian random vectors that our proposed scheme outperforms other widely used estimators in both the low- and high-dimensional regimes.

2 **Unique Sparse Decomposition of Low Rank Matrices**

Dian JIN[1], Xin Bing[2], Yuqian Zhang[1], [1]Rutgers, Piscataway, NJ, [2]Cornell, Ithaca, NY, Contact: dj370@soe.rutgers.edu

The problem of finding the unique low dimensional decomposition of a given matrix has been a fundamental and recurrent problem in many areas. In this paper, we study the problem of seeking a unique decomposition of a low-rank matrix Y that admits a sparse representation. Specifically, we consider Y=AX where the matrix $A\in \R^{p\times r}$ has full column rank, with $r < \min\{n,p\}$, and the matrix $X\in \R^{r\times n}$ is element-wise sparse. We prove that this low rank, sparse decomposition of Y can be uniquely identified, up to some intrinsic signed permutation. Our geometric analysis for its nonconvex optimization landscape shows that any strict local solution is close to the ground truth, and can be recovered by a simple data-driven initialization followed with any second-order descent algorithm. Our theoretical findings are corroborated by numerical experiments.

3 **A Generalized Moment Approach to Sharp Bounds for Conditional Expectations**

Wouter van Eekelen, Tilburg University, Tilburg, Netherlands. Contact: w.j.e.c.vaneekelen@tilburguniversity.edu

In this paper, we consider the problem of bounding conditional expectations given information on the moments of the underlying distribution and the observed random event. We introduce an adapted version of the generalized moment problem, which deals with this conditional information through a simple transformation, and obtain sharp bounds through conic duality. In addition, we derive tractable conic programs for distributionally robust optimization (DRO) with side information by leveraging recent results from ambiguity-averse uncertainty quantification, thereby establishing a moment-based DRO framework for prescriptive stochastic programming.

4 **End-to-end Simultaneous Prediction and Optimization Framework**

Bing Zhang[1], Yuya Ong[2], [1]IBM, San Jose, CA, [2]IBM

Research - Almaden, San Jose, CA
Many predictive machine learning (ML) models are integrated within the context of a larger system as part of a key component for decision making processes. Concretely, the models are built first, then the model outputs are used to generate decision values separately. However, it is often the case that the prediction values that are trained independently of the optimization process produce sub-optimal solutions. In this paper, we propose a formulation for the Simultaneous Prediction and Optimization (SimPO) framework. This framework introduces the use of a joint weighted loss of a decision-driven predictive ML model and an optimization objective function, which is optimized end-to-end directly through gradient-based methods.

Monday, 5 PM–6:15 PM

ME43

CC - Room 205

Learning-assisted Dynamic Decision-making Under Uncertainty

General Session

Session Chair

Rohit Kannan, Los Alamos National Laboratory, Los Alamos, NM

1 Information-directed Policy Sampling for Episodic Bayesian Markov Decision Processes

Victoria Diaz, Archis Ghate, University of Washington, Seattle, WA, Contact: vdiaz@uw.edu

We will present a class of provably efficient information theoretic methods to approximately solve Markov decision processes (MDPs) and hierarchical MDPs under incomplete information. We will consider an episodic Bayesian framework, where the decision-maker sequentially interacts with a stochastic system over T episodes. The true parameters describing the system belong to a particular finite set. The decision-maker begins with a prior probabilistic belief about the true parameters and updates this belief after each episode. The decision-maker aims to maximize the expected total reward earned over all episodes. We will present regret bounds and computational results for this setting.

2 A Data-Driven Approach for a Class of Stochastic Dynamic Optimization Problems

Davi Valladão[1], Thuener Silva[2], Tito Homem-de-Mello[3], [1]PUC-Rio, Rio de Janeiro, Brazil; [2]PUC-Rio LAMPS, Rio de Janeiro, Brazil; [3]Universidad Adolfo Ibañez, Santiago, Chile. Contact: davimv@puc-rio.br

We propose a data-driven prescriptive analytics framework aiming to integrate the machine learning and dynamic optimization machinery in a consistent and efficient way to build a bridge from data to decisions. The proposed framework tackles a relevant class of dynamic decision problems comprising many important practical applications. The basic building blocks of our proposed framework are: (1) a Hidden Markov Model as a predictive (machine learning) method to represent uncertainty; and (2) a distributionally robust dynamic optimization model as a prescriptive method that takes into account estimation errors associated with the predictive model and allows for control of the risk associated with decisions. A complete case study on dynamic asset allocation illustrates the proposed framework showing superior out-of-sample performance against selected benchmarks.

3 Robust Data-Driven Stochastic Dual Dynamic Programming

Hyuk Park[1], Grani Adiwena Hanasusanto[2], Zhuangzhuang Jia[3], [1]The University of Texas at Austin, Astin, TX, [2]The University of Texas at Austin, Austin, TX, [3]University of Texas at Austin, Austin, TX, Contact: hyuk.park@utexas.edu

In this talk, we study sequential decision-making under uncertainty in which the underlying stochastic process is Markovian. We develop a data-driven Stochastic Dual Dynamic Programming (SDDP) algorithm that solely utilizes the historical sample trajectories in the procedure. Unfortunately, the data-driven algorithm exhibits a high optimistic bias yielding overfitted decisions and poor out-of-sample performances. We apply the recent distributionally robust optimization methodology over a modified chi-square ambiguity set to mitigate the overfitting effects. We derive the theoretical performance guarantees of the distributionally robust algorithm and demonstrate its effectiveness through extensive numerical experiments.

4 Integrating Time Series Predictions Within Multistage Stochastic Optimization

Rohit Kannan[1], Nam Ho-Nguyen[2], Jim R. Luedtke[3], [1]Los Alamos National Laboratory, Los Alamos, NM, [2]The University of Sydney Business School, Sydney, Australia; [3]University of Wisconsin-Madison, Madison, WI, Contact: rohitk@alum.mit.edu

We study data-driven approaches for multistage stochastic programs assuming only access to a single historical trajectory of the underlying stochastic process. The goal is to determine a decision policy that minimizes the expected cost conditioned on the immediate history of the stochastic process. We investigate approaches that integrate a time series prediction model within a sample-based approximation. Our formulations are flexible and can accommodate nonlinear VARX and multivariate GARCH models. We derive conditions under which solutions to our approximations possess asymptotic and finite sample guarantees. Experiments on a hydrothermal scheduling model illustrate the potential benefits of our data-driven formulations even when the time series model is misspecified. Finally, we also explore extensions to the distributionally robust setting.

Monday, 5 PM–6:15 PM

ME44

CC - Room 206

Integer Programming and Combinatorial Optimization

Contributed Session

Session Chair

Gabriele Dragotto, Polytechnique Montreal, Montreal, QC, Canada.

1 A Branch-and-bound Algorithm for Parametric Mixed Binary Quadratically Constrained Quadratic Programs

Andrew Pangia, Clemson University, Clemson, SC

The pooling problem, a quadratic multicommodity network flow problem modeling flow of materials at uncertain proportions is of high importance to the petrochemical industry. The properties of this problem naturally imply modeling via parametric mixed binary quadratically constrained quadratic programs; however, the uncertainty of the proportions gives rise to parameters in several locations of the mathematical model, preventing previously devised algorithms from being utilized. We design a branch-and-bound (BB) algorithm to be applied to this optimization problem. At every node of the BB tree we apply a state-of-the-art algorithm we have recently developed to approximately optimize programs containing objectives and constraints biconvex in the variables and parameters.

2 Harmonic Algorithms for Packing Cuboids into Bins

Eklavya Sharma, University of Illinois, Urbana-Champaign, Urbana, IL

We explore approximation algorithms for the d-dimensional geometric bin packing problem (dBP). Caprara (MOR 2008) gave a harmonic-based algorithm for dBP having an asymptotic approximation ratio (AAR) of 1.692^(d-1). However, their algorithm doesn't allow items to be rotated. This is in contrast to some common applications of dBP, like packing boxes into shipping containers. We give approximation algorithms for dBP when items can be orthogonally rotated about all or a subset of axes. We first give a fast and simple harmonic-based algorithm having AAR 1.692^d. We next give a more sophisticated harmonic-based algorithm, which we call HGaP, having AAR (1+⍰)*1.692^(d-1). This gives an AAR of roughly 2.860+⍰ for 3BP with rotations, which improves upon the best-known AAR of 4.5.

3 The Feasibility Jump: An LP-free Lagrangian MIP Heuristic

Giorgio Sartor, Bjørnar Luteberget, Volker Hoffman, Oddvar Kloster, SINTEF, Oslo, Norway.

We present the Feasibility Jump: a primal heuristic for mixed-integer linear programs using stochastic guided local search over a Lagrangian relaxation.The method is essentially incomplete: it does not necessarily produce solutions to all feasible problems, the solutions it produces are not in general optimal, and it cannot detect infeasibility. But it is extremely fast.Starting from any variable assignment, we store the optimal value assignment of each variable, evaluated separately (assuming all other variables are fixed). We keep performing these assignments as long as they improve the objective value, updating the optimal values lazily. The objective is augmented with a weighted sum of constraint violations, and these weights are eventually increased for constraints that remain violated in local minima. Contrary to many other primal heuristics, the Feasibility Jump does not require a solution of the continuous relaxation. We even see good results applying the heuristic without presolve, which can be time-consuming for large problems. This algorithm is effective on a range of problems from the MIPLIB benchmark suite, improving the time to first solution even for state-of-the-art commercial MIP solvers, and it won 1st place in the MIP 2022 Computational Competition on LP-free heuristics.

4 Mathematical Programming Games

Gabriele Dragotto, Polytechnique Montreal, Montreal, QC, Canada.

In many decision-making settings, a selfish agent optimizes its benefit given some situational constraints. Mathematically, the agent often solves an optimization problem whose solution provides a prescriptive recommendation on the best decision. However, decision-making is rarely an individual task: each selfish decision-maker often interacts with other similarly self-interested decision-makers. We introduce the taxonomy of Mathematical Programming Games (MPGs), games where each agent decision problem is a parametric optimization problem expressing a heterogeneous and possibly complex set of constraints. This talk overviews the challenges and opportunities MPGs offer, explicitly focusing on MPGs where players solve Mixed-Integer programs.

Monday, 5 PM–6:15 PM

ME45

CC - Room 207

AI4OPT: Ethical AI and Optimization - Part I

General Session

Session Chair

Swati Gupta, ISyE Georgia Tech, Atlanta, GA

1 Fair and Reliable Reconnections for Temporary Disruptions in Electric Distribution Networks Using Submodularity

Cyrus Hettle[1], Swati Gupta[2], Daniel K. Molzahn[3], [1]Georgia Institute of Technology, Lexington, KY, [2]ISyE Georgia Tech, Atlanta, GA, [3]Georgia Institute of Technology, Atlanta, GA, Contact: chettle@gatech.edu

We model reconfiguration in electricity distribution networks after short-term disruptions using switches that sequentially close after detecting an anomaly. We introduce the Minimum Reconnection Time (MRT) problem of ordering switches to minimize outage duration and show it is an NP-hard special case of the minimum linear ordering problem from submodular optimization. We approximate MRT using a randomized rounding approach and improve the state-of-the-art for a broad class of MLOP instances. By reconfiguring the system’s base tree, we optimize reliability, outage times, and energy losses simultaneously. The choice of MRT objective results in significant outage differences for buses in residential and industrial regions, and we study the resulting group fairness issues. We computationally validate our methods on the NREL SMART-DS Greensboro synthetic network.

2 Assessing and Improving Fairness in The Operation of Resilient Electric Power Grids

Amanda West[1], Alyssa Kody[2], Mario Augusto Neves Lopes[1], Abigail Ivemeyer[1], Daniel Molzahn[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]Argonne National Laboratory, Lemont, IL, Contact: awest93@gatech.edu

The frequency and intensity of extreme weather events are increasing due to climate change. To mitigate the impacts of extreme events on electric power grids, utility companies and governments are making investments in new infrastructure and changing how power grids are operated during severe weather. However, the fairness of these investments and operational changes across various groups of customers has not been thoroughly investigated. This presentation describes recent work in assessing and enhancing the fairness of power system resilience improvement efforts.

3 Fairness in Wealth Feedback Loops

Krishna Acharya[1], Juba Ziani[1], Eshwar Ram Arunachaleswaran[2], Sampath Kannan[2], Aaron Roth[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of Pennsylvania, Philadelphia, PA, Contact: krishna.acharya@gatech.edu

In this work, we study the effect of fairness interventions in the long run. We introduce a wealth feedback loop in which wealth affects access to opportunities, and in turn access to opportunities impacts future wealth. Our contributions are three-fold. We provide a game theoretic model to explain how educational opportunities are accessible diversely across populations with disparate wealth, and how this translates to wealth for future generations. We characterize the dynamics of our model and show that different populations converge to two different fixed points based on their initial wealth. Initial wealth gaps not only propagate, but can also be amplified. Finally, we study the effect of interventions on improving wealth dynamics for the disadvantaged populations, and consider the trade-offs between costs of intervention and time to convergence to higher wealth.

4 Bias Reduction for Police Report Text in Predictive Algorithms

Yao Xie, ISyE Georgia Tech, Atlanta, GA

We use a bias reduction transformation for the Bag-of-Words model to remove implicit bias in the text as a preprocessing step in the predictive algorithms. The implicit bias here refers to the unfair association of people from certain social groups. Implicit bias can be difficult to remove since some other keywords can be highly related to these biased keywords. For example, racial descriptions can be correlated with neighborhood information. Simply removing these biased keywords sometimes can not eliminate implicit bias. Embedding will also be affected since it is trained using these data. The bias reduction technique finds an optimal transformation of the Bag-of-Words vector to decorrelate the biased keywords from the remaining keywords. We demonstrate the effectiveness of the method using large-scale Atlanta Police reports data.

Monday, 5 PM–6:15 PM

ME46

CC - Room 208

Emerging Themes in Data-Driven Urban Transportation Planning

General Session

Session Chair

Yifei Sun, Dartmouth College, Lebanon, NH

1 End-to-end Learning of User Equilibrium with Implicit Neural Networks

Zhichen Liu[1], Yafeng Yin[2], [1]University of Michigan, ANN ARBOR, MI, [2]University of Michigan, Ann Arbor, MI, Contact: zhichliu@umich.edu

We integrate game theory with implicit deep learning to develop an end-to-end framework that directly learns travelers' route choice preferences and estimates the equilibrium network flow of urban traffic networks from historical flow data. The proposed framework promises to leverage emerging traffic data sources and recent advancements in implicit deep learning to facilitate data-driven transportation planning.

2 Bikes and Buses: A Heuristic Adaptive Discretization Scheme for Multimodal Network Design

Yifei Sun[1], Vikrant Vaze[2], [1]Dartmouth College, Lebanon, NH, [2]Dartmouth College, Hanover, NH

Shared micromobility services have rebounded strongly after early pandemic dip. Given the pandemic disruptions to public transit, cities are investing more in micromobility infrastructure. Thus, a natural question is: Can we better integrate shared micromobility with the public transit network by jointly optimizing transit frequencies, and shared micromobility network design? To address this question, we formulate a large-scale nonconvex mixed integer program and develop a solution heuristic combining adaptive discretization, coordinate descent, and anchor point parsimony. Evaluated against exact adaptive discretization method, the heuristic scales far better, and achieves optimality gap of well under 1%. Detailed case study in the city of Boston demonstrates substantial systemwide gains including a 3.5% reduction in vehicle miles traveled.

3 Resiliency of On-demand Multimodal Transit Systems During a Pandemic

Ramon Auad, Kevin Dalmeijer, Connor Riley, Tejas Santanam, Anthony Trasatti, Pascal Van Hentenryck, Hanyu Zhang, Georgia Institute of Technology, Atlanta, GA

During the COVID-19 pandemic, the collapse of the public transit ridership led to significant budget deficits. Additionally, public transit agencies are facing challenges of reduced capacity, additional costs of cleaning and protective equipment, and increased downtime. This paper studies the resiliency during a pandemic of On-Demand Multimodal Transit Systems (ODMTS), a new generation of transit systems that combine a network of high-frequency trains and buses with on-demand shuttles to serve the first and last miles. It presents an optimization pipeline that provides an end-to-end ODMTS solution by bringing together methods for demand estimation, network design, fleet sizing, and real-time dispatching. A case study in Atlanta demonstrates how ODMTS provide a resilient solution in terms of cost, convenience, and accessibility for this wide range of scenarios.

4 Analysis of Multi-zonal Ride-sharing Service Under Heterogeneous Demand with Detour Requirements

Yining Liu[1], Yanfeng Ouyang[2], [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois at Urbana-Champaign, Urbana, IL

This presentation focuses on planning ride-sharing services under spatially heterogeneous demand with detour requirements. The study region is partitioned into a set of disjoint zones, such that trip origins and destinations within each zone are approximately uniform. A queuing network model is developed to describe passenger movement, passenger matching, and vehicle state evolution within each zone, as well as across neighboring zones. Steady-state agency costs and passengers' level of service are quantified in analytical formulas, which are used to optimize the ride-sharing service, such as zone-level vehicle deployment, vehicle routing paths at the zone level, and vehicle rebalancing operations.

Monday, 5 PM–6:15 PM

ME47

CC - Room 209

Optimization and Simulation in Railroads

General Session

Session Chair

Rajah Varadarajan, 1</sup

1 Optimizing The Rollout of Alternative Propulsion Locomotives Using Full Corridor Simulation

Geordie Roscoe[1], Tyler Dick[2], [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]U of Illinois at Urbana-Champaign, Urbana, IL, Contact: groscoe2@illinois.edu

As railroad decarbonization efforts intensify, alternative locomotive propulsion technologies are an important pathway to achieving emissions targets. With multiple technologies such as batteries and fuel cells under development, railroads must determine locomotive rollout strategies that maximize future economic, operational, and emissions benefits. As such, a complete optimization framework that can evaluate current and proposed powertrain technologies for actual rail corridor traffic and topography will be invaluable to industry practitioners. This research develops a full railroad corridor simulation tool that is integrated with multiple detailed locomotive powertrain models to evaluate fuel/energy consumption, emissions, and costs. It will also serve as a basis for optimizing complete locomotive rollout strategies.

2 Econometric Modeling and Railcar Demand

Daniel Windle, Joseph Towers, Trinity Industries, Dallas, TX, Contact: daniel.windle@trin.net

In an effort to better predict market needs for railcar services, we have developed a process to combine econometric modeling techniques with subject matter expertise. These results help filter to other parts of our organization to set forward looking expectations for supply and demand of railcars. This presentation will focus on the process of developing these forecasts and describe the downstream effects of these results.

3 Digital Signal Systems and Their Impact on Freight Traffic

Steven Harrod, Technical University of Denmark, Glostrup, Denmark.

Railway signal systems in North America and Europe have a plan to replace old analog signal systems with digital signal systems. This talk explains the history and motivations for each continent, and the general technical and capability differences between the two signal systems. In general, North America revised their signal systems to respond to safety concerns, and Europe committed to replace their signals for operational reasons. The impact on freight traffic is documented for each continent, and success and failures discussed.

4 Analysis and Prediction of Freight Railroad Shipping Rates: Regression Versus Machine Learning

Diwen Shi, University of Illinois Urbana-Champaign, Urbana, IL

The research applies advanced analytical techniques to the problem of predicting freight railroad revenues (shipper costs) for specific freight shipments. Using revenue data per shipment and ton-mile from the Surface Transportation Board (STB) Carload Waybill Sample, linear and non-linear relationships between revenue and predictive parameters were developed, and neural networks were constructed to provide better prediction results. Although the neural network model achieved better revenue predictions, the regression models provided insights on relationships between revenue and various shipment characteristics. Revenue per shipment was strongly correlated with ton-miles, followed by mileage, tonnage, number of interchanges and commodity types, and exhibits mathematical relationships that reflect expected railroad economies of scale.

Monday, 5 PM–6:15 PM

ME48

CC - Room 210

Modeling of Transportation Systems

Contributed Session

Session Chair

Amin Keramati, Widener University, Chester, PA

1 Integer Programming Formulations for Optimization of Angle Parking Layouts

Helen Thomas, Kiran Bedi Badavathu, Tarun Rambha, Indian Institute of Science, Bangalore, India.

We consider the problem of optimizing the parking spaces and access pathways for vehicles of different sizes, such as buses and cars, within a given parking lot. Inspired from Stephan et al. (2021), we use mixed integer programming to extend perpendicular parking designs to angle parking for better vehicle manoeuvrability. The proposed formulation maximizes the number of parking spaces by altering parking lot grid shape and resolutions. The designs are optimized using CPLEX, and then simulated in VISSIM to estimate other metrics of relevance such as average time to park.

2 **Estimating Emission Distribution in Traffic Networks: Data-driven Vs Model-based Approaches**

Changyu Zhou, Zhanbo Sun, Yiling Huang, Southwest Jiaotong University, Chengdu, China. Contact: zhouchangyu@my.swjtu.edu.cn

The paper proposes several data-driven and model-based methods to estimate emission distribution in traffic networks, including spatial interpolation, deep learning, and integrated traffic-emission-dispersion models. Comparisons are made with respect to different sparsity of real-world emission monitoring data collected in Chengdu, China. Results indicate that data density significantly affects the performance of data-driven approaches, while not so much on model-based approach.

3 **Improving Commercial Vehicle Routing with Parking Information**

Klaas Fiete Krutein, Giacomo Dalla Chiara, Todor Dimitrov, Anne V. Goodchild, University of Washington, Seattle, WA, Contact: todord@uw.edu

In this study, we explore how historic cruising and parking delay data can be leveraged to improve the routes of carriers in urban environments to increase cost efficiency. To do so, we develop a vehicle routing model which accounts for parking delay estimates and apply it to both a real-world case study to show immediate application as well as a synthetic dataset to identify environments and route characteristics which benefit the most from considering this information. Our preliminary results on the real-world dataset show a mean total drive time savings of 1.5%. The synthetic dataset shows potential mean total drive time saving of 21.6% with routes with fewer stops, concentrated shape, and high cruising time variance showing the largest savings potential at up to 62.3%.

4 **Modeling Accident Hazard Index for Highway-rail Grade Crossings Using Analytic Hierarchy Process**

Amin Keramati[1], Pan Lu[2], Afrooz Moatari-Kazerouni[1], [1]Widener University, Chester, PA, [2]North Dakota State University, Littleton, CO, Contact: akeramati@widener.edu

Considering crash severity in the grade crossing hazard-ranking is essential for transportation agencies and decision-makers as they need to recognize grade crossings that are more likely to have severe crashes, hazard-ranking models take severity into consideration are needed by decision-makers. However, such practice will increase the complexity of the prioritization model as the hazard-ranking model should convert three quantities associated with the fatal crash, injury crash, and property damage only (PDO) crash likelihoods to one priority index for each crossing. This study proposes a hybrid prediction model/hazard index to apply such conversion using the analytic hierarchy process (AHP) method.

Monday, 5 PM–6:15 PM

ME49

CC - Room 211

TSL Flash Session I

Flash Session

Session Chair

Amro El-Adle, Old Dominion University, Norfolk, VA

1 **Optimizing Multi-trip Mobility Allowance Shuttle Transit (mast) with Frequency with Respect to Capacity Constraints and Valid Inequalities**

Pierre Hosteins[1], Paola Pellegrini[2], Pierre-Olivier Vandanjon[3], [1]University of Gustave Eiffel, Villeneuve d'Ascq, France; [2]University of Gustave Eiffel, Villeneuve d'Ascq, France; [3]University of Gustave Eiffel, Bouguenais, France.

3 **Commuter Preferences for Microtransit in The US**

Ricardo A. Daziano, Cornell University, Ithaca, NY, Contact: daziano@cornell.edu

Using stated preference data from four US cities, we report value-of-time (VOT) estimates for microtransit, a shared first-mile/last-mile mobility service. We found an in-vehicle VOT for microtransit of $24.98/hr and an access VOT of $65.71. The former is similar to the VOT we found for personal car travel ($25.57) and public transit ($21.54). We also found that men, younger riders, the highly educated, and transit riders are more likely to be interested in microtransit. Since the disutility of time spent on microtransit is not higher than that of other modes, we believe this new service has the potential to attract riders, and particularly if the system is designed with low waiting and walking times.

4 **A Split Delivery Inventory Routing Problem**

Luca Bertazzi[1], Claudia Archetti[2], Nho Minh Dinh[1], [1]University of Brescia, Brescia, Italy; [2]University of Brescia, Brescia, Italy. Contact: luca.bertazzi@unibs.it

We propose a mathematical formulation for the Split Delivery Inventory Routing Problem, both under the ML and the OU replenishment policies. We solve these formulations, enriched with valid inequalities, through branch-and-cut algorithms. We carry out a worst-case analysis and perform extensive computational tests on benchmark IRP instances to evaluate the benefits of split deliveries.

5 An Optimization-based Approach to Compare Home Deliveries and Pick-up Points on E-commerce Last Mile Distribution

Claudio B. Cunha[1], Rhandal F. Masteguim[2], [1]University of Sao Paulo, Sao Paulo, Brazil; [2]University of Sao Paulo, Sao Paulo, Brazil. Contact: cbcunha@usp.br

Motivated by the importance to reduce the negative impacts of e-commerce last mile distribution in urban areas, we investigate in what conditions a network of package retrieving stations (i.e., pickup points and parcel lockers) can be more efficient than home deliveries from an operational point of view. Differently from the extant literature, which relies on analytical models, we propose an optimization-based approach comprising location and routing models. Several realist scenarios related to the megacity of Sao Paulo, Brazil, comprising different combinations of delivery densities, distances to the fulfillment center (from where vehicles depart) and proportion of packages destined to the stations, were evaluated and compared. The results show that such facilities can be a promising alternative as fleet size and vehicle distances can be reduced by more than 50%.

6 Characterizing Transportation Network Company Vehicle Supply with Time-evolving Bipartite Graph

Yanshuo Sun, Sajeeb Kirtonia, FAMU-FSU College of Engineering, Tallahassee, FL

This study is motivated by the lack of understanding of ridesourcing vehicle characteristics (e.g., quantity and distribution) because the private-sector nature of Transportation Network Companies (TNCs) determines that no detailed operational statistics are shared, especially those involving their customers. Instead, TNCs only report highly aggregated data, such as the average number of Uber trips worldwide per day. In this study, we collected large-scale trajectory data about idle TNC vehicles from Uber and Lyft websites and examined TNC vehicle supply with a time-evolving bipartite graph. We proposed two graph-based metrics, namely rider-vehicle edge density and edge length, to fully characterize the relation between riders and vehicles. The findings expect to help local transportation authorities understand how TNC vehicles operate in their jurisdictions

7 A LOCATIOn and ALLOCATION MODEl for OPTIMIZING COVID-19 VACCINE DISTRIBUTION USING REAL-WORLD SHIPMENT DATA

Leila Hajibabai, Ali Hajbabaie, Asya Atik, Kuangying Li, Dayang Zheng, North Carolina State University, Raleigh, NC, Contact: kli32@ncsu.edu

We have formulated an enhanced maximum covering problem as a mixed-integer linear model to minimize the total cost of vaccine distribution and maximize the total number of vaccines allocated to population blocks under equity constraints. Block-level census data are utilized to define the demand locations, where gender and age groups in each block are identified using the population data. We have conducted a set of empirical case studies in North Carolina and Pennsylvania based on the real-world data collected from the Centers for Disease Control and Prevention (CDC) and health department websites. The preliminary results indicate that the proposed model can solve the problem effectively.

8 Enhanced Matheuristic for The Inventory Routing Problem (IRP)

Marcus V. Poggi, Bruno Castro, Rafael Martinelli, PUC-Rio - Pontificia Universidade Catolica do Rio de Janeiro, Rio de Janiero, Brazil. Contact: poggi@inf.puc-rio.br

In the context of Vendor-Managed Inventory, the IRP provides a minimum cost logistics for a given period. In this talk, we explore the joint use of an extended version of the formulation proposed by Manousakis et al., the fast computation of the inventory problem given the routes and hot-start strategies within a framework of ILS/Fix-and-Optimize heuristics. Search space reduction by alternatively improving upper and lower bounds is the main feature of the resulting algorithm. Results are presented over the DIMACS recent benchmark instances.

9 The performance and productivity change of US airline mergers

Dariush Khezrimotlagh[1], Sepideh Kaffash[2], Joe Zhu[3], [1]Pennsylvania State University - Harrisburg, Middletown, PA, [2]Suffolk University, Boston, MA, [3]Worcester Polytechnic Institute, Worcester, MA

The U.S. airline industry has experienced waves of entries and mergers since 1978. The three waves of mergers in the U.S. airline industry happened in the 1980s, 1990s, and late 2000s. In this study, we study the performance of U.S. airlines and the influence of recent mergers on the efficiency of airlines. We investigate whether the efficiency changes of airlines improved in the post-merger years. We also compare the improvement of the network carriers versus the low-cost carriers in period of time.

10 **Rural Parcel Delivery by Drone**

Amro El-Adle[1], Ahmed Ghoniem[2], Mohamed Haouari[3], [1]Old Dominion University, Norfolk, VA, [2]Isenberg School of Management, UMass Amherst, Amherst, MA, [3]Qatar University, Qatar, Qatar. Contact: aeladle@odu.edu

We investigate last-mile parcel delivery using a vehicle-drone system, with a focus on rural areas. The areas are characterized by low customer density and extended vehicle miles traveled. Over a planning horizon, we propose a model that minimizes the set of roads traversed by the vehicle while permitting aerial delivery by drones. In a computational study, we highlight potential savings for the vehicle-drone system in this context using real-world instances matching historical delivery and customer data from the United States Parcel Service.

Monday, 5 PM–6:15 PM

ME50

CC - Room 212

Platform Design, Security and Social Responsibilities

General Session

Session Chair

Ling Ge, 1</sup

1 **The Experimental Imposition of a Worker Level Minimum Wage**

Emma van Inwegen[1], Apostolos Filippas[2], John Joseph Horton[3], [1]MIT, Cambridge, MA, [2]Fordham, New York, NY, [3]MIT Sloan, Cambridge, MA, Contact: emmavani@mit.edu

We study a field experiment where workers were randomly assigned to binding minimum wages in an online labor market. Treated workers commanded up to 20% higher hourly wages. However, they were 30% less likely to get hired for jobs they did apply for. They also worked fewer hours, with no effect on workers' earnings. Rather than increase their search intensity, they lowered it. Treated workers with the highest minimum wage applied to 12% fewer job openings. Workers did not shift to applying in the uncovered sector, or to jobs with a fixed price rather than an hourly wage. The platform eventually implemented the minimum wage to all workers, so we are able to do a difference-in-differences analysis to capture effects in equilibrium.

2 **An Emperical Study of Open-Market B2B Transaction Digitalization**

Nils Van den Steen[1], Steve Muylle[2,3], Amit Basu[1], Willem Standaert[4,3], [1]Cox School of Business - Southern Methodist University, Dallas, TX, [2]Vlerick Business School, Ghent, Belgium; [3]Ghent University, Ghent, Belgium; [4]HEC Management School - University of Liège, Liège, Belgium.

When business-to-business transactions are conducted in an open-market setting, where any firm can be a buyer or a seller, digital technologies such as Ecommerce websites, social media, and mobile applications can be used by firms to support these transactions. However, key questions about the effective digitalization of such open-market transactions remain unaddressed. In this work, we use a large field study of matched-pair buyer-seller dyads to examine the impact of various factors on the benefits firms realize from digitalizing their open-market transactions. These factors include the transaction stages that were digitalized, the role of the firm in the transaction, and the digital technologies that were used.

Monday, 5 PM–6:15 PM

ME51

M - Santa Fe

Optimization for Sustainable Chemical and Energy Systems III

General Session

Session Chair

Alexander Dowling, University of Notre Dame, Notre Dame, IN

Session Chair

Jaffer H. Ghouse, 1</sup

1 **Disjunctive Optimization Model for Capacity Planning of Reliable Power Systems**

Seolhee Cho[1], Ignacio E. Grossmann[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: seolheec@andrew.cmu.edu

This research aims to develop an advanced Generalized Disjunctive Programming (GDP) model for the optimal capacity planning of reliable power systems. The model optimizes the number and size of redundant units to maximize the reliability and to minimize the cost, by considering operation strategies that can affect the system reliability. The embedded GDP model includes two penalty terms in the objective function for the loss of expected power, and is reformulated as a mixed-integer linear programming (MILP) using either Big-M method. The proposed GDP model is tested with an expansion planning problem of a power generation system, and compared with a simple sequential design approach. The results show that the proposed model can effectively design reliable power generation systems, and yield significant economic savings compared to simplified design approaches.

2 Market-integrated Optimization of Wind-battery-hydrogen Hybrids for Peaking Capacity Via Storage

Darice Guittet, National Renewable Energy Laboratory, Golden, CO, Contact: Darice.Guittet@nrel.gov

As Integrated Energy Systems (IES) combine multiple energy and storage technologies to provide potentially more value and less risk via resource diversification, complementary overbuild, increased flexibility, and revenue-stacking, IES value is dependent on electricity market dispatch and grid interactions should play an important role in IES design and operation. This study hybridizes and retrofits wind and combustion turbine plants to study the impacts of replacing gas generation capacity with wind, battery, PEM electrolysis, hydrogen tanks and hydrogen turbines. The optimized design is co-simulated in a production cost model with different bidding strategies in order to compare performance and highlight the importance of grid-interactions. We analyze the revenue and dispatch changes as well as the price and cost implications of wind-battery-hydrogen IESs.

3 Mathematical Modeling and Economic Optimization of a Novel Amine-based Post-combustion Carbon Capture Process

Ilayda Akkor[1], Shachit Shankaran Iyer[2], John Dowdle[2], Le Wang[2], Chrysanthos E. Gounaris[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]The Dow Chemical Company, Freeport, TX, Contact: iakkor@andrew.cmu.edu

The novel Piperazine/Advanced Flash Stripper (PZ/AFS) process is a promising amine scrubbing technology that can benefit from additional process optimization effort to make it more viable economically. In this work, we present an equation-oriented, rate-based, rigorous mathematical model of this process built in Pyomo. After validating simulation results with published pilot plant data, we implemented an economic objective, which we used as the basis for performing model optimization to determine the minimum cost design.

4 Machine Learning-Enabled Optimization of Classical Molecular Modeling Force Fields

Bridgette Befort, Ryan DeFever, Edward Maginn, Alexander Dowling, University of Notre Dame, Notre Dame, IN, Contact: bbefort@nd.edu

In this work, we propose a machine learning-enabled optimization framework to calibrate classical molecular modeling force fields. We find that our surrogate-assisted optimization approach, which utilizes Gaussian Process surrogate models to represent computationally expensive simulations, provides a quick and efficient route to accurate, physics-based force field parameters. Then, we compare the efficiency of this workflow with automated Bayesian sampling of force field parameter space, showing that Bayesian optimization finds lower error parameter sets in half the time. In our demonstration case, we optimize force fields for two environmentally relevant hydrofluorocarbons, HFC-32 and HFC-125. As further capabilities are developed, this workflow will be harnessed to rapidly calibrate molecular models for other systems of interest.

Monday, 5 PM–6:15 PM

ME52

M - Lincoln

Connecting Scheduling Under Uncertainty with Data Science

General Session

Session Chair

Rodrigo A. Carrasco, Universidad Adolfo Ibanez

1 Scheduling Wine Grapes Fermentation Tanks in Uncertain Environments

Jorge R. Vera[1], Carlos Monardes[2], [1]Pontificia Universidad Católica de Chile, Santiago, Chile; [2]Universidad Católica del Norte, Coquimbo, Chile. Contact: jvera@ing.puc.cl

Wine industry requires efficient operations to achieve good quality products. One important part of the process is the harvesting followed by the fermentation of the grapes, an operation which is done in tanks with various capacities during several days. The whole operation is also subject to various uncertainties, weather, among others. In this work we show an optimization-based scheduling model for allocating harvested lots of grapes to the various tanks. We compare a time indexed model with another one where time periods are handled implicitly. We also present the extensions needed to consider weather uncertainty, which affects the quality of grapes and might require adapting harvesting and fermentation schedule. Computational results for various problems, including industry size ones, are presented

2 Scheduling with Speed Predictions

Hao-Ting Wei, Eric Balkanski, Clifford Stein, Tingting Ou,

Columbia University, New York, NY, Contact: hw2738@columbia.edu
Algorithms with predictions is a recent framework that has been used to overcome pessimistic worst-case bounds in incomplete information settings. In the context of scheduling, very recent work has leveraged machine-learned predictions to design algorithms that achieve improved approximation ratios in settings where the processing times of the jobs are initially unknown. In this paper, we study the speed-robust scheduling problem where the speeds of the machines, instead of the processing times of the jobs, are unknown and augment this problem with predictions.
Our main result is an algorithm that improves over the previously best known result when the predictions are accurate, while simultaneously maintaining a worst-case guarantee even when the predictions are wrong.

3 Scheduling Activities Under Uncertainty with Prediction Errors

Rodrigo A. Carrasco, Constanza Lorca, Universidad Adolfo Ibanez, Santiago, Chile. Contact: rodrigo.carrasco@gmail.com

In many settings, decision-makers need to schedule activities without having certainty about their durations. Thanks to the increasing data availability, one approach has been to use machine learning tools to predict activity durations. Nevertheless, this approach is seldomly devoid of errors, and prediction mistakes are common, particularly when environmental variables are involved. This talk introduces a novel stochastic optimization model for scheduling activities under uncertainty. Using Chernoff Bounds, we construct chance constraints that allow the decision-maker to account for the effect of prediction errors. These constraints add a new tuning parameter through which the user can balance competing metrics. We show the benefits of this approach through experimental results, developing schedules that are more robust to estimation errors.

Monday, 5 PM–6:15 PM

ME53

M - Denver

Award - Service Science Best Paper Finalist

Flash Session

Session Chair

Guiping Hu, Iowa State University, Ames, IA

1 Flash Paper

Kejia Hu, Vanderbilt University, Nashville, TN

2 Multi-criteria Course Mode Selection and Classroom Assignment Under Sudden Space Scarcity

Lauren N. Steimle[1], Mehran Navabi[2], Mohamed El Tonbari[2], Natashia Boland[3], Dima Nazzal[3], [1]Georgia Tech ISyE, Atlanta, GA, [2]Georgia Tech, Atlanta, GA, [3]ISyE Georgia Tech, Atlanta, GA

During the COVID-19 pandemic, social distancing led to sudden drops in classroom capacity. This presented a challenging problem for colleges wanting to deliver a meaningful amount of in-person instruction. In response, campus planners had to decide which classes to deliver in remote, in-person, and hybrid formats, and how to make the most of existing classroom space on campus by reassigning classes to classrooms. We present a multi-objective optimization approach that considers various trade-offs and administrative preferences for assigning course modes and classrooms under sudden space scarcity. We discuss insights from our model that informed a collaborative decision-making process with the Georgia Tech COVID-19 Task Force.

3 Flash Paper

Junyu Cao[1], Wei Qi[2], [1]The University of Texas at Austin, Austin, TX, [2]Tsinghua University, Beijing, China.

Urban open space emerges as a new territory to embrace retail innovations. Transition into such a "stall economy" paradigm is being spurred by the rapidly advancing self-driving technologies. Motivated by this transformation, this paper provides models, theory, and insights of spatial queueing systems in which one server moves around to meet mobile customers/machines and in which the "last 100 meters" is expensive. Specifically, we study two service modes i) on-demand and ii) spatially and temporally pooling customer demands. Our main finding is that the stall economy potentially profits more than stationary retail because of the mobility of stalls as well as its operational flexibilities that allow for avoiding the "last 100 meters" and pooling demands. In a broader sense, this work looks toward an expanded scope of future retail empowered by self-driving technologies.

4 Dynamic Learning in Large Matching Markets

Anand Kalvit, Assaf Zeevi, Columbia Business School, New York, NY

We consider the archetypal problem of sequentially matching "jobs" to "workers" at a large centralized matching platform. On the demand side, an arriving job may have one among several possible "types" (from a finite universe) observable upon arrival. On the supply side, there exist *latent* clusters in the population of available workers reflecting a low-dimensional discretization of their skill levels w.r.t. job-types; a fixed distribution governs the relative sizes of said clusters. Subject to worker labels (w.r.t. clusters), their distribution as well as mean payoffs being unobservable attributes, the platform's goal is to sequentially match incoming jobs to workers in a way that maximizes its cumulative payoffs over the planning horizon. Our work resolves several foundational questions pertaining to complexity and achievable performance in this problem setting.

5 Optimal Feature-based Market Segmentation and Pricing

Michael L. Hamilton, Titing Cui, University of Pittsburgh, Pittsburgh, PA

In this work we study semi-personalized pricing strategies where a seller uses features about their customers to segment the market, and customers are offered segment-specific prices. First, we establish novel hardness and approximation results in the case when model noise is independent. Second, in the common case when the noise in the model is log-concave, we show the joint segmentation and pricing problem can be efficiently solved, and characterize a number of attractive structural properties of the optimal feature-based market segmentation and pricing. Finally, we conduct a case study using home mortgage data. Along the way we also prove a number of structural properties about pricing from regression models that may be of independent interest.

6 Multi-armed Bandits with Endogenous Learning Curves and Queueing: An Application to Split Liver Transplantation

Yanhan (Savannah) Tang, Andrew A. Li, Alan Scheller-Wolf, Sridhar R. Tayur, Carnegie Mellon University, Pittsburgh, PA

We formulate a multi-armed bandit (MAB) problem, in which parametric learning curves are embedded in the reward functions to capture experience-based learning, to model split liver transplantation (SLT). In addition, our model includes fairness constraints (ensuring equity), incorporates queueing dynamics (to capture waiting time dynamics), and arm dependence (to capture learning across similar surgeries). To solve our MAB problem, we propose three variants of the upper confidence bound (UCB) algorithm that attain guaranteed performance: All of our algorithms have regret bounded by O(log t). Numerical experiments show that our algorithms have superior numerical performance compared to standard bandit algorithms in our problem setting.

7 Flash Paper

Park Sinchaisri, University of California, Berkeley, Berkeley, CA

8 Operating Room-to-Downstream Elective Surgery Planning Under Uncertainty

Karmel S. Shehadeh[1], Man Yiu Tsang[1], Rema Padman[2], Arman Kilic[3], [1]Lehigh University, Bethlehem, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Medical University of South Carolina, Charleston, SC

Motivated by our collaboration with a health system, we propose a new stochastic optimization problem: the elective surgery assignment, sequencing, and scheduling problem (ESASSP), involving multiple operating rooms and their downstream recovery units (intensive care unit (ICU) and ward). We propose stochastic programming and distributionally robust optimization methodologies for modeling and solving the ESASSP, assuming known and unknown distributions of surgery durations and post-operative recovery time in the surgical ICU and ward. Numerical experiments based on real surgery data from large health systems are used to compare the proposed methodologies and illustrate the potential for impact in practice.

9 Flash Paper

Neha Sharma, Kellogg School of Management, Evanston, IL

We study sharing platforms that allow guests to reserve assets ahead of service. On such platforms, 'hosts', asset owners who rent their assets, *commit to the assets' availability* by 'listing' it for a future time. We find *empirical evidence* of hosts' strategic decisions regarding whether to list early or later from one of the largest car-sharing platforms in India. Given that platforms use dynamic pricing and share revenue with the hosts, they may not always prefer listing early. We use a two-period game-theoretic framework to model such a platform. We first analyze the platform's equilibrium supply and service level for guests under the widely used revenue-share contract. We theoretically show that there always exists a region where no hosts list their assets early. Our results show the limitations of revenue-share contracts in sharing platforms.

10 Flash Paper

N. Bora Keskin[1], Yuexing Li[2], Nur Sunar[3], [1]Duke University, Durham, NC, [2]Johns Hopkins Carey Business School, Baltimore, MD, [3]UNC, Chapel Hill, NC, Contact: bora.keskin@duke.edu

We consider an electric utility company that serves N customers over T periods. In each period, the company observes the customers' consumption and high-dimensional features on customer characteristics and exogenous factors. The space of features is partitioned into clusters based on similarity, and in each cluster, there is a distinct relationship between consumption and features. The company knows neither the underlying cluster structure nor the corresponding consumption models. We design a data-driven clustering-and-pricing policy to learn these elements on the fly and prove that our policy achieves near-optimal performance in terms of N and T. Through a case study on a real-life data set, we show that our policy significantly outperforms the historical decisions of the utility company.

11 Help and Haggle: Boosting Social Reach Through Randomized, All-or-nothing Discounts

Chen Jin[1], Luyi Yang[2], Zhen Shao[3], [1]National University of Singapore, Singapore, Singapore; [2]University of California, Berkeley, Berkeley, CA, [3]The University of Science and Technology of China, Hefei, China.

This paper studies a novel social e-commerce practice known as "help-and-haggle": an online shopper can ask friends to help her "haggle" over the price of a product. When a friend agrees to help, the price is cut by a random amount, and if she cuts the product price down to 0 within a time limit, she will get the product for free; otherwise, the product reverts to the original price. Help-and-haggle enables the firm to promote its product and boost its social reach as consumers effectively refer their friends to the firm. Two innovative features distinguish this social e-commerce scheme: the amount of the tentative discount each successful referral triggers is randomized and the total discount the consumer effectively enjoys is all-or-nothing in nature. We model the consumer's dynamic referral behavior and provide prescriptive guidance on how the firm should randomize price cuts.

12 Flash Paper

Jiding Zhang, New York University Shanghai, Shanghai, China.

Monday, 5 PM–6:15 PM

ME54

M - Marriott 1

APS Student Paper Competition

Award Session

Session Chair

Itai Gurvich, Northwestern University, Kellogg School of Management, Evanston,, IL

A Closer Look at The Worst-case Behavior of Multi-armed Bandit Algorithms

Anand Kalvit, Assaf Zeevi, Columbia Business School, new york, NY

This work provides new results on the arm-sampling behaviorof two classical multi-armed bandit algorithms; the canonical UCB (UpperConfidence Bound) and Thompson Sampling (TS) policies. Our work culminates in afascinating discovery that arm-sampling rates under UCB are asymptoticallydeterministic in probability, regardless of the hardness of the probleminstance. This leads to the first "complete" characterization of theworst-case regret of UCB, as well as a diffusion limit characterization of theproblem, the first under UCB-type algorithms. We also identify and elucidate aninstability result for TS that explains some long-standing empiricalobservations. Among other things, our analysis reveals profound distinctionsbetween the behavior of UCB and TS, which have complex implications forfairness, off-policy inference and more general learning problems.

Optimal and instance-dependent guarantees for Markovian linear stochastic approximation

Wenlong Mou, UC Berkeley, Berkeley, CA

We study stochasticapproximation procedures for approximately solving a linear fixed-pointequation based on an ergodic Markov chain trajectory. First, we exhibit anon-asymptotic error bound for the last iterate, with near-optimal dependenceon the problem dimension and mixing time. We then prove an instance-dependentbound on the averaged iterates, which matches the local asymptotic minimaxlimit whenever the sample size exceeds the product of dimension and mixingtime. Such an estimator is further shown to be instance-optimal via a localminimax lower bound. Application of our results includes temporal differencemethods with linear function approximation, for which the instance-dependentbounds guide the selection of tuning parameters.

Markovian Interference in Experiments

Tianyi Peng, Andrew Zheng, Massachusetts Institute of Technology, Cambridge, MA

We consider experiments in dynamical systems where interventions on some experimental units impact other units through a limiting constraint (such as a limited inventory). Despite outsize practical importance, the best estimators for this `Markovian' interference problem are largely heuristic in nature, and their bias is not well understood. We formalize the problem of inference in such experiments as one of policy evaluation. Off-policy estimators, while unbiased, apparently incur a large penalty in variance relative to state-of-the-art heuristics. We introduce an on-policy estimator: the Differences-In-Q's (DQ) estimator. We show that the DQ estimator can in general have exponentially smaller variance than off-policy evaluation. At the same time, its bias is second order in the impact of the intervention. This yields a striking bias-variance tradeoff so that the DQ estimator effectively dominates state-of-the-art alternatives. Our empirical evaluation includes a set of experiments on a city-scale ride-hailing simulator.

Efficient decentralized multi-agent learning in asymmetric queuing systems

Wentao Weng, MIT, Cambridge, MA

We study decentralized multi-agent learning in bipartite queuing systems, a standard model for service systems. In particular, N agents request service from K servers in a fully decentralized way, i.e, by running the same algorithm without communication. Previous decentralized algorithms are restricted to symmetric systems, have performance that is degrading exponentially in the number of servers, require communication through shared randomness and unique agent identities, and are computationally demanding. In contrast, we provide a simple learning algorithm that, when run decentrally by each agent, leads the queuing system to have efficient performance in general asymmetric bipartite queuing systems while also having additional robustness properties. Along the way, we provide the first UCB-based algorithm for the centralized case of the problem.

Monday, 5 PM–6:15 PM

ME55

M - Marriott 2

Matchings in Random Graphs

General Session

Session Chair

Jiaming Xu, Duke University, Durham, NC

Session Chair

Sophie H. Yu, Durham, NC

1 Attributed Graph Alignment: Fundamental Limits and Efficient Algorithms

Ziao Wang[1], Ning Zhang[1], Weina Wang[2], Lele Wang[1], [1]University of British Columbia, Vancouver, BC, Canada; [2]Carnegie Mellon University, Pittsburgh, PA

We consider the graph alignment problem, where the goal is to identify the vertex/user correspondence between two correlated graphs. Existing work mostly recovers the correspondence by exploiting the user-user connections. However, in many real-world applications, additional information about the users, such as user profiles, might be publicly available. In this talk, we introduce the attributed graph alignment problem, where additional user information, referred to as attributes, is incorporated to assist graph alignment. We establish both the information-theoretic limits and the feasible region by polynomial-time algorithms for the attributed graph alignment. Our results span the full spectrum between models that only consider user-user connections and models where only attribute information is available.

2 Correlated Stochastic Block Models: Graph Matching and Community Recovery

Miklos Racz, Princeton University, Princeton, NJ

I will discuss statistical inference problems on edge-correlated stochastic block models. We determine the information-theoretic threshold for exact recovery of the latent vertex correspondence between two correlated block models, a task known as graph matching. As an application, we show how one can exactly recover the latent communities using multiple correlated graphs in parameter regimes where it is information-theoretically impossible to do so using just a single graph. Furthermore, we obtain the precise threshold for exact community recovery using multiple correlated graphs, which captures the interplay between the community recovery and graph matching tasks. This is based on joint work with Julia Gaudio and Anirudh Sridhar.

3 Constant Regret Primal-dual Polices for Multi-way Dynamic Matching

Yehua Wei, Jiaming Xu, Sophie Yu, Duke University, Durham, NC

In this paper, we study a dynamic multi-way matching model where agents arrive dynamically and wait to be matched. A network topology determines a match's feasibility, in which each match may contain one or multiple agents. We propose a primal-dual policy that is the first to achieve constant regret at all times under unknown arrival rates, when the fluid relaxation of the matching problem has a unique dual solution. The regret of our primal-dual policy scales with the general position gap (GAP) from the literature. In addition, we show that if the arrival rates are known, then the primal-dual policy matches the best-known regret in the literature. Furthermore, we find that the primal-dual policy significantly outperforms the sum-of-squares policy in numerical simulations.

4 **The Planted Matching Problem: Phase Transitions and Exact Results**

Mehdrad Moharrami[1], Cristopher Moore[2], Jiaming Xu[3], [1]University of Illinois, Urbana, IL, [2]Santa Fe Institute, Santa Fe, NM, [3]Duke University, Durham, NC, Contact: jiaming.xu868@duke.edu

What happens when an optimization problem has a good solution built into it, but which is obscured by randomness? Here we revisit the classic assignment problem, i.e., the minimum perfect matching problem on bipartite graphs. If the edges have random weights in [0,1], Aldous proved that the minimum matching has expected weight zeta(2) = pi^2/6. We consider a "planted" version where a particular matching has weights drawn from an exponential distribution with mean mu/n. When mu < 1/4, the minimum matching is almost identical to the planted one. When mu > 1/4, the overlap between the two is given by a system of differential equations that result from a message-passing algorithm.

Monday, 5 PM–6:15 PM

ME58

M - Marriott 5

Resilience of Infrastructure and Supply Chain Networks

General Session

Session Chair

Andres David Gonzalez, University of Oklahoma, Norman, OK

1 **Addressing The Principal-agent Problem in Public Private Partnerships Via Mixed-integer Bi-level Linear Programming**

Samuel Rodriguez, 1</sup

Public Private Partnerships (PPPs) are associations between a government and a private party with the objective of delivering public assets and/or services. A key challenge arises due to the Principal-Agent problem (PA problem), namely: a conflict of interests in which the public may not be able to ascertain whether the private party's actions respond to its own interests rather than the project's. We model a PPP interaction in the context of a road maintenance project as a bi-level optimization problem, for which we incorporate Branch & Cut resolution techniques. Our implementation finds solutions within reasonable computation times, allowing for analysis of trade-offs in PPPs to overcome drawbacks such as the Principal-Agent problem.

2 **Supply Chain and Infrastructure Disruption of Small and Minority-owned Businesses After Compound Events**

Maria Watson[1], Joy Semien[2], Michelle Meyer[2], Rebekka Dudensing[2], [1]University of Florida, Gainesville, FL, [2]Texas A&M University, College Station, TX, Contact: maria.watson@ufl.edu

Since 2017, U.S. communities along the Texas and Louisiana border including Beaumont, TX, Port Arthur, TX, and Lake Charles, LA are recovering from Hurricane Harvey, Tropical storm Imelda, a chemical plant explosion, and even more recently Hurricane Laura, Hurricane Delta, a deadly freeze, and riverine flooding amid the pandemic. These businesses are economically and socially vulnerable; many businesses in these areas are minority-owned and service low-income and majority-minority neighborhoods. We present the results of a survey effort to understand the effects of infrastructure disruption from these compounding events on these businesses—including changes in supplier locations and changes in the ability of businesses to provide their goods and services to different markets—with special attention given to size, sector, and minority ownership of the business.

3 **Resilience Quantification of Coastal Intermodal Freight Networks Subject to Storms Hazards**

Anibal Tafur[1], Jamie E. Padgett[2], [1]Rice University, Houston, TX, [2]Rice University, Houston, TX, Contact: tafur@rice.edu

This paper presents a framework to quantify resilience of port-roadway-railway freight intermodal networks disrupted by storm hazards, encompassing mainly container, dry bulk and liquid bulk terminals. The framework measures resilience by tracking the time evolution of the class and volume of goods disrupted across the affected region, leveraging network modelling and flow optimization. Crucial components such as terminals, bridges, roadways and railways are modeled as links, susceptible to damage by the considered hazard. Functionality over time of network components is informed by fragility and restoration models. To showcase the application of the framework a case study based on the Port of Mobile, AL is analyzed, which plays a major role in the regional economy. The framework enables further coupling with community-scale social and economic impact models.

4 **Optimal Scheduling to Minimize Multi-product Order Fulfillment Risk**

Leili Soltanisehat, Kash Barker, Andres David Gonzalez, University of Oklahoma, Norman, OK, Contact: Leili.soltanisehat@ou.edu

This study proposes a mathematical decision framework to capture the impact of interconnected risk source, on the efficiency of manufacturing processes. The proposed framework utilizes a novel MILP model to minimize the time of satisfying orders while considering the relationships among (i) material and suppliers and (ii) work operations to measure the propagation of risks throughout the production system. The proposed framework also utilizes Monte Carlo simulation to calculate the associated likelihood of delay and the distribution of the delivery time of orders. We also consider the addition of inventory buffers and storage parameters, restrictions that allow multi-product customer orders minimization of holding costs, and order late fees in satisfying different orders of various sizes.

Monday, 5 PM–6:15 PM

ME59

M - Marriott 6

Advancements in Spatial-temporal Analytics - I

General Session

Session Chair

Jian Liu, University of Arizona, Tucson, AZ

Session Chair

Fenglian Pan, University of Arizona, Tempe, AZ

1 Tensor Completion for High-dimensional Data with Graph-structured and Weakly-dependent Sample Dimension

Jiuyun Hu[1], Hao Yan[2], Ziyue LI[3], Chen Zhang[4], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, AZ, [3]The Hong Kong University of Science and Technology, NT, Hong Kong; [4]Tsinghua University, Beijing, China. Contact: jiuyunhu@asu.edu

Two major topics in spatial-temporal data analysis are missing data completion and data prediction. This paper proposed two parallel algorithms based on the CANDECOM/PARAFAC (CP) and Tucker tensor decomposition to solve the two types of tensor completion problems based on weak dependency on graph structure. The proposed method is applied to metro passenger flow missign data imputation and prediction. Better results are achieved in comparison to other state-of-the-art methods.

2 Physics-informed Machine Learning for Additive Manufacturing

Raghav Gnanasambandam[1], Bo Shen[1], Jihoon Chung[1], Xubo Yue[2], Zhenyu James Kong[1], [1]Virginia Tech, Blacksburg, VA, [2]University of Michigan, Ann Arbor, Ann Arbor, MI, Contact: raghavg@vt.edu

Additive manufacturing simulations capture the physics of the process by solving the appropriate differential equations for the given boundary conditions. These simulations are expensive and quite often needs a cheaper substitute model for various tasks. In this work, a physics informed machine learning method is proposed for modeling the additive manufacturing process. The traditional data-driven models can be enhanced with the information of the underlying physics and can be used to predict various properties of interest. The physics information is added as a set of differential equations into the machine learning model. The model also imposes boundary conditions which are typically needed to solve those equations. The results of the model are compared with the real simulation.

3 Spatial-Temporal Event Prediction Considering Latent Triggering Pattern

Fenglian Pan[1], Jian Liu[2], [12]University of Arizona, Tucson, AZ

Accurate prediction of spatial-temporal (ST) event occurrence is a critical problem with various applications, such as transportation optimization and location-based marketing. Because of the latent correlations among ST events, the occurrence of an event at a certain time and location might trigger the occurrence of new events spatially and temporally. Without explicitly considering the ST triggering mechanism, existing methods fall short in prediction accuracy. In this research, a multivariate Hawkes process is proposed to predict ST event occurrence, with latent ST triggering pattern represented in the form of structural kernel function. An algorithm is developed to enable the estimation of the model with latent triggering pattern parameters. The performance of proposed model is demonstrated in a real-world case study.

4 Data-driven Pathwise Sampling Approaches for Online Anomaly Detection

Dongmin Li[1], Miao Bai[2], Xiaochen Xian[1], [1]University of Florida, Gainesville, FL, [2]University of Connecticut, Storrs, CT, Contact: dongmin.li@ufl.edu

We propose a data-driven strategy for quick anomaly detection with Moving Vehicle-based sensors. We integrate statistical process control and mathematical optimization to monitor the system and adaptively sample from suspicious locations based on real-time data. We provide theoretical investigations and present its performance in a numerical study on wildfire detection.

Monday, 5 PM–6:15 PM

ME60

M - Marriott 7

Data-driven Methods for Process Monitoring in Advanced Manufacturing

General Session

Session Chair

Bo Shen, Virginia Tech, Blacksburg, VA

Session Chair

jihoon Chung, Blacksburg, VA

1 **Knowledge Assist Rapid Qualification of Metal-additive Manufactured Parts**

Zhaohui Geng, The University of Texas Rio Grande Valley, McAllen, TX

Additive manufacturing (AM), especially metal-AM, has become a popular manufacturing process in high-value-added industries, such as aerospace, defense, etc., because of its flexibility in design and fabrication. However, the quality of parts is still debatable in critical applications, which prevents its wider adoption by the industry. Conventional testing and qualification procedure can be time- and cost-consuming, which prolongs the throughput time of AM-printed parts. This study proposes a rapid qualification framework assisted by a knowledge base for metal-AM. The proposed system could automatically establish criteria for the parts printed by metal-AM processes based on standards, prior studies, and literature and provide recommendations for optimal production plans and equipment settings.

2 **A Continual Learning Framework for Adaptive Defect Classification and Inspection**

Wenbo Sun[1], Raed Al Kontar[2], Judy Jin[2], [1]University of Michigan Transportation Research Institute, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI

Machine-vision-based defect classification techniques have been widely adopted for automatic quality inspection in manufacturing processes. This article describes a general framework for classifying defects from high volume data batches with efficient inspection of unlabelled samples. The concept is to construct a detector to identify new defect types, send them to the inspection station for labelling, and dynamically update the classifier in an efficient manner that reduces both storage and computational needs imposed by data samples of previously observed batches. Both a simulation study on image classification and a case study on surface defect detection via 3D point clouds are performed to demonstrate the effectiveness of the proposed method.

3 **A Model-agnostic Explanations Approach to Characterize Machining Micro-dynamics Due to Material Heterogeneity: A Study of Machining Fiber-reinforced Composites**

Qiyang Ma[1], Zimo Wang[2], [1]State University of New York at Binghamton, Binghamton, NY, [2]SUNY Binghamton, Binghamton, NY

We report a model-agnostic explainable machine learning approach to unravel a fundamental understanding of the relationships between material microstructure and the in-situ machining dynamics. A convolutional neural network (CNN) links the microstructural reinforcing fibers and their impacts on changing the cutting dynamics. Next, a model-agnostic explainable machine learning approach is implemented to decipher this CNN black-box model. The investigations into machining processes of the natural fiber reinforced plastic (NFRP) composites, which possess significant structural heterogeneity, suggest that the presented approach can discover the causality of material microstructures on the resultant process dynamics and accurately predict the cutting behaviors during machining.

4 **A Decomposition-guided Attention Mechanism for Nonstationary Time Series Forecasting**

Hao Wang[1], Yu Jin[2], [1]Binghamton University, Vestal, NY, [2]Binghamton University, Binghamton, NY, Contact: hwang147@binghamton.edu

Time series forecasting of future process behavior is essential for the process monitoring and control of advanced manufacturing systems. To model complex time series dynamics of critical process signals while maintaining sufficient temporal information for accurate forecasting, a decomposition-guided attention mechanism is proposed to search for the most informative reference points to predict the target future series.

Monday, 5 PM–6:15 PM

ME61

M - Marriott 8

PERFORM: New Paradigms for Power System Operations II

General Session

Session Chair
Richard Paul O'Neill, ARPA-E, Silver Spring, MD

Session Chair
Daniel Bienstock, Columbia University, New York, NY

1 **Risk-Aware Market Clearing**
Mathieu Tanneau[1], Pascal Van Hentenryck[2], [1]Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA
The growing penetration in power grids of intermittent, renewable energy sources, have led to significant increases in prediction errors, affecting the reliability and efficiency of existing deterministic market-clearing optimization models. The Risk-Aware Market Clearing (RAMC) project was initiated to investigate how to move from this deterministic setting into a risk-aware framework where uncertainty is quantified explicitly and incorporated in the market-clearing optimizations. Risk-aware market-clearing raises challenges on its own, primarily from a computational standpoint. This paper reviews how RAMC approaches risk-aware market clearing and presents some of its innovations in uncertainty quantification, optimization, and machine learning. Experimental results on real networks are presented.

2 **Presenter**
Michael C. Caramanis, Boston University, Boston, MA

3 **Power Grid Forecasting, Decision Learning, and Risk Evaluation**
Sankaran Mahadevan, Vanderbilt University, Nashville, TN
In the renewable generation-dominated power grid of the future, grid operators will need the ability to evaluate operational risk due to the variability of weather, generation, and/or load forecasts during the day. The risk evaluation requires solving the security-constrained economic dispatch (SCED) optimization problem for many scenarios. We present an efficient computational approach that combines scenario forecasting, machine learning of optimization solutions, and evaluation of risk metrics. The risk metrics are evaluated at three levels: conditional expectation, probability of occurrence, and risk cost. Techniques are proposed to significantly reduce the computational burden of the forward uncertainty propagation and allow fast, real-time risk estimation. The proposed approach is illustrated through application to a power grid of realistic size.

Monday, 5 PM–6:15 PM

ME62

M - Marriott 9
Sector Coupling and Electrification
General Session

Session Chair
Michael Craig, University of Michigan, Ann Arbor, MI

1 **Deployment Pathways of Small Modular Reactors in Electric Power and Industrial Markets to Achieve Cost Reductions and Widespread Use**
Max Vanatta, Michael T. Craig, University of Michigan, Ann Arbor, MI, Contact: mvanatta@umich.edu
Hard to decarbonize industrial heat processes provide a niche for early deployment of Small Modular Reactors (SMRs). We quantify the economic viability of SMRs selling heat and electricity to industrial and wholesale power markets, respectively. We use a profit maximizing optimization model that controls hourly heat and power output by the SMR with and without thermal energy storage. By running this model through a parameter sweep of reactor characteristics, we identify high-value SMR design features. We find that SMRs are only profitable for certain low temperature industries and within higher electricity price markets under current conditions.

2 **Investigating Technical and Market Synergies Between Nuclear Power Plants and Hydrogen Production in The USA**
Ruaridh Macdonald[1], Dharik Sanchan Mallapragada[2], Jacopo Buongiorno[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, Contact: rmacd@mit.edu
Many have suggested co-locating hydrogen electrolyzers with nuclear power plants (NPPs) in order to directly access low-cost heat and electricity. Such a joint facility might shield NPPs from low electricity prices while also producing cheaper and greener hydrogen than from an independent electrolyzer purchasing electricity from the grid. In this study, we compared these joint and independent facilities for existing NPPs in the USA and upcoming advanced reactors. To do so, we have developed a detailed non-linear model of NPPs and several electrolyzer types which optimizes their sizing and operation, considering both heat and electricity. We show that market effects and technical synergies may allow joint facilities to produce cheaper hydrogen and how this depends on the scale of the hydrogen facility, future electricity prices and future equipment costs.

3 Infrastructure Planning for Integrated Transportation and Energy Distribution Networks

Sijia Geng[1], Thomas Lee[2], Dharik Sanchan Mallapragada[3], Audun Botterud[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, Contact: sgeng@mit.edu

Transportation electrification is an important pathway to decarbonize the transportation sector. Promising directions include battery electric vehicles that draw electricity from the grid or local renewable resources, and fuel cell electric vehicles that utilize low-carbon fuels such as hydrogen. Electrified transportation leads to tighter integration between transportation and energy distribution systems. We develop optimization models for planning infrastructures for fast-charging and hydrogen fueling for heavy-duty electric vehicle fleets. Various energy technologies, including renewable generation and on-site hydrogen production, are evaluated to identify the optimal configuration to meet future transportation needs. We demonstrate the integrated optimization framework on a case study of Boston's transit bus and energy distribution networks.

Monday, 5 PM–6:15 PM

ME63

M - Marriott 10

Learning-enabled Control and Management of Distributed Energy Resources

General Session

Session Chair

Bolun Xu, Columbia University, New York, NY

Session Chair

Yuanyuan Shi, 1</sup

1 A Neural Lyapunov Approach to Transient Stability Assessment of Power Electronics-interfaced Networked Microgrids

Tong Huang, San Diego State University, San Diego, CA, Contact: tonghuang21@gmail.com

This talk introduces a novel Neural Lyapunov method-based transient stability assessment framework for networked microgrids. The assessment framework aims to determine the large-signal stability of the networked microgrids and to characterize the disturbances that can be tolerated by the networked microgrids. The challenge of such assessment is how to construct a behavior-summary function for the nonlinear networked microgrids. By leveraging strong representation power of neural network, the behavior-summary function, i.e., a Neural Lyapunov function, is learned in the state space. Case studies suggest that in comparison with conventional methods that are based on quadratic Lyapunov functions, it can characterize the stability regions with much less conservativeness.

2 Network-aware Electric Load Coordination

Johanna L. Mathieu, University of Michigan, Ann Arbor, MI

Aggregations of flexible electric loads can be coordinated to provide a variety of services to the power grid. However, we must be careful that, when coordinated, they do not cause problems like over/undervoltages in the distribution grid. This problem is challenging because the entity that controls the loads (e.g., a load aggregator) may not have detailed knowledge of the network. We propose a method for the aggregator and distribution network operator (electric utility) to coordinate, and different approaches to solve the aggregator's control problem and distribution network operator's problem, which must ensure network safety.

3 Degradation-aware Optimal Battery Control Using Reinforcement Learning

Kyung-bin Kwon[1], Hao Zhu[2], [1]The University of Texas at Austin, Ausitn, TX, [2]The University of Texas at Austin, Austin, TX, Contact: kwon8908kr@utexas.edu

To solve the optimal battery control problem that minimizes the operational costs using the reinforcement learning algorithms, this talk aims to develop a new representation of the cycle-based battery degradation model according to the rainflow algorithm. We propose a new Markov Decision Process form by introducing additional state variables to keep track of past switching points for determining the cycle depth. The proposed degradation model allows to adopt deep Q-Network algorithm to efficiently search for the policy. Numerical tests have demonstrated the performance improvements of the proposed cycle-based degradation model in mitigating its degradation, as compared to earlier work using the linearized approximation.

4 Demand Response Model Identification and Behavior Forecast with Optnet: A Gradient-based Approach

Yuexin Bian[1], Ningkun Zheng[2], Yang Zheng[1], Bolun Xu[2], Yuanyuan Shi[1], [1]University of California San Diego, La Jolla, CA, [2]Columbia University, New York, NY, Contact: yubian@ucsd.edu

Price-responsive demand side resources can adjust their energy usage in response to time-varying price signals, which provides flexibility and promotes system reliability. In this work, we propose a novel data-driven approach that incorporates prior model knowledge for predicting the behaviors of price-responsive demand resources. We propose a gradient-descent method to find the model parameters given the historical price signals and observations. We demonstrate the effectiveness of our approach through computation experiments with synthetic data using demand models including batteries, buildings, and aggregations of price-responsive loads. The proposed approach significantly improves the accuracy of both DR model identification and behavior forecasting compared to previous blackbox data-driven approaches and inverse optimization approaches.

Monday, 5 PM–6:15 PM

ME64

M - Indiana A

Michael H. Rothkopf Junior Researcher Paper Prize

Award Session

Session Chair

Martin Bichler, Technical University of Munich, Garching B. München, Germany.

1 The Best of Many Worlds: Dual Mirror Descent for Online Allocation Problems

Haihao Lu, University of Chicago Booth School of Business, Chicago, IL

Online allocation problems with resource constraints are central problems in management science and online advertising. In these problems, requests arrive sequentially during a finite horizon and, for each request, a decision maker needs to choose an action that consumes a certain amount of resources and generates reward. The objective is to maximize cumulative rewards subject to a constraint on the total consumption of resources. In this paper, we consider a data-driven setting in which the reward and resource consumption of each request are generated using an input model that is unknown to the decision maker. We design a general class of algorithms that attain good performance in various input models without knowing which type of input they are facing. In particular, our algorithms are asymptotically optimal under independent and identically distributed inputs as well as various non-stationary stochastic input models, and they attain an asymptotically optimal fixed competitive ratio when the input is adversarial. Our proposed algorithms are simple, fast, and do not require convexity in the revenue function, consumption function and action space, in contrast to existing methods for online allocation problems. Furthermore, it is robust to estimation error in landscape estimation. We discuss applications to budget pacing in online advertising.

2 Effective Wages under Workforce Scheduling with Heterogeneous Time Preferences

Omar Besbes[1], Vineet Goyal[1], Garud Iyengar[1], Raghav Singal[2], [1]Columbia University, New York, NY, [2]Tuck School of Business at Dartmouth, Hanover, NH

Motivated by the substandard drivers' welfare in on-demand platforms, we propose a market design framework for workforce scheduling. The platform maximizes profit by gathering supply via an admission control policy, which allocates hourly slots ("right to drive") to drivers. Each driver maximizes her expected utility, which depends on her temporal preference regarding when to drive, the slots she receives, and the time she spends on-road. We use our framework to evaluate existing policies and show they can result in highly suboptimal effective wage. Then, we propose a mechanism and establish tight performance guarantees with respect to both profit and wages. We support our theoretical developments via numerical simulations calibrated to New York City data.

3 Asymmetric Risk and Fuel Neutrality in Electricity Capacity Markets

Jacob Mays, Cornell University, Ithaca, LA

Monday, 5 PM–6:15 PM

ME65

M - Indiana B

Issues in Renewable Energy Auctions and Market Design

General Session

Session Chair

Joseph Edward Duggan, University of Dayton, Grove City, OH

1 Pricing Under Uncertainty in Multi-interval Real-time Markets

Jehum Cho, CORE (Center for Operations Research and Econometrics), Louvain-la-Neuve, Belgium. Contact:

jehum.cho@uclouvain.be

Recent research has demonstrated that real-time auctions can generate the need for side payments, due to the rolling nature of real-time market clearing. This observation has inspired proposals for modifying the real-time market clearing model. We extend this analysis in order to account for uncertainty by proposing a real-time market clearing model with look-ahead and an endogenous representation of uncertainty. We define two different types of expected lost opportunity cost as performance metrics. Our market clearing model provides the price signal minimizing one of these metrics using the Stochastic Gradient Descent algorithm. We present results from a case study of the ISO New England system under a scenario of significant renewable energy penetration while accounting for ramp rates, storage, and transmission constraints.

2 The Impact of Discontinuous Costs in Markets with High Variable Renewable Generation

Muireann Lynch[1], Mel Devine[2], [1]Economic and Social Research Institute, Dublin, Ireland; [2]University College Dublin, Dublin, Ireland.

Electricity market dispatch on the basis of short-run marginal costs ensures efficiency, with the correct short and long run incentives. However, this in turn assumes no discontinuities in the dispatch. In practice, discontinuities appear in the dispatch problem, including start costs, no load costs and minimum generation values. Generally, these discontinuous costs are low enough to ignore from the dispatch problem. As variable renewable generation increases, however, discontinuous costs make up a larger share of total costs. The impact of this has not been studied in a market (as opposed to a least-cost) framework. This research presents an examination of electricity market dispatch via a competitive auction with market power and high levels of RES-E to examine these issues.

3 Auction Format in Energy Procurements

Margarita Patria, Charles River Associates, Boston, MA

Auction-based energy procurements are used widely in the US. This study focuses on procurement mechanisms used by utilities to secure default service supply and renewable energy resources. We start with the history of auction implementation in energy, introduce the main stakeholders, and cover the regulatory approval process. We examine key aspects that inform the auction design: objectives and constraints of the stakeholders, product definition, likely participants, feasibility and timing. Two auction designs known to industry insiders are Requests for Proposal (RFPs), which often is the term used for one-shot sealed bid, and structured round-by-round bidding auctions such as “clock” auctions. We discuss the reasons one format is chosen over the other, provide real-life examples, and cover practical mechanism design tools used in auction implementations.

4 Pricing Optimal Outcomes in Coupled and Non-convex Markets: Theory and Applications to Electricity Markets

Mete Ş. Ahunbay[1], Martin Bichler[2], Johannes Knörr[1], [1]Technical University of Munich, Garching B. München, Germany; [2]Technical University of Munich, Garching B. München, Germany.

In many real-world markets, participants have non-convex preferences and the allocation problem needs to consider complex constraints. Electricity markets are a prime example. In such markets Walrasian prices are impossible, and heuristic pricing rules based on the dual of the relaxed allocation problem are used. We show that existing pricing heuristics optimize specific design goals that can be conflicting. The trade-offs can be substantial, and we establish that the design of pricing rules is fundamentally a multi-objective optimization problem. In addition to traditional weighing techniques, we introduce a novel parameter-free pricing rule to balance trade-offs in a principled manner. Our findings show how the new pricing rule capitalizes on the upsides of existing pricing rules under scrutiny today, addressing an important policy issue in electricity markets.

Monday, 5 PM–6:15 PM

ME66

M - Indiana C
ENRE/Energy Flash Session
Flash Session

Session Chair
Kylie Meier, Wichita State University, Wichita, KS

1 Targeted Demand Response for Mitigating Price Volatility and Enhancing Grid Reliability in Synthetic Texas Electricity Markets

Kiyeob Lee[1], Xinbo Geng[1], S. Sivaranjani[1], Bainan Xia[2], Hao Ming[3], Srinivas Shakkottai[1], Le Xie[1], [1]Texas A&M University, College Station, TX, [2]Breakthrough Energy, Seattle, WA, [3]Southeast University, Nanjing , Jiangsu, China. Contact: kiyeoblee@tamu.edu

Demand response (DR) holds great potential to enhance the grid reliability with deep renewable energy penetration. We reveal that small load reductions at a handful of targeted locations can lead to significant decrease in price volatility and grid congestion levels based on a synthetic Texas grid model. Our findings suggest that targeted DR at specific locations, rather than across-the-board DR, can have substantial benefits to the grid.

2 Optimally Scheduling Public Safety Power Shutoffs

Antoine Lesage-Landry[1], Félix Pellerin[1], Joshua A. Taylor[2], Duncan S. Callaway[3], [1]Polytechnique Montréal, Montréal, QC, Canada; [2]University of Toronto, Toronto, QC, Canada; [3]University of California, Berkeley, Montréal, QC, Canada. Contact: antoine.lesage-landry@polymtl.ca

In an effort to reduce power system-caused wildfires, utilities carry out public safety power shutoffs (PSPS) in which portions of the grid are de-energized to mitigate the risk of ignition. The decision to call a PSPS must balance reducing ignition risks and the negative impact of service interruptions. In this work, we consider three PSPS scheduling scenarios, which we model as dynamic programs. We provide optimal or asymptotically optimal policies for each case, the first two of which have closed-form expressions. Lastly, we show the equivalence between the first PSPS model and critical-peak pricing, and obtain an optimal scheduling policy to reduce the peak demand based on weather observations.

3 The Cost of Privacy for Energy Sectors Coordination

Iesia Mitridati, ETH Zurich, Zurich, Switzerland.

In this talk we address the privacy concerns arising from market-based coupling of multiple energy systems, such as natural gas, district heating and electricity. We propose a novel privacy-preserving Stackelberg mechanism (w-PPSM) which generates differentially-private data streams with high fidelity.

This approach facilitates the exchange of privacy-preserving information between independent market and system operators in energy systems while ensuring near-to-optimal coordination between them. It also opens the way to quantify the value of information and design privacy-aware market mechanisms.

4 Understanding The Evolution of Water Recycling Production Cost: An Experience Curve Approach

Christian Hernandez-Negron, Erin Baker, University of Massachusetts-Amherst, Amherst, MA

Recycling and reuse of treated water from the wastewater stream is a priority in building a more sustainable water system. There is, however, a lack of understanding of how this industry has evolved in terms of annual production and costs over time. We propose to estimate the *learning rate* for water recycling technology, especially related to production costs, using experience curve analysis based on data gathered from wastewater treatment plants in the United States. Exploring how water recycling technologies have been adopted and advanced historically will provide a basis for forecasting the evolution of new technologies under development.

5 Climate and Carbon-aware Supply Chain Decision Making

Kedar Kulkarni[1], Isaac Wambugu[2], Reginald Bryant[2], Varun Punnathanam[3], Yogendra Shastri[3], [1]IBM Research, Bangalore, India; [2]IBM Research, Nairobi, Kenya; [3]IIT-Bombay, Mumbai, India. Contact: kdkulkar@in.ibm.com

Many enterprises are under significant pressure from investors, consumers, and policymakers to mitigate and adapt to the ill-effects of climate change due to their supply chains. However, a major challenge in realizing the benefits of carbon and climate-aware decision making is effectively addressing the inherent trade-off between costs, carbon emissions and climate risk. In this talk, we will present a generic multi-objective optimization approach that effectively balances this tradeoff with minimal cost over-runs. We will also illustrate this approach with a few results from standard supply chain use-cases like supplier selection, inventory optimization and last-mile delivery.

6 Redefining Resource Adequacy in Modern Power Systems

Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX

Resource adequacy (RA) refers to the ability of a power system to satisfy demands for electricity using its supply-side and demand-side resources. Monitoring and planning to achieve RA are becoming more difficult due to changes in the power sector including the expansion of variable renewables, coal plant retirements, and energy storage deployment. This flash talk will (1) identify common weaknesses of current RA assessment practices and (2) summarize technical results from a study about which power system operational details are crucial to capture in a model-based, probabilistic RA assessment.

7 Enhancing Policy Realism in Energy System Optimization Models: Politically Feasible Decarbonization Pathways for The United States

Qianru Zhu[1], Benjamin D. Leibowicz[2], Joshua W. Busby[2], Sarang Shidore[2], David E. Adelman[2], Sheila M. Olmstead[2], [1]Electric Power Research Institute, Palo Alto, CA, [2]University of Texas-Austin, Austin, TX, Contact: qzhu@epri.com

We adopt a novel approach to integrate political-organizational and techno-economic considerations to analyze decarbonization pathways for the United States. We implement three portfolios of granular policies that target greenhouse gas emissions reductions in the US-TIMES model. Our findings reveal that greater political alignment enables electrification to play a more significant role as a central component of decarbonization. Moreover, if the political environment allows more ambitious climate policies, deeper decarbonization can be achieved at a lower average abatement cost because more economically efficient policy instruments become politically feasible.

8 Degradation Modeling in Overhead Transmission Lines Due to Operational and Severe Weather Conditions

Kylie Meier[1], Visvakumar Aravinthan[1], Al Tamimi[2], Mehmet Bayram Yildirim[1], Ryan Yokley[2], Ehsan Salari[1], [1]Wichita State University, Wichita, KS, [2]Sunflower Electric, Wichita, KS

Overhead transmission lines are an essential component of transmission networks. Excessive power flow and severe weather events may adversely affect the health of transmission lines. The goal of this study is to develop a stochastic model to quantify and project the degradation of overhead transmission lines over time. Using permanent elongation as a surrogate for the conductors' health, we employ stress-strain models to calculate existing permanent elongation based on the observed sag in conductors. We then employ creep prediction models to project any additional elongation that may occur when the conductor is exposed to a sequence of future stress events due to operational and weather conditions. The proposed degradation model can be applied to perform asset condition monitoring and prediction for transmission lines.

Monday, 5 PM–6:15 PM

ME67

M - Indiana D

Dynamic Decision-making in Revenue Management

General Session

Session Chair

Dana Pizarro, University of Chile, Santiago, Chile.

1 An Improved Analysis of Lp-based Control for Revenue Management

Guanting Chen[1], Xiaocheng Li[2], Yinyu Ye[3], [1]University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]Imperial College Business School, London, United Kingdom; [3]Stanford University, Stanford, CA, Contact: guanting@stanford.edu

We study the revenue management problem where the decision maker aims to maximize the total reward subject to budget constraints on multiple type of resources over a finite horizon. We propose fairness in a way that a fair online algorithm should treat similar agents similarly, and the decision made for similar agents should be consistent over time. We define the fair offline solution as the analytic center of the offline optimal solution set, and introduce cumulative unfairness as the cumulative deviation from the online solutions to the fair offline solution over time. We develop a fair algorithm that achieves cumulative unfairness on the order of O(log(T)), while maintains the regret to be bounded without dependency on T under a less restrictive nondegeneracy assumption compared to the literature.

2 Real-Time Omnichannel Fulfillment Optimization

Zuguang Gao, Zi Ling, Varun Gupta, Linwei Xin, Booth School of Business, University of Chicago, Chicago, IL, Contact: zling@chicagobooth.edu

Motivated by the rapid development of e-commerce business, we study an online optimization problem in the context ofomnichannel. Suppose a retailer has multiple brick-and-mortar stores and each store has an initial inventory. There are two streams of demands: online and offline. An online customer can be fulfilled by any store, whereas an offline customer must be satisfied by the local store. We assume that the offline customers have higher margin than online customers. We develop efficient online algorithms with performance guarantees. Interestingly, when there is only one store, our model reduces to the classical one-itinerary two-fare RM model by Ball and Queyranne (2009), and we extend their model and results to the multi-itinerary setting.

3 Subscription Vs. Spot Pricing in On-demand Economy

Ming Hu, Taojie Qin, Zhoupeng Zhang, Rotman School of Management, University of Toronto, Toronto, ON, Canada.

We study and compare the implications of two practically grounded pricing schemes in an on-demand service economy, the subscription and spot pricing. We develop a game-theoretic queueing framework to model the matching process between consumers and workers on a platform. When consumers' valuations for the services are homogeneous, we show that the subscription always yields a lower profit than the spot pricing for the platform operator; yet if the market size is not very high relative to the labor pool size, we find that the ratio of the subscription profit to the spot pricing profit is bounded below by a constant about 90%. In addition, the transaction volume can be higher under the subscription than the spot pricing. The operational implications of these two pricing schemes change dramatically when consumers' valuations become heterogeneous ex post.

4 Dynamic Resource Constrained Reward Collection Problems: Unified Model and Analysis

Santiago Balseiro[1], Omar Besbes[2], Dana Pizarro[3,4], [1]Columbia University, Armonk, NY, [2]Columbia University, New York, NY, [3]Toulouse School of Economics, Toulouse, France; [4]Universidad de O'Higgins, Rancagua, Chile. Contact: danapizarro@gmail.com

Dynamic resource allocation problems arise under a variety of settings and have been studied across disciplines such as Operations Research and Computer Science. In this talk, we introduce a unifying model for a very large class of dynamic optimization problems, that we call dynamic resource constrained reward collection. We show that this class encompasses a variety of disparate and classical dynamic optimization problems such as dynamic pricing with capacity constraints, network revenue management, or online matching, to name a few. Furthermore, we characterize the performance of the fluid certainty equivalent control heuristic for this class. This result recovers some existing specialized results, generalizes others by weakening the assumptions required, but also yields new results in specialized settings for which no such characterization was available.

Monday, 5 PM–6:15 PM

ME68

M - Indiana E

Data, Society, and Algorithms

General Session

Session Chair

Asuman Ozdaglar, Massachusetts Institute of Technology, Cambridge, MA

Session Chair

Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA

1 Algorithmic Design: Fairness Versus Accuracy

Annie Liang, Evanston

Algorithms are increasingly used to guide consequential decisions, such as who should be granted bail or be approved for a loan. In some cases, the errors of these algorithms differ sharply across subgroups of the population. What are the tradeoffs between accuracy and fairness, and how do these tradeoffs depend on the inputs to the algorithm? We propose a model in which a designer chooses an algorithm that maps observed inputs into decisions, and introduce a *fairness-accuracy Pareto frontier*. We identify how the algorithm's inputs govern the shape of this frontier, showing (for example) that access to group identity reduces the error for the worse-off group everywhere along the frontier. We then apply these results to study an "input-design" problem where the designer controls the algorithm's inputs, but the algorithm itself is chosen by another agent.

2 Privacy Costs of Strategic Data Sharing: Implications of Shuffling

Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA

We consider a data market problem in which privacy-concerned users strategically share data with a platform. The users' data contains information about the underlying parameter of interest (to both users and the platform) but also reveals information about the private type of users, harming their utility. We first establish that a shuffling-based mechanism, in which the platform observes users' data only after being shuffled, is optimal in the class of all mechanisms. Next, we characterize the equilibrium of the game among the users and the platform and establish that when users gain from learning the underlying parameter increases, interestingly, their overall equilibrium utility could decrease.

3 Evaluating Stochastic Seeding Strategies in Networks

Alex Chin[1], Dean Eckles[2], Johan Ugander[3], [1]Lyft, San Francisco, CA, [2]MIT, Cambridge, MA, [3]Stanford University, Stanford, CA

Many strategies for seeding in networks have been proposed, but empirical evaluations have demanded large field experiments designed specifically for this purpose and have yielded relatively imprecise comparisons of strategies. Here we show how stochastic seeding strategies can be evaluated more efficiently in such experiments, how they can be evaluated "off-policy" using existing data arising from experiments designed for other purposes. We apply our proposed analyses to two field experiments, one that assigned households to an intensive marketing intervention and one that assigned students to an anti-bullying intervention.

4 Improving Communication with End Users About Differential Privacy

Priyanka Nanayakkara[1], Mary Anne Smart[2], Rachel Cummings[3], Gabriel Kaptchuk[4], Elissa Redmiles[5], [1]Northwestern University, Evanston, IL, [2]University of California San Diego, San Diego, CA, [3]Columbia University, New York, NY, [4]Boston University, Boston, MA, [5]Max Planck Institute, Saarbrucken, Germany.

As differential privacy (DP) grows in popularity, it is important for end users (i.e., those contributing data) to be able to reason about the strength of the protection it provides. Drawing on theory and best practice from the domains of human-computer interaction and risk communication, we develop prototype descriptions designed to help end users understand DP guarantees. We also propose a plan for refining and evaluating our descriptions.

Monday, 5 PM–6:15 PM

ME69

M - Indiana F

Statistical Learning and Optimization for Revenue Management

General Session

Session Chair

Ruihao Zhu, Purdue Krannert School of Management, Chicago, IL

1 Active Learning for Non-parametric Choice Models

Fransisca Susan[1], Negin Golrezaei[2], Ehsan Emamjomeh-Zadeh[3], David Kempe[4], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Lexington, MA, [3]Meta Platforms, Inc., Seattle, WA, [4]University of Southern California, Los Angeles, CA, Contact: fsusan@mit.edu

We study the problem of actively learning a non-parametric choice model based on consumers' decisions. We show that such choice models may not be identifiable, then introduce a directed acyclic graph (DAG) representation of the choice model, which captures as much information about the choice model as could information-theoretically be identified. We design an efficient and polynomial-time active-learning algorithm to estimate the DAG representation of the non-parametric choice model. The algorithm learns the distribution over the most popular items of frequent preferences by actively and repeatedly offering assortments of items and observing the item chosen. We show that our algorithm performs better empirically compared to the existing non-active learning algorithms, demonstrating the value of our algorithm and active-learning approaches more generally.

2 Provably Efficient Constrained Reinforcement Learning with Offline Data

Yufeng Zhang, Evanston, IL

We consider constrained reinforcement learning (CRL) with offline data, which aims to maximize the expected total reward subject to constraints on the expected total utilities based on a dataset collected a priori. Offline CRL suffers from insufficient coverage over the state-action space. To this end, we propose Pessimistic Primal-Dual Policy Optimization and Pessimistic Learning and Planning for offline CRL. The algorithms follow the approach of pessimism-in-face-of-uncertainty.We show that both the suboptimality and the constraint violation of the learned policy are upper bounded by the sum of optimization errors and the intrinsic uncertainty. In tabular CMDP and linear kernel CMDP, the upper bound matches the information-theoretic lower bound in offline RL. To the best of our knowledge, we provide the first provably efficient offline CRL algorithms.

3 Optimal Non-Parametric Pricing

Achraf Bahamou[1], Omar Besbes[2], Amine Allouah[2], [1]Columbia University, NYC, NY, [2]Columbia University, New York, NY, Contact: ab4689@columbia.edu

We study the following fundamental data-driven pricing problem. How can/should a decision-maker price its product based on observations at a limited number of historical prices? The decision-maker optimizes over randomized pricing policies to maximize the worst-case ratio of the revenue she can garner compared to an oracle with full knowledge of the distribution of values when the latter is only assumed to belong to the broad non-parametric set of regular distributions. The framework we develop is general and leads to fundamental novel insights on the value of limited demand information for pricing. As applications, we characterize the value of a single gradient observation as well as one additional price experiment.

4 Combining a Smart Pricing Policy with a Simple Replenishment Policy: Managing Uncertainties in The Presence of Stochastic Purchase Returns

Alys Liang, Michigan Ross, Ann Arbor, MI

Returns have cost retailers hundreds of billions of dollars in the US. Undesirable as returns are, it is generally accepted that they cannot be entirely eliminated and lenient return policies are necessary to maintain customer loyalty.

Motivated by this reality, we ask: How can a retailer offering a free return policy improve profitability through joint inventory and pricing control? We model a single store/warehouse setting with lost sales, positive lead time, periodic review, and Binomial demand. Any purchase can be returned at a full refund within a grace period. We develop an easy-to-implement heuristic policy that combines a ``smart'' adaptive pricing policy with a very simple replenishment policy. We show that uncertainties in both demands and returns can be effectively managed by the price control and our results can be extended to various general settings.

Monday, 5 PM–6:15 PM

ME70

M - Indiana G

ICS Awards

Award Session

Session Chair

Akshay Gupte, University of Edinburgh, Edinburgh, United Kingdom.

1 ICS Prize

Ricardo Fukasawa[1], Jonathan Eckstein[2], Ignacio Grossmann[3], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Piscatway, NJ, [3]Carnegie Mellon University, Pittsburgh, PA

Winners: Saeed Ghadimi (Waterloo), Guanghui Lan (Georgia Tech), Hongchao Zhang (Louisiana State)Citation: For their pioneering work on nonconvex stochastic optimization methods, as detailed in the papers:•Saeed Ghadimi and Guanghui Lan, "Stochastic first- and zeroth-order methods for nonconvex stochastic programming", SIAM Journal on Optimization 23(4), 2341-2368, 2013.•Saeed Ghadimi, Guanghui Lan and Hongchao Zhang, "Mini-batch stochastic approximation methods for nonconvex stochastic composite optimization", Mathematical Programming 155(1-2), 267-305, 2016.•Saeed Ghadimi and Guanghui Lan, "Accelerated gradient methods for nonconvex nonlinear and stochastic programming", Mathematical Programming 156 (1-2), 59-99, 2016.Nonconvex stochastic optimization comprises an important class of problems that are extremely challenging and have many applications. The three prize-winning papers contain several groundbreaking results in this area. In the first paper, the authors propose a novel randomized stochastic gradient descent method for unconstrained problems and establish, for the first time in the literature, complexity results for such types of algorithms. In the second paper, the authors adapt their methods to the constrained case by using a mini-batch of samples at each iteration. Their complexity results in such situations are shown to be near-optimal for the convex case. The third paper provides a generalization of Nesterov's accelerated gradient (AG) method for nonconvex stochastic optimization problems and derives for the first time convergence results for these kinds of algorithms in the nonconvex case, showing optimal/best known rates of convergence when applied to some specific classes of problems. This work is based on solid, original, and innovative mathematical ideas and significantly advances the state-of-the-art in the field. In addition, given the amount of interest in these kinds of algorithms, the work is expected to have a significant impact in Operations Research, Computer Science, and other areas. Indeed, the three papers already have a total of over 1800 citations.

2 Harvey J. Greenberg Research Award

Archis Ghate[1], Ariela Sofer[2], David Woodruff[3], [1]University of Washington, Seattle, WA, [2]George Mason University, Fairfax, VA, [3]University of California - Davis, Davis, CA

Winners: Zeyu Liu and Anahita Khojandi and Xueping Li and Akram Mohammed and Robert L Davis (Tennessee), and Rishikesan Kamaleswaran (Emory). Citation: For their paper "A Machine Learning-Enabled Partially Observable Markov Decision Process Framework for Early Sepsis Prediction", INFORMS Journal on Computing, published online March 22,2022.Sepsis can be triggered by the body's extreme response to an infection and can be life-threatening. Existing sepsis prediction algorithms suffer from high false-alarm rates. The authors present an integrated machine learning (ML) and partially observable Markov decision process framework to address this issue. This approach is calibrated and tested using physiological data collected from bedside monitors. The framework reduces false-alarm rates and improves sepsis prediction accuracy compared to existing ML benchmarks. This is a comprehensive paper with novel contributions to computing and important practical implications. The committee members commend the authors for this excellent work.

3 Student Paper Award

Erick Moreno-Centeno[1], Manish Bansal[2], Susan Hunter[3], Alain Zemkoho[4], [1]Texas A&M University, College Station, TX, [2]Virginia Tech, Blacksburg, VA, [3]Purdue University, Indianapolis, IN, [4]University of Birmingham, Southampton, United Kingdom.

Winner: Irina Wang (Princeton) for the paper "Mean Robust Optimization", arXiv:2207.10820, co-authored with Cole Becker (Princeton), Bart Van Parys (MIT), and Bartolomeo Stellato (Princeton) This paper introduces a framework that combines robust optimization with Wasserstein distributionally robust optimization. Notably, her algorithm provides an elegant mechanism to balance the trade-off between computational effort and conservatism. In a nutshell, the technique reduces the data points significantly (expediting computation) and carefully (preserving fundamental properties). The framework is accompanied by elegant theory giving finite-sample performance guarantees and conditions for which clustering does not increase conservatism and otherwise provides bounds on the effect on conservatism. The paper illustrates the efficiency and effectiveness of the framework with a thorough and meticulous computational study. The committee also praises the authors for making their code publically available.

Monday, 5 PM–6:15 PM

ME71

M - Arizona

Mathematical Optimization for Large-scale Problems

General Session

Session Chair

Chen Chen, The Ohio State University, Columbus, OH

1 Rank Pump for Polynomial Optimization

Daniel Bienstock[1], Pablo Carrasco[2], Chen Chen[3], Gonzalo Munoz[4], [1]Columbia University, New York, NY, [2]Universidad De O'Higgins, Rancagua, Chile; [3]The Ohio State University, Columbus, OH, [4]Universidad de O'Higgins, Rancagua, Chile.

The feasibility pump is a well-known primal heuristic for integer programming that involves two alternating sequences of projections. The original pump was designed for binary problems, and found such projections using linear programming and simple rounding. Unfortunately, the elegance of the pump may be lost in other settings. For instance, a natural extension of the pump to nonconvex MINLP involves NP-hard projection problems. We present our adaptation of the feasibility pump to polynomial optimization, called the rank pump. The rank pump has polynomial-time iterations, as its projection problems can be solved in polynomial time.

2 A First-order Algorithm to Optimize Functions with Biased Stochastic Oracles

Sam Davanloo[1], Yin Liu[2], [1]The Ohio State University, Columbus, OH, [2]The Ohio State University, Columbus`, OH, Contact: davanloo.1@osu.edu

This work considers optimization of functions which are only available through biased first-order stochastic oracles. While the bias of the oracle can be controlled, reduced biased demands higher computation. The purpose of this work is to propose a first-order stochastic optimization algorithm which considers overall computational complexity instead of regular iteration or sample complexity and establish its convergence properties under different convexity settings.

3 Distributed Projections onto a Simplex

Yongzheng Dai, Chen Chen, The Ohio State University, Columbus, OH, Contact: dai.651@osu.edu

Projecting a vector onto a simplex is a well-studied problem that arises in a wide range of optimization problems. Numerous algorithms have been proposed for determining the projection; however, all but one of these algorithms are serial. We address this gap by developing a method that preprocesses the input vector by decomposing and distributing it across multiple processors for local projection. Our method is especially effective when the projection is highly sparse; which is the case, for instance, in large-scale problems. Moreover, the method can be adapted to work with a broad range of serial algorithms from the literature. We fill in theoretical gaps in serial algorithm analysis, and develop similar results for our parallel analogues. Numerical experiments conducted on a wide range of large-scale instances demonstrate the practical effectiveness of the method.

4 Exact Approaches for Stochastic Vehicle Routing Problems with Scenarios

Matheus Jun Ota, University of Waterloo, Waterloo, ON, Canada. Contact: matheusota@gmail.com

The Vehicle Routing Problem with Stochastic Demands (VRPSD) is a variant of the classic CVRP where the demands are random variables. In this work, we study different exact approaches for solving the VRPSD. The two most common approaches for dealing with uncertainty is to model the VRPSD as a Two-Stage Stochastic Program (2S-VRPSD) or as a Chance-Constraint Program (CC-VRPSD). A third model, which has not been investigated previously, is a combined approach, called the Two-Stage Chance-Constraint Vehicle Routing Problem with Stochastic Demands (2SCC-VRPSD): in this variant we aim to minimize the total cost (accounting for the recourse costs) over the same feasible region as in CC-VRPSD. We propose new exact algorithms for the 2S-VRPSD and 2SCC-VRPSD when the probability distribution of the demands are given by a finite set of scenarios.

Monday, 5 PM–6:15 PM

ME72

M - California
Persuasion in Social Networks
General Session

Session Chair
Tauhid Zaman, Prague

1 **Narrative Transitions Using Neural Networks**
Khizar Qureshi, MIT, San Francisco, CA
We are given twonarratives, and the goal is to generate a sequence of messages that connect theinitial narrative to the final narrative in a logical and coherent manner. Werefer to this as a narrative transition. These messages can be used to persuadeindividuals who support one narrative to support another narrative. Weconstruct these messages using two steps. First, we train two Word2Vec modelson sentiment specific social media posts supporting the initial and finalnarratives. Then we use these models to find a logical path of narrativesbetween the initial and final narratives. Finally, we use the GPT-3 transformerto generate messages that transition between the narratives on this path. Wegenerate human sounding messages to transition from topics such as football orcryptocurrency to a final narrative of supporting (or opposing) vaccines.

2 **Cryptocurrency Performance and Social Media**
Tauhid Zaman, Yale University, New Haven, CT, Contact: tauhid.zaman@yale.edu
We study the relationship between social media activity about cryptocurrencies and their financial performance. We propose a Poisson model for the engagement of an audience with a topic discussed in social media. This model allows us to estimate an engagement coefficient for a topic based on interactions with posts about the topic. We estimate this model for cryptocurrencies created between 2019 and 2021. We find that cryptocurrencies with either very low or very high values for the engagement coefficient have low future returns. Low values indicate lack of engagement, while high values suggest artificial engagement from bots. We use the engagement coefficient to select cryptocurrencies for investment and find that we are able to improve the returns of our portfolio substantially.

3 **Control of Nonlinear Opinion Dynamics in Social Networks**
Yen-Shao Chen, Tauhid Zaman, Yale University, New Haven, CT, Contact: yen-shao.chen@yale.edu
Our goal is to persuade large-scale social networks. Persuasion here means using agents to optimize a function of the opinions in the network. Many of the opinion dynamics models which capture realistic behaviors are nonlinear. This nonlinearity makes it difficult to learn a policy that optimizes the opinion function. In this study, we provide a mathematical model that describes nonlinear opinion dynamics and learn a policy to maximize the mean opinion using optimal control theory. Our control policy not only achieves the optimal objective in certain networks, but it is interpretable, scalable, and efficient for human-like agents in large-scale social networks.

Monday, 5 PM–6:15 PM

ME73

M - Colorado
Smart City Operations: Innovative Technologies
General Session

Session Chair
Neda Mirzaeian, Carnegie Mellon University, Pittsburgh, PA

1 **Getting out of Your Own Way: Managing Human Drivers and Autonomous Vehicles on a Ride-hailing Platform**
Francisco Castro[1], Andrew E. Frazelle[2], [1]UCLA Anderson School of Management, Los Angeles, CA, [2]The University of Texas at Dallas, Dallas, TX
We study a game-theoretic model of a ride-hailing platform with a private AV fleet that also recruits self-interested human drivers. The platform sets the human-driver wage and the AV deployment quantity, and human drivers make strategic joining decisions based on a rational anticipation of their expected earnings. We show that growing its AV fleet too quickly while the AV cost is still relatively high can be a costly mistake for the platform. Doing so triggers a feedback loop of increasing wages and increasing AV deployment, such that the platform prices itself out of the market for human drivers. This “race to the top” effectively prevents the platform from attracting more than a limited number of human drivers, and it increases the cost of attracting a given number. Nonetheless, we prove that the platform can escape the race to the top by optimally limiting its AV fleet size.

2 **Integrated Planning and Control of Drone Networks for Emergency Medical Response**
Jamal Chu[1], Sheng Liu[1], Wei Qi[2], Timothy Chan[1],

[1]University of Toronto, Toronto, ON, Canada; [2]McGill University, Montreal, QC, Canada. Contact: jamal.chu@mail.utoronto.ca

Drones have been proposed as a supplemental response to medical emergencies such as cardiac arrest and anaphylactic shock through the delivery of time-critical supplies. Recent work has focused on separate drone base placement and heuristic dispatch policies via two-stage models, which may lead to performance loss compared to an integrated model. We first propose a new dispatch policy and prove that it is optimal under the assumption that drones have non-overlapping coverage zones. We then propose a novel stochastic integer program to jointly optimize base placements and dispatch policies and compare our integrated placement-dispatch model to a two-stage model.

3 Evolution of Ride Services: From Ride-hailing to Autonomous Vehicles

Tunay Tunca[1], Daehoon Noh[2], Yi Xu[3], [1]Robert H. Smith School of Business, College Park, MD, [2]University of California, San Diego, San Diego, CA, [3]University of Maryland, College Park, MD

We study the strategic interaction between a ride-hailing platform service model and a vertically integrated autonomous vehicle based ride service model. Utilizing a game-theoretical model, we examine the competition between the two business models and its effects on market outcome, firm profits and social welfare.

Monday, 5 PM–6:15 PM

ME74

M - Florida

Derivatives Market

General Session

Session Chair

XUEWEI Yang, Nanjing University, Nanjing, China.

Session Chair

Yanchu Liu, Sun Yat-sen University, Guangzhou, China.

1 Leverage and Individual Investors' Performance:

XUEWEI Yang, Nanjing University, Nanjing, China.

We use transaction-level data from the futures market to analyze the relationship between leverage and trading performance. We show that leverage stimulates de facto liquidity provision by skilled investors, and enhances their daily returns by 19.3 bps per unit. Unskilled investors' leverage amplifies their losses. Forced liquidations largely account for the negative impact of leverage on performance.

2 Stochastic Gradient Hamiltonian Monte Carlo for Non-convex Stochastic Optimization

Xuefeng Gao[1], Mert Gurbuzbalaban[2], Lingjiong Zhu[3], [1]Chinese University of Hong Kong, Hong Kong, Hong Kong; [2]Rutgers University, Piscataway, NJ, [3]Florida State University, Tallahassee, FL, Contact: lz465@nyu.edu

Stochastic gradient Hamiltonian Monte Carlo (SGHMC) is a variant of stochastic gradient with momentum where a controlled and properly scaled Gaussian noise is added to the stochastic gradients to steer the iterates towards a global minimum. Many works reported its empirical success in practice for solving stochastic non-convex optimization problems. In this work, we provide finite-time performance bounds for the global convergence of SGHMC for solving stochastic non-convex optimization problems with explicit constant, which lead to non-asymptotic guarantees for both population and empirical risk minimization problems. Our results show that acceleration with momentum is possible in the context of global non-convex optimization.

3 Option Pricing Via Neural Jump-diffusion Models

Yanchu Liu, Sun Yat-sen University, Guangzhou, China.

In this paper we integrate the classical stochastic volatility jump-diffusion models with deep learning techniques. Numerical and empirical evidences show that our method have better performance compared with alternative approaches.

Monday, 5 PM–6:15 PM

ME75

M - Illinois

Fintech

General Session

Session Chair

Mingwen Yang, University of Washington, Seattle, WA

1 Token Incentives and Platform Competition: A Tale of Two Swaps

Xiaofeng Liu[1], Wei Chen[2], Kevin Zhu[3], [1]UC San Diego, La Jolla, CA, [2]The University of Arizona, Tucson, AZ, [3]University of California-San Diego, La Jolla, CA, Contact: xil760@ucsd.edu

This paper studies impacts of token incentives, an alternative incentive approach, in the competition of two decentralized exchange platforms, Uniswap and Sushiswap. Decentralized exchanges rely on liquidity providers to supply liquidity that facilitates the trading from the demand side, which makes the amount of liquidity supply the key to platform success. The entrant, Sushiswap, launched token incentives to attract liquidity from Uniswap, who then also retaliated with its own token incentives. Our empirical analysis shows that Uniswap's token incentives attract more liquidity to its platform. Surprisingly, we find that Sushiswap's token incentives also bring positive spillovers to Uniswap. For the potential mechanism, we find that increased liquidity is mainly from attracting more providers. We further study the heterogeneous effects of token incentives.

2 Blockchain Technology Adoption in Digital Advertising: A Game-theoretic Model

Yi Gao[1], Subodha Kumar[2], Dengpan Liu[1], [1]Tsinghua University, Beijing, China; [2]Fox School of Business, Temple University, Philadelphia, PA, Contact: gaoy6.18@sem.tsinghua.edu.cn

Recently, the disruptive impact of blockchain technology on the digital advertising industry has caught widespread attention. However, this issue has not been formally analyzed in the literature. In order to fill this important gap, we develop a game-theoretic model to study whether and when digital advertisers should adopt blockchain technology in a competitive environment. We also analyze how the publisher should adapt his advertising slot assignment strategies accordingly. We identify the existence conditions for all possible equilibria and find that the advertisers can benefit from adopting the blockchain channel under certain circumstances. Moreover, we investigate how social welfare changes with the adoption of blockchain.

3 Observational Learning in Cryptocurrency Trading

Ye Liu[1], Mingwen Yang[1], Matthias Pelster[2], Yong Tan[1], [1]University of Washington, Seattle, WA, [2]Paderborn University, Paderborn, Germany. Contact: yeliu@uw.edu

Due to the intransparency of the technology and high volatility, investment in cryptocurrencies is subject to high levels of risk and uncertainty. Social media, with a wide range of individual information providers, also attracts many discussions regarding cryptocurrencies. In this paper, we investigate whether cryptocurrency adoption is influenced by information received from social media, and---if so---what specific factors affect one's adoption choice of cryptocurrencies. Using a novel dataset from a social trading platform, where we observe both social interactions and trading behavior, we find that the rate of adoption from neighbors, stronger tie strength, neighbors' positive and relevant posts, credibility of information sources, and profitable trading records all significantly increase the likelihood of user's adoption choice of cryptocurrencies.

Monday, 5 PM–6:15 PM

ME76

M - Michigan
Supply Chain Risk and Disruptions Flash Session
Flash Session

Session Chair
Yihua Li, IBM, San Francisco, CA

1 Information Dependency in Mitigating Disruption Cascades

Nitin Bakshi[1], Shyam Mohan[2], [1]University of Utah, Salt Lake City, UT, [2]Manchester Business School, Manchester, United Kingdom.

Shocks that trigger supply chain disruptions inflict initial losses by damaging firms' assets. The disruption can then cascade across multiple tiers. To protect against such cascades, firms can make ex-ante investments in risk mitigation. These investments potentially depend on extensive network characteristics, and gathering the required information can be challenging. Our aim is to shed light on the forces that govern information requirements for risk mitigation.

2 Trust-based Newsvendor Model for Disaster Relief

Mohammad E. A. Saoud, Kuwait University, Shadadiya, Kuwait. Contact: mohammad.saoud@ku.edu.kw

We take the position of a not-for-profit organization offering relief for a disaster. In this effort, we aim to find the optimal inventory level for an area under the effect of a disaster. We assume IoT is used to extract information on the disaster. Also, a novel trust-based newsvendor model is constructed to provide the optimal quantity of necessary supplies

3 Blockchain Technology Enabled Supply Chain Performance Improvement

Gangaraju Vanteddu, Southeast Missouri State University, Cape Girardeau, MO, Contact: gvanteddu@semo.edu

In this research, key blockchain technology capabilities are identified and aligned with the traditional supply chain performance drivers for improved supply chain performance. Specifically, the impact of the adoption of blockchain technology on supply chain safety stock placement is investigated.

4 Data Contamination Resistance Robust Optimization Model for Rebalancing Medical Supplies in Response to Epidemics

Xuehong Gao[1], Kanglin Liu[2], Guozhong Huang[1], Haoxuan Li[1], Zhou Jianlan[1], [1]University of Science and Technology Beijing, Beijing, China; [2]Beijing Jiaotong University, Beijing, China.

After an epidemic, the dissimilar prevalence of infection resulted in an imbalance of supply and demand for medical supplies. To relieve the serious situations, it is required to rebalance medical supplies under an uncertain environment with data contamination, which makes the solution located far away from the true optimal solution. In this sense, finding a newly robust optimization method that is less sensitive to data contamination is warranted. Thus, this study investigated a medical supply rebalancing problem with data uncertainty and contamination. To cure the detrimental consequences, a robust optimization model was proposed and then a linearization approach was developed. To validate the proposed model and method, a real case study is implemented, where implications and insights are obtained to provide the main needs and benefits of the study.

5 Multi-period Location Analysis of Distribution Centers for Humanitarian Operations with Multiple Agencies

Hugo T. Y. Yoshizaki[1], Maria Clara R. Pinheiro[1], Irineu Brito Junior[2], Otavio A. F. Costa[3], [1]University of Sao Paulo, São Paulo, Brazil; [2]State University of Sao Paulo, São José dos Campos, Brazil; [3]World Food Programme, Rome, Italy. Contact: hugo@usp.br

This work aims to evaluate economic benefits of cooperation between humanitarian agencies using a multi-period location model of warehouses which supply refugee camps. Models with multiple periods are better suited to problems with high variability in demand, as in complex humanitarian operations which are considered temporary. A mixed-integer linear programming model was applied to the response operation during and after the Mosul Offensive in Iraq during the years 2016 and 2017. Results show that financial gains related to the centralization of operations and the sharing of resources are significant, and benefits are well balanced among all agencies.

6 Blockchain Based Solution for Recall and Traceability in Automotive Supply Chain

Pratyush Patro[1], Raja Jayaraman[1], Khaled Salah[2], [1]Khalifa University, Abu Dhabi, United Arab Emirates; [2]Khalifa University, Abu Dhabi, United Arab Emirates. Contact: raja.jayaraman@ku.ac.ae

Product recall and traceability management are challenging problems that affect human lives and the safe operation of the supply chains. Hence, monitoring and tracking product activity in the supply chain can assist system stakeholders in identifying the origins and causes of product and process defects. Existing solutions for product recall and traceability management fall short in providing transparency, traceability, reliability, audit, security, and trust features. In this presentation, we present a blockchain-based approach to overcome the operational decisions related to recall and traceability in the automotive supply chain. The proposed solution is cost-effective, secure, and enables supply chain stakeholders to have end-to-end visibility of information during product recalls and product traceability.

7 Natural Language Processing for Automatic Problem-solving Steps Capture and Assembly

Yihua Li[1], Xiaowei Bao[2], Zuochun Tang[1], [1]IBM, San Francisco, CA, [2]IBM, Seattle, WA

Natural language processing models are developed to understand and learn from conversations in a chat room that identify and resolve supply chain problems. Steps and actions that uses take to resolve the problem can be automatically captured and assembled by the model.

8 Investigation of Agent-based Simulation for Evacuation Modeling Under Wildfire Using O-U Processes

Seunghan Lee, Akshaya Ramesh, University at Buffalo, SUNY, East Amherst, NY

As the frequent recent occurrences of wildfires and their catastrophic consequences in the US, developing efficient disaster relief and recovery strategies is imperative. However, a high level of uncertainty about the wildfire development hinders predicting residents' evacuation behaviors, preventing authorities from devising an efficient disaster management policy. In this work, the authors investigate the agent-based simulation evacuation models using the Overview-Design-Details (ODD) framework to improve reusability. The O-U processes are also used to represent residents' evacuation behaviors, deriving to estimate community status after the disaster. The work will aid in relieving the Wildfire consequences and sustaining any disaster relief efforts.

Monday, 5 PM–6:15 PM

ME77

M - Texas
Empirical Research in Behavioral Operations
General Session

Session Chair
Dennis Zhang, Washington University in St Louis, ST LOUIS, MO

Session Chair
Bing Bai, Washington University-St Louis, Saint Louis, MO

1 Correlation Neglect in Supply Chains

Anugna Reddy Gondi[1], Andrew M. Davis[1], Stephen Leider[2], [1]Cornell University, Ithaca, NY, [2]University of Michigan, Ann Arbor, MI, Contact: ag2446@cornell.edu

We study the effect of correlation on decision making in two operational contexts: supply risk and demand uncertainty. Through controlled lab experiments, we investigate ordering decisions under non-zero correlation (positive or negative) and zero correlation scenarios in simplified supply chain settings. We find that participants set orders that are virtually the same across pairs of non-zero and zero correlation scenarios despite it being optimal to do otherwise. In the supply risk setting, subjects over-diversify under positive correlation with the resulting order deviations leading to a significant profit loss whereas under negative correlation subjects sometimes under-diversify but without clear profit implications. We run two additional treatments to understand the role of interventions in alleviating correlation neglect and improving decisions.

2 The Value of Logistic Flexibility in Online Retailing

Bing Bai[1], Tat Y. Chan[2], Dennis Zhang[3], Fuqiang Zhang[4], [1]Washington University in St Louis, Saint Louis, MO, [2]Washington University, St. Louis, MO, [3]Washington University in St Louis, ST LOUIS, MO, [4]Washington University in St. Louis, St. Louis, MO, Contact: bing.bai@wustl.edu

In recent years, improving shipping speed in online retailing has faced significant diminishing marginal returns and significant cost increases. As a consequence, many online retailers have started to explore improving other aspects of the shipping experience to attract customers. In this paper, we use the introduction of local pick-up stations by Alibaba to study the impact of improving logistic flexibility on online retailing. We develop a choice model to study how logistic flexibility affects customers' purchase decisions. We find that customers value two types of logistic flexibility -- the value of time flexibility, which offers them the flexibility to receive their packages in their most preferred time; and the value of choice flexibility, which offers them the flexibility to make pick-up choices until the last minute to accommodate time uncertainty.

3 Timing Matters: Crowd-sourcing Workers in On-demand Freight Matching Platforms

Ziqi Dong[1], Guangwen (Crystal) Kong[2], Qiuping Yu[3], [1]Temple University, Philadelphia, PA, [2]Temple University, Wynnewood, PA, [3]Scheller College of Business, Georgia Tech, Atlanta, GA, Contact: tul24322@temple.edu

Freight-matching platforms are becoming flourishing to mitigate the overcapacity and supply-shortage risk existing in the traditional long-haul transportation industry. Despite the disruptive growth of this business model, the role of lead time, which is an important influencer in the operational management field, has not been explicitly examined in this context. Therefore, based on industrial data and utilizing a comprehensive estimation strategy, our study empirically explores the association between shippers' request lead time and freight-matching performance. We establish that the association is nuanced and it holds important practical values for the industry.

Monday, 5 PM–6:15 PM

ME78

M - Utah
Multimedia and Online Platforms
General Session

Session Chair
Shun Ye, George Mason University, Fairfax, VA

1 Managing Sales Via Livestream Commerce

Luyi Gui[1], Xi Lin[2], Yixin Lu[3], [1]The Paul Merage School of Business, UC Irvine, Irvine, CA, [2]The Paul Merage School of Business, UC Irvine, Irvine, CA, [3]The George Washington University, Washington, DC, Contact: xlin32@uci.edu

Livestream commerce has become an important sales channel with billions of revenue potential. In this paper we analyze the negotiation dynamics between the brand and the key opinion leader who promotes the product in a livestream sale. We also study how consumer search affects such dynamics and the profitability of a livestream sale.

2 Performance-based Team Formation: Video Collaboration Recommendations in An Online Video Community

Yihong Liu, The University of Texas at Dallas, RICHARDSON, TX

Online platforms and traditional firms use teams to address complex tasks. We focus on forming effective teams of content creators for video collaboration in an online video community. Specifically, we propose a performance-based team formation framework for video collaboration recommendations. Based on the Input-Process-Output paradigm in team research, we consider individual, team, and environmental factors as team performance determinants. The first part of this framework applies machine learning with relevant features for each factor to forecast team performance using data collected from an online video community. The second part efficiently recommends an effective team with good predicted performance to focal content creators. We demonstrate the efficacy of our performance-based team formation framework through extensive experimentation.

3 The Impact of Streaming in Video Game Price Competition

Kay-Yut Chen[1], Jennifer Zhang[2], Jiang Hu[3], Jeff Hou[4], [1]University of Texas at Arlington, Arlingon, TX, [2]University of Texas Arlington, Arlington, TX, [3]University of Texas at Arlington, arlington, TX, [4]National Cheng Kung University, Tainan, Taiwan. Contact: kychen@uta.edu

Streaming (e.g. twitch) and secondary content creation (e.g. game strategy youtube videos) are common to the video game industry ($178B in 2021 with 2.9B players). We study the impact of streaming/content creation on video competition by the use of a modified Hotelling model. Game theoretic analysis shows that the introduction of a prominent streamer can destabilize price competition between video game publishers, and pure strategy Nash equilibria may not exists in such a scenario. Behavioral experiments reveal that while streaming/content creation increases the total surplus, the total profits of firms decreases. In addition, we verify that individuals do not play mixed strategy equilibrium. We develop a bounded rationality based behavioral model to explain observations.

4 Search Cost Reduction on Online Platforms: An Empirical Investigation

Lianlian Jiang[1], Shun Ye[2], Liang Zhao[3], Bin Gu[4], [1]University of Houston, Houston, TX, [2]George Mason University, Fairfax, VA, [3]Northeastern University, Boston, MA, [4]Boston University, Boston, MA, Contact: l.zhao@northeastern.edu

This study investigates the cognitive miser issues generated by search cost reduction tool on online platforms. We conduct a natural experiment at leading online review platforms (Yelp and TripAdvisor), wherein Yelp introduced a search cost reduction tool (sorted image) in August 2015. By constructing a unique panel dataset based on matched pairs of restaurants across the two platforms and using deep learning models, we apply a difference-in-difference (DID) model to assess the impact of sorted image as a search cost reduction tool. We find that displaying sorted images have a negative effect on consumer decision quality, and the decline in decision quality is mainly attributed to the lack of information in service, which is difficult to present through visual cues but is better learned from textual reviews. We discuss the implications of these findings.

Monday, 5 PM–6:15 PM

ME79

JWM - Room 201

TIMES Distinguished Speaker

Award Session

Session Chair

Philipp Benjamin Cornelius, Rotterdam School of Management, Rotterdam, Netherlands.

1 Theory and Evidence on ESG Investments

Christoph H. Loch, Cambridge University, Cambridge, United Kingdom.

Hope is widely being expressed that ESG rankings may prompt firms and investors to embrace more environmental, social and governance initiatives. However, investors act as guardians of profits and are not equipped to pursue ESG initiatives in their own right. We show empirical evidence and theory suggesting that markets may act to limit rather than support ESG initiatives.

Monday, 5 PM–6:15 PM

ME80

JWM - Room 202

Building MCDM/A Models: Practical and Methodological Issues

General Session

Session Chair

Adiel Almeida, 1</sup

Session Chair
Eduarda Asfora Frej, Universidade Federal de Pernambuco, Recife, Brazil.

1 **A Framework for Structuring and Building Multicriteria Decision Models**
Adiel Teixeira De Almeida[1], Lucia R. P. Roselli[1], Eduarda A. Frej[1], Danielle C. Morais[2], [1]Universidade Federal de Pernambuco, Recife PE, Brazil; [2]Universidade Federal de Pernambuco - UFPE, Recife-PE, Brazil. Contact: adielta@gmail.com
This presentation discusses the process for building multicriteria decision models. Issues related to the choice of MCDM/A methods are considered. Compensatory and non-compensatory rationalities are analyzed in the course of preliminary preference modeling in order to guide the first steps in choosing the MCDM/A method. Finally a framework is presented for Structuring and building the model, which is going to be the basis for the decision.

2 **An Application of The Benefit-to-cost Approach of The FITradeoff Method for Portfolio Selection in a Problem Related to The Retail Sector**
Maria Elvira Borges Tunú Pessoa[1], Eduarda Asfora Frej[2], Adiel Teixeira De Almeida[1], [1]Universidade Federal de Pernambuco, Recife PE, Brazil; [2]Universidade Federal de Pernambuco, Recife, Brazil.
The benefit-to-cost approach of the FITtradeoff Method for portfolio selection uses incomplete information provided by the decision maker to classify projects and select them according to the available budget. In Brazil, the retail sector is impacted by high taxes, logistical difficulties, among other issues. The companies need to create strategies to increase profitability. The problem addressed in this paper is related to the formation of a portfolio for projects to improve the structure of a retail company. The Framework composed of twelve steps and successive refinements to build decision models is used. In the first steps, the basic elements of the problem are established. In this case, four criteria and twelve alternatives were defined. After applying the FITradeoff method, it was possible to find a recommended portfolio that includes seven projects.

3 **Multicriteria Decision Model for Supplier Selection in a Construction Company**
Layra Almeida[1], Eduarda Asfora Frej[1], Jonatas Almeida[2], [1]Universidade Federal de Pernambuco, Recife, Brazil; [2]Universidade Federal de Pernambuco, Caruaru, Brazil. Contact: layra.nayara@gmail.com
A multicriteria decision process needs to be structured to be conducted effectively. The framework of twelve phases supports the development of the decision problem, allowing to encompass all the necessary elements for a proper multicriteria decision making. Therefore, the framework is used in an iron supplier selection problem for a small construction company in Pernambuco - Brazil. These small construction companies have more difficulties due to limited resources, however they have a great impact on country's economy, generating employment and income. Thus, this decision will bring more efficiency to the resources allocated. A properly structured multicriteria decision provides a representation of problem closer to reality and provides a recommendation more proper.

Monday, 5 PM–6:15 PM

ME81

JWM - Room 203
Navigating the Industry Job Market: Early and Late Stage Students
Panel Session

1 **Moderator**
Jeremy Watts, University of Tennessee, Knoxville, TN
Looking to know more about jobs in industry? Then join us to hear industry professionals give advice, discuss skills and answer your questions about navigating the industry job market. This panel is targeted at students during any stage in their academic program but is open to everyone.

2 **Panelist**
Jon Orwant, Google, Cambridge, MA

3 **Panelist**
William Christian, Paygevity, Inc., Severn, MD

4 **Panelist**
Kendra C. Taylor, KEYFFICIENCIES, Inc., Atlanta, GA

Monday, 5 PM–6:15 PM

ME82

JWM - Room 204
Minority Issues Forum (MIF) Career Award
Award Session

Session Chair
Wesley Marrero, [1]</sup

1 HEALTH-Engine Lab: Simulation and Optimization of Stochastic Healthcare Systems

Michelle M. Alvarado, University of Florida, Gainesville, FL

Sophisticated stochastic modeling techniques are often necessary to make and evaluate decisions for complex healthcare problems. This talk will feature Dr. Alvarado's latest research on healthcare systems engineering from the HEALTH-Engine Laboratory, focusing on stochastic programming and discrete-event simulation modeling. I will showcase several applications, including recent publications on developing and solving models to reduce hospital readmissions, schedule skin cancer surgeries, and support patient-centered selection of health insurance plans. I will also discuss promising new directions and upcoming projects. Lastly, I will highlight my service and outreach to recruit and support underrepresented minorities in OR/MS research and the HEALTH-Engine Lab.

2 Equity and Sustainability in Energy Decision Making

Destenie S. Nock, Teagan Goforth, Carnegie Mellon University, Pittsburgh, PA

In the fight against climate change countries have set strong electricity sector decarbonization targets. However, there is uncertainty regarding whether these policies will exacerbate social inequities, and how they will impact environmental sustainability across different income groups. Currently, most electricity planning models determine the least cost option, without considering how the recommended pathways impact distributional equity. Dr. Nock will discuss her previous work in energy trade-off analyses, integrating equity and equality into decision making models, and plans for future work. This research will explore the sustainability and equity trade-offs between different energy transition pathways for the US. She will also discuss her service interests.

3 Redefining the Status Quo through Mentorship, Research, and Outreach

Jessye Talley, Morgan State University, Baltimore, MD

As current supply chain disruptions become more prevalent it becomes more challenging to obtain common everyday products in a timely manner. Due to the importance of this undertaking, it is of significant interest that there is innovative research to create new sustainable strategies and methods for future generations. As a result, this presentation features my research on identifying and evaluating supply chain vulnerabilities. Specifically, an overview will be provided of my modeling contributions which include evaluating contamination, consumer behavior, and optimization in food supply chains. Based on this work, I will highlight my service and mentoring to underrepresented students in OR/MS. Lastly, I will share my outreach efforts with high school students to spark their interest in pursuing STEM careers.

Monday, 5 PM–6:15 PM

ME83

JWM - Room 205
OR and Analytics in Music and Television
Contributed Session

Session Chair
Andrew Henshaw, Kennesaw State University, Smyrna, GA

1 Optimal Content-sharing Strategy for Online Streaming Platforms

Eunsol Yoo, Kihoon Kim, Korea University, Seoul, Korea, Republic of. Contact: graceat@korea.ac.kr

Many subscription-based video-on-demand (SVoD) platforms are currently focusing on creating exclusive content to attract more subscribers. However, it is not clear that an exclusive-content strategy will eventually increase the platforms' profits and/or increase the number of the platforms' subscribers. This research models two competing platforms' choices between leasing and not leasing exclusive content investigating the impact of their choices on the SVoD market size and the competition results. We show the conditions under which the two platforms can increase their profits by sharing a certain amount of exclusive content.

2 Unifying Model of Conjoint Analysis and MCDM : Focused on Music Streaming Services

Sangwon Eum[1], Hosun Rhim[2], Jeunghyun Kim[2], Zili Xu[1], [1]Korea University Business School, Seoul, Korea, Republic of; [2]Korea University Business School, Seoul, Korea, Republic of. Contact: 781900925@qq.com

In this study, we presents a model unifying conjoint analysis and MCDM. Attributes of conjoint analysis are configured using text mining method. Profile of conjoint analysis model are compared to obtain multiple criteria of decision making. Three criteria are selected and evaluated. Sample dataset is collected using web based survey method.

3 Complexity Analysis of Pop Song Lyrics

Andrew Henshaw, Kennesaw State University, Atlanta, GA, Contact: ahensha2@students.kennesaw.edu

This project attempts to analyze the complexity of pop song lyrics by quantifying the repetition of lyrics using tokenization and a lossless-compression algorithm. 10,000 songs by the Billboard 100 Top Pop Artists are evaluated and used to compare the artists against each other. An interactive web site was deployed to support the project. In addition to the complexity analysis, sentiment analysis is used for artist classification.

Monday, 5 PM–6:15 PM

ME84

JWM - Room 206

Recent Advances in Simulation Metamodeling

General Session

Session Chair

Xi Chen, Virginia Tech, Blacksburg, VA

Session Chair

Jie Xu, George Mason University, Fairfax, VA

1 Projected Gaussian Markov Improvement Algorithm for High-dimensional Discrete Optimization Via Simulation

Xinru Li[1], Eunhye Song[2], [1]Pennsylvania State University, State College, PA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: xul277@psu.edu

The projected Gaussian Markov Improvement Algorithm (pGMIA) is an inference-based algorithm designed for Discrete Optimization via Simulation (DOvS) defined on a high-dimensional integer lattice. A Gaussian Markov random field (GMRF) is adopted as the underlying response surface model in pGMIA. The pGMIA applies axis-aligned projection to create hierarchical GMRF models: region- and solution-layer GMRFs, and alternates between the two layers to search for the global optimum with low computational overhead. We show that the dense region-layer precision matrix can be approximated with an easy-to-compute matrix that inherits the sparsity of original GMRF's precision matrix and its computational benefits. We prove that pGMIA finds the global optimum almost surely in the limit and empirically demonstrate its efficiency and effectiveness.

2 Gaussian Processes for High-dimensional, Large Data Sets: A Review

Mengrui (Mina) Jiang[1], Giulia Pedrielli[2], Szu Hui Ng[3], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, [3]National University of Singapore, Singapore, Singapore. Contact: mjiang42@asu.edu

Gaussian processes show important advantages to several alternative approaches while controlling model complexity. However, the use of this family of models is hindered for high dimensional inputs and large sample sizes due to the intractability of the likelihood function, and the growth of the variance covariance matrix. This article investigates state-of-art solutions to these challenges according classifying them into categories. The goal is to select several algorithms covering each category and perform empirical experiments to compare their performances on the same set of test functions. Our preliminary results focus on deterministic implementations of a set of selected approaches. The results of the experiments may serve as a guidance to future readers who want to study and use Gaussian process in problems with high dimensions and big data sets.

3 Multilevel Monte Carlo Metamodeling for Variance Function Estimation

Jingtao Zhang, Xi Chen, Virginia Tech, Blacksburg, VA, Contact: jingtaozhang@vt.edu

In this work, we propose a multilevel Monte Carlo (MLMC) metamodeling approach for efficient estimation of variance functions. While metamodeling typically requires a careful experiment design, the MLMC metamodeling approach can adaptively adjust the number of design points and budget allocation at each level, automatically leading to an efficient design. We show that, under some conditions, the proposed MLMC metamodeling approach can achieve better computational complexity than standard Monte Carlo (SMC) while attaining a prescribed estimation accuracy level for variance function estimation. Numerical evaluations corroborate our theoretical findings.

4 Sequential Metamodel-based Procedures for Stochastic Simulation Level Set Estimation

Yutong Zhang, Xi Chen, Virginia Tech, Blacksburg, VA, Contact: yutongz@vt.edu

In this work, we propose two sequential heteroscedastic metamodel-based level set estimation procedures, respectively, Predictive Variance Reduction (PVR) and Expected Classification Improvement (ECI). PVR aims at reducing the predictive uncertainty whereas ECI exploits classification improvement. Both procedures strike a balance between exploration and exploitation to enhance the level-set estimation performance. Numerical evaluations demonstrate the superior performance of the proposed procedures in comparison with benchmarking methods.

Monday, 5 PM–6:15 PM

ME85

JWM - Room 207
Additive Manufacturing and Service Operations Management
Contributed Session

Session Chair
Jiahui Ye, Texas A&M University, College Station, TX

1 **Thermal Field Modeling in Additive Manufacturing Using Spatiotemporal Statistical Methods**
David Shoukr, Peter Morcos, Raymundo Arróyave, Alaa Elwany, Texas A&M University, College Station, TX, Contact: davidshoukr@tamu.edu
Modeling the thermal field histories in additive manufacturing (AM) is the first step in understanding the process-structure-properties-performance (PSPP) relationships. Thermal histories provide information about the melt-pool dynamics, solidification growth rate, and temperature gradients. These parameters can help understand crack susceptibility and formation as well as microstructure and dendritic arm spacing. Due to the thermodynamics of AM, understanding the PSPP relationships of a part requires the simulation of the thermal history of the entire part. Current thermal models are expensive. Spatiotemporal statistical methods are used here to provide a fast and accurate description of the evolution of the thermal field. This model considers the thermal field spatial and temporal rate of change, temperature-dependent properties, and part geometry.

2 **Supply Chain Cooperation for Dual Product Rollover**
Audrey Bazerghi[1], Jan A. Van Mieghem[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL
Dual product rollovers put a strain on supply chains. Suppliers want to retire old generations of parts with declining demand to focus on new growth products, whereas manufacturers want to continue selling old parts as an after sales service. We present a two-stage game to analyze the equilibria in supplier-manufacturer negotiations on the obsolescence of legacy products, supported by extensive interviews. We design interventions that leverage the new product generation to influence the outcome of the negotiations, achieving cooperation on legacy products previously not observed. Our work is the first to study how two supply chain players could coordinate the simultaneous retirement of a legacy product and introduction of its successor.

3 **Response-surface-based Printability Assessment in Directed Energy Deposition Metal Additive Manufacturing Processes**
Jiahui Ye, Matthew Vaughan, Ibrahim Karaman, Raymundo Arróyave, Alaa Elwany, Texas A&M University, College Station, TX, Contact: jhy@tamu.edu
Recent research roadmaps by the research and industrial communities call for an urgent need to design new alloys specifically for additive manufacturing (AM) processes. To effectively assess a particular designed alloy and identify optimal processing conditions, efficient printability assessment frameworks are required for AM processes. However, such a framework is lacking for the significant powder-based laser directed energy deposition (L-DED) processes. In this study, we propose a framework to conduct Bayesian calibration and uncertainty quantification of a response surface method model, and then we demonstrate its use for printability assessments in L-DED using a case study of 316L stainless steel. The contribution of this work is providing a time- and cost-effective method to determine the printability of both existing and newly designed alloys for L-DED.

Monday, 5 PM–6:15 PM

ME86

JWM - Room 208
Energy, Policy, and Planning
Contributed Session

Session Chair
Seonho Park, Georgia Institute of Technology, GAINESVILLE, FL

1 **Digging into The Data: Cost-benefit Analyses of Undergrounding Strategies in Electric and Broadband Networks**
Mahsa Arabi[1], Nasko Apostolov[1], Anna Goldstein[2], Michael Bloomberg[3], Taneja Jay[4], Jimi Oke[1], [1]University of Massachusetts Amherst, Amherst, MA, [2]University of Massachusetts Amherst, Amherst, MA, [3]Cornell Tech, New York, NY, [4]University of Massachusetts Amherst, Amherst, MA, Contact: marabi@umass.edu
The human and economic impact of power outages has been a focus of attention for policy makers over the past several decades. Undergrounding electric and broadband cables is a viable approach for improving resilience. The massive investment costs require frameworks to analyze costs and

benefits of competing strategies. Prior efforts have been too generalized and not accounted for broadband. Thus, we present framework that demonstrates a localized approach, using Shrewsbury, MA, as a case study. We analyze the co-deployment of electric and broadband lines, and develop new data-driven cost and benefit models. Our synthetic and disaggregated approach is readily deployable to other similar study areas and provides effective decision-making capabilities with limited amounts of data.

2 Performance-based Contracts for Energy Efficiency Projects

Ali Shantia[1], Sam Aflaki[2], Roman Kapuscinski[3], [1]Toulouse Business School, Toulouse, France; [2]HEC Paris, Jouy en Josas, France; [3]University of Michigan-Ann Arbor, Ann Arbor, MI, Contact: a.shantia@tbs-education.fr

Energy Service Companies use performance-based contracts for Energy Efficiency projects. The performance of these contracts, however, is unverifiable by the clients. The achieved efficiency also encourages the client to consume more energy (the rebound effect). We show that the mentioned effects, along with the client's risk aversion, diminish the performance of such contracts; therefore, they never achieve the first-best (FB) outcomes. We define and characterize a group of piece-wise linear contracts that perform reasonably well when FB outcome is difficult to achieve.

3 Learning to Accelerate Globally Optimal Solutions to The Ac Optimal Power Flow Problem

Fatih Cengil[1], Harsha Nagarajan[2], Russell Bent[2], Sandra D. Eksioglu[3], Burak Eksioglu[3], [1]University of Arkansas, Fayetteville, AR, [2]Los Alamos National Laboratory, Los Alamos, NM, [3]University of Arkansas, Fayetteville, AR, Contact: mfcengil@uark.edu

This talk proposes machine learning-based (ML) methods to accelerate convergence to global solutions for the AC Optimal Power Flow (ACOPF) problem. Optimality-Based Bound Tightening (OBBT) algorithm, providing near-global optimum solutions for ACOPF problems by tightening the variable domains, comes with a computational burden. We replace this exhaustive algorithm by choosing a subset of variables whose tightening of bounds still contributes to the best improvement for relaxations of the ACOPF problem. Historical data is used to learn a DNN-based mapping between the loads and subset selection of variables, finding near-global optimal solutions in shorter times. We observe up to 14x speed-up on different-scale (up to 2000 buses) instances.

4 Confidence-aware Graph Neural Networks for Large Scale Reliability Assessment Commitments in Power Systems

Seonho Park[1], Wenbo Chen[2], Dahye Han[2], Mathieu Tanneau[3], Pascal Van Hentenryck[4], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, [3]Georgia Tech, Atlanta, GA, [4]ISyE Georgia Tech, Atlanta, GA, Contact: seonho.park@gatech.edu

Reliability assessment commitment (RAC) is critical for the reliable and economic scheduling of energy production. Machine learning (ML) has been highlighted for accelerating or possibly replacing time-consuming optimization processes. In this work, the confidence-aware graph neural network (GNN)-based model enhancing credibility is proposed. First, a novel GNN-based architecture customized for RAC problems is proposed. Second, the confidence measurement on the ML predictions is utilized to figure out which prediction is likely to be correct or wrong. Furthermore, using the confidence measurement and the transmission constraints estimation the reduced problem for speed-up is defined and its effectiveness is also demonstrated empirically.

Tuesday, 8AM–9:15AM

TA01

CC - Room 101

Recent Advances in Reinforcement Learning in Finance

General Session

Session Chair

Huining Yang, Oxford, United Kingdom.

1 Reinforcement Learning with Dynamic Risk Measures

Anthony Coache[1], Sebastian Jaimungal[2], Alvaro Cartea[3], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada; [3]University of Oxford, Oxford, United Kingdom.

Reinforcement learning (RL) problems aim to construct agents which can discover the best possible behaviors by interacting with an environment and updating their actions in an experience-driven manner, observing feedback in the forms of costs. In RL, *uncertainty* in the environment can have substantial effects on performance, and agents may wish to account for this variability in the environment and the results of its actions to avoid large potential losses.

We develop here an approach for solving time-consistent risk-aware stochastic optimization problems using RL. We assume agents assess the risk of a sequence of costs using *dynamic risk measures*, and develop *actor-critic algorithms* using neural networks to optimize over policies. We demonstrate the performance of our approach on problems, such as statistical arbitrage, robot control, and financial hedging.

2 Representation Learning for Stochastic Factors in Portfolio Optimization

Sinong Geng[1], Max Reppen[2], Ronnie Sircar[1], [1]Princeton University, Princeton, NJ, [2]Boston University, Boston, MA, Contact: sgeng@princeton.edu

We study portfolio optimization with stochastic factors. Specifically, we propose a data-driven representation learning method to construct stochastic factors from observed features for a designated portfolio optimization model. Our method is performance-driven by directly optimizing a so-called performance objective function via machine learning methods like deep learning. Meanwhile, it benefits from the structure of the portfolio optimization model by leveraging results in model calibration and stochastic optimal control. Theoretically, we bound the expected terminal utility of the policy delivered using the proposed method.

3 Finrl Framework for Financial Reinforcement Learning

Shuaiyu Chen, Purdue University, West Lafayette, IN

The FinRL project is a unified framework that includes various markets, state-of-the-art algorithms, financial tasks (portfolio allocation, cryptocurrency trading, high-frequency trading), and live trading. We demonstrate the application of deep reinforcement learning in finance and provide educational materials for newcomers.

4 Reinforcement Learning for Mean Field Problems, with Applications to Finance

Andrea Angiuli[1], Jean-Pierre Fouque[2], Mathieu Lauriere[3], [1]Amazon Services LLC, Santa Barbara, CA, [2]University of California-Santa Barbara, Santa Barbara, CA, [3]Princeton University, Fontenay-sous-bois, France.

Mean field games (MFG) and mean field control problems (MFC) are frameworks to study Nash equilibria or social optima in games with a continuum of agents. These problems can be used to approximate competitive or cooperative games with a large finite number of agents and have found a broad range of applications, in particular in economics. In recent years, the question of learning in MFG and MFC has garnered interest, both as a way to compute solutions and as a way to model how large populations of learners converge to an equilibrium. Of particular interest is the setting where the agents do not know the model, which leads to the development of reinforcement learning (RL) methods. We present a two timescale approach with RL for MFG and MFC, which relies on a unified Q-learning algorithm. To illustrate this method, we apply it to mean field problems arising in Finance.

Tuesday, 8AM–9:15AM

TA02

CC - Room 102

Interpretable Machine Learning via Mixed-integer and Robust Optimization

General Session

Session Chair

Vassilis Digalakis, Massachusetts Institute of Technology, CAMBRIDGE, MA

Session Chair

Leonard Boussioux, MIT, Cambridge, MA

1 Optimal Robust Classification Trees

Nathan Justin, Sina Aghaei, Andres Gomez, Phebe Vayanos, University of Southern California, Los Angeles, CA, Contact: njustin@usc.edu

In many high-stakes domains, the data used to drive machine learning algorithms is noisy (due to e.g., the sensitive nature of the data being collected, limited resources available to validate the data, etc). This may cause a distribution shift to occur, where the distribution of the training data does not match the distribution of the testing data. In the presence of distribution shifts, any trained model can perform poorly in the testing/deployment phase. In this paper, motivated by the need for interpretability and robustness, we propose a mixed-integer optimization formulation and a tailored solution algorithm for learning optimal classification trees that are robust to adversarial perturbations in the data. We evaluate the performance of our approach on numerous publicly available datasets, and compare the performance to a regularized, non-robust optimal tree.

2 Training Optimal Diagrams for Classification

Alexandre Florio[1], Pedro Martins[2], Maximilian Schiffer[3], Thiago Serra[4], Thibaut Vidal[5], [1]Polytechnique Montreal, Montreal, QC, Canada; [2]Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil; [3]Technical University of Munich, München, Germany; [4]Bucknell University, Lewisburg, PA, [5]Polytechnique Montreal, Montréal, QC,

Canada.
Decision diagrams for classification have notable advantages over decision trees, as their internal connections can be determined at training time and their width is not bound to grow exponentially with their depth. However, the inherent complexity of training these classifiers acted as a long-standing barrier to their widespread adoption. In this talk, we introduce mixed-integer linear programming models for training optimal decision diagrams (ODDs) and demonstrate their usefulness for many data sets of practical importance. We present numerical analyses showing that ODDs are more parsimonious than their decision tree counterparts and generally achieve better accuracy. Finally, training through mathematical programming gives enough flexibility to capture other important requirements related to fairness and transparency.

3 Adaptive Robust Ensemble Modeling for Time Series Forecasting

Leonard Boussioux, Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA, Contact: leobix@mit.edu
Time series forecasting plays a crucial role in a wide range of problems with a temporal component. Since time series data is prone to distribution shifts, a single predictive model's performance can vary significantly across time. Therefore, ensemble modeling proposes leveraging several available models to improve accuracy further. We contribute a new methodology for robust ensemble modeling of time series forecasting models. We develop an adaptive robust optimization (ARO) approach to formulate a linear regression ensemble where the models' weights change over time. We show the impact of our ensemble method on a range of real-world challenges, including tropical cyclone intensity forecasting, pollution management, and energy consumption forecasting, and hope to open the door for further use of ARO in machine learning.

4 Slowly Varying Machine Learning

Vassilis Digalakis, Massachusetts Institute of Technology, CAMBRIDGE, MA
We introduce the framework of slowly varying machine learning, which aims at building machine learning that vary slowly over time, or space, or any other dimension. In the first half of the talk, we consider the problem of parameter estimation in slowly varying regression models with sparsity constraints, and make both theoretical and algorithmic contributions. The second half of the talk is focused on slowly varying classification trees.

Tuesday, 8AM–9:15AM

TA03

CC - Room 103

Recent Advances in Provably Efficient Reinforcement Learning with Safety Guarantee

General Session

Session Chair
Yuhao Ding, UC Berkeley

Session Chair
Javad Lavaei, University of California, Berkeley, Berkeley, CA

1 Finite-time Performance of Policy Optimization Methods for Constrained Reinforcement Learning

Dongsheng Ding, University of Southern California, Los Angeles, CA
Despite the recent success of incorporating constraints into policy optimization for constrained reinforcement learning, convergence properties of associated algorithms are less understood due to the non-convex nature of policy optimization and the lack of exact gradient computation. In this talk, we introduce a new primal-dual method based on the natural policy gradient that searches for the policy as a primal variable while adjusting the price of violating constraints in a dual update. In the tabular case, we employ the softmax policy to establish dimension-free convergence with a sublinear rate in terms of optimality gap and constraint violation. In the function approximation case, we establish similar convergence up to a function approximation error. Finally, we introduce our sample-based algorithms and provide finite-sample complexity guarantees.

2 Policy-based Primal-dual Methods for Convex Constrained Markov Decision Processes

Donghao Ying[1], Mengzi Guo[1], Yuhao Ding[1], Javad Lavaei[2], Zuo-Jun Max Shen[3], [1]University of California, Berkeley, Berkeley, CA, [2]University of California, Berkeley, Berkeley, CA, [3]University of California Berkeley, Berkeley, CA, Contact: donghaoy@berkeley.edu
We study convex Constrained Markov Decision Processes in which the objective is concave and the constraints are convex in the state-action visitation distribution. We propose a policy-based primal-dual algorithm that updates the primal variable via policy gradient ascent and updates the dual variable via projected sub-gradient descent. Despite the loss of additivity structure, we establish the global convergence of the algorithm under the general parameterization, and proves the $O(T^{-1/3})$ convergence rate in terms of both

optimality gap and constraint violation. When the objective is strongly concave in the visitation distribution, we prove an improved convergence rate of $O(T^{-1/2})$. By introducing a pessimistic term to the constraint, we further show that zero-constraint violation can be achieved while preserving the same convergence rate for the optimality gap.

3 Trustworthy Reinforcement Learning for Safety-critical Systems

Ming Jin, Virginia Tech, Blacksburg, VA

Assurance is integral to trust and conducive to widespread adoption in energy infrastructures. However, such safety and performance guarantees are currently lacking for learning-based control methods, especially when high-capacity models such as deep neural networks are involved. In this talk, I will discuss some recent works towards addressing this challenge. In the first part, I will present an implicit reinforcement learning framework that leverages the synergistic strength of optimization and reinforcement learning for online adaptivity and trustworthy sequential decision making. This strategy also wins the 1st place in the 2021 CityLearn Challenge. In the second part (if time permits), I will discuss meta-safe reinforcement learning with provable guarantees.

4 Variational Policy Gradient Method for Reinforcement Learning with General Utilities

Alec Koppel, Amazon, Bellevue, WA, Contact: aekoppel314@gmail.com

We consider policy optimization in MDPs, where the objective is a general concave utility function of the state-action occupancy measure, which invalidates the Bellman equation. As this means that dynamic programming no longer works, we focus on direct policy search. Analogous to the Policy Gradient Theorem for RL with cumulative rewards, we derive a Variational Policy Gradient Theorem for RL with general utilities, which establishes that the parametrized policy gradient may be obtained as the solution of a saddle point problem involving the Fenchel dual of the utility. We develop a variational gradient estimation algorithm to compute the policy gradient based on sample paths. We prove that the variational policy gradient scheme converges globally to the optimal policy for the general objective, though the optimization problem is nonconvex, at a O(1/t) rate.

Tuesday, 8AM–9:15AM

TA04

CC - Room 104

The Digital Society

General Session

Session Chair

Ying Wang, Northern Illinois University, DeKalb, IL

1 How Influencer Videos Shape Viewers' Attitude Towards Products? A Machine Learning Approach

Ying Wang[1], Jaeki Song[2], [1]Northern Illinois University, DeKalb, IL, [2]Texas Tech University, Lubbock, TX, Contact: ywang15@niu.edu

This study explores how influencer videos polarize the audience's opinions on promoted products. Based on opinion polarization literature and framing theory, we propose that influencer video content polarizes the audience's opinions towards products, and video type moderates the polarizing effect of video content. We collected information about videos posted by tech influencers on YouTube and applied sentiment analysis and regression analysis to test the related hypotheses. The findings show that comparative advertising video relieves opinion polarization. This study reveals that content design manipulates the polarizing effects of influencer content and offers a solution to depolarize audience opinions towards products, enriching our understanding of the impact of social media on public opinion polarization and guiding organizations in brand management.

2 Emotion and Ideology Factors in the Persuasiveness of Online Petitions

Jiao Wu, Northern Illinois University, Aurora, IL

Successful online petitions help the mass people to influence decision-makers and arouse broad attention. Different linguistic cues are found to influence the persuasiveness of the petition. In this work, we combine discrete emotional cues and political ideology cues. We developed an analytical model which illustrates the relationship between the discrete emotion cues and ideology cues with the success of the online petitions. The data were from Change. Org. Our results highlight the need to use objective data to reduce the drawbacks of survey methods. Also, the findings can be used to design and develop more efficient petitions.

3 The Impact of Media Type and Media Complexity Consistency on Social Media Hot Streaks

Timothy Kaskela[1], Jaeki Song[2], Alireza Zadeh[2], [1]Oregon State University, Corvallis, OR, [2]Texas Tech University,

Lubbock, TX
Social media engagement between an organization and individuals has been studied through a multitude of components. There is an additional research opportunity examining how the consistency of social media messaging and delivery can impact engagement behavior. Once a company has a social media post that is successful, we examine how consistency between posts impacts the continuation of a string of successful posts, termed a hot streak. To study the consistency between social media posts, the social media Twitter feeds of the constituents of the NASDAQ 100 were collected. Similarity is measured by media type and complexity of media. The study contributes theoretically by lending understanding as to how the consistency between social media posts from a single organization affects social media engagement behavior.

4 Influence of Covid-19 on Student Campus Ratings: A Sentiment Analysis

Jiaxi Luo, Midwestern State University, Wichita Falls, TX
In the context of higher education, the campus has been considered not only a place for faculty teaching and student learning, but also an environment where nurturing, development and growth take place. Previous researches has been devoted to exploring the influence of specific aspects of campus environment on student outcomes.
On the findings, it is clearly evident that a quality campus environment strengthens students' academic, physical, and mental outcomes.
The COVID-19 has affected the operation of the campus in higher education. What students need from and care about a campus environment might have been reshaped by the pandemic.
This study seeks to provide such and understanding by examining students' ratings and textual reviews of higher education institutions posted on a public review website prior to and after the pandemic.

Tuesday, 8AM–9:15AM

TA05

CC - Room 105
Imbalanced Class in Machine Learning: Applications and Methods
General Session

Session Chair
Lin Lu, Fairfield University, Fairfield, CT

1 Financial Restatement Prediction Using Machine Learning Techniques

Lin Lu[1], Dawn Massey[2], [1]Fairfield University, Fairfield, CT, [2]Fairfield University, Fairfield, CT
Financial restatements have implications for firm market value and shareholder wealth, auditor reputation and regulator activities. Early knowledge of a company's future restatement before a restatement is announced can help market participants make financially advantageous stock purchase/sale decisions, auditors promote audit quality, and regulators serve the public interest. Typically, studies in financial restatement prediction focus on frauds rather than material misstatements; yet, financial statement misstatements are far more common than financial frauds. Thus, this study predicts the probability of material restatements and considers multi-type features from disparate sources which affect the detection performance. The results identify significant factors and examine how they associate with the probability of financial restatement.

2 Improving Classification Performance of Logistic Regression for Imbalanced Dataset

Patrick Lee, Lin Lu, Fairfield University, Fairfield, CT, Contact: plee@fairfield.edu
Logistic regression is one of the most popular and interpretable classification methods. It works well when the class distribution of dependent variable is balanced. However, in real cases, the imbalanced class dataset can be prevalent, which affects the predictive performance for minority class. To deal with this problem, existing studies have applied sampling techniques, multiple types of classifiers, and cost-sensitive approaches. This study proposes a sequential boosting and stacking method based on logistic regression analysis to improve classification performance and interpretability when facing imbalanced datasets. We also performed experiments over two publicly available datasets to examine the effectiveness and reliability of our approach.

3 Examining It Vendor Efficiency on Care Quality Improvement and Patient Experience

Jianliang Hao, California State University, Chico
Most hospitals rely on I.T. vendors to adopt and implement EMRs rather than self-developing. So, it is important to manage the relationship with I.T. vendors to increase the effectiveness of I.T. In this study; we examine the impact of the I.T. vendor relationship on organizational performance in a hospital setting. In particular, we examine a critical research issue of interest: the effect of the relationship length and quality on hospital performance. We will use several years of data from a national sample of U.S. hospitals

and econometrics methods. Our study contributes to the literature by deepening our understanding of the accrual benefits of I.T. vendor relationship management.

Tuesday, 8AM–9:15AM

TA07

CC - Room 107

Statistics and Machine Learning Applications in Marketing

General Session

Session Chair

Lili Zhang, 1</sup

Session Chair

Xinglong Ju, The University of Oklahoma, Norman, OK

1 **Zero to One: Sales Prospecting with Augmented Recommendation**

Saiquan Hu[1], Juanjuan Zhang[2], Yuting Zhu[3], [1]Hunan University, Changsha, China; [2]MIT Sloan School of Management, Cambridge, MA, [3]National University of Singapore, Singapore, Singapore. Contact: y.zhu@nus.edu.sg

Helping new salespeople succeed is critical in sales force management. We develop a deep learning based recommender system to help new salespeople recognize suitable customers, leveraging historical sales records of experienced salespeople. One challenge is how to learn from experienced salespeople's own failures which are prevalent but often do not show up in sales records. We develop a parsimonious model to capture these missing by choice sales records and incorporate the model into a neural network to form an augmented, deep learning based recommender system. We validate our method using sales force transaction data from a large insurance company. Our method outperforms common benchmarks in prediction accuracy and recommendation quality, while being simple, interpretable, and flexible. We demonstrate the value of our method in improving sales force productivity.

2 **Recommendation Engine in B2B Marketing**

Swarup Chandra, HPE, San Jose, CA

In B2B marketing, developing a product or content online recommendation system is challenging. Particularly, the efficacy of customer response signals captured from various marketing and sales activities is attenuated due to two main effects: a large variety of product offerings, and a hierarchy of customer identifiers having different privacy concerns at each level. Here, a customer may be identifier either at an individual email address, and/or a higher organization-level the individual belongs to. In this talk, I will present a suite of recommendation engines we have developed which utilizes available data at each customer and product hierarchy to improve online customer experience, and discuss various data and modeling challenges in developing these systems.

3 **When Artificial Intelligence Meets Weather-based Marketing**

Liyuan Liu, Saint Joseph's University, Philadelphia, PA, Contact: lliu@sju.edu

Artificial intelligence has become an innovative technology tool to improve the customer journey in marketing. Many studies observed that weather changes could impact human mood, behavior, and economics. Weather-based marketing strategies can help enterprises to predict revenues, resolve the promotions, and adjust distribution. However, from a scientific point of view, the link between weather and marketing is more complicated: The traditional linear models can't handle the non-linear relationships and uncertainties; Most advertisements are images, we don't have sufficient models to deal with them; Weather is streaming data, there lack models to design the promotion strategies on the mobile apps in a real-time. Therefore, this study proposed artificial intelligence weather-based marketing models to help enterprises with automated marketing solutions.

Tuesday, 8AM–9:15AM

TA08

CC - Room 108

Practical Application and Development Decision-making of Sharing Economy

General Session

Session Chair

Jialing Zhao, Shanghai,China, China.

Session Chair

Hongwei Wang, Tongji University, Shanghai, China.

1 **Uncovering Airbnb Reviews**

Carol Nguyen, Tanner Chambers, Rajeshwari Jayabarathi, Nathan Tayero, Ho-Chang Chae, University Of Central Oklahoma, Edmond, OK, Contact: tanner.chambers@probatacorp.com

Most research on Airbnb has focused on price prediction, and there has been little understanding of review score even if it contains valuable information. Using listings data from five major US cities, we developed a binary predictive model to distinguish high-scoring listings. Various predictive models were used to predict such listings with 63 percent accuracy. For this, we included not only the standard features in the Airbnb dataset but also created new variables about the description and amenities using text mining. This paper proposes an interpretable model for predicting high review scores and provides a new perspective on identifying factors influencing listing success. We identified key amenities such as BBQ, Keurig and Nespresso machines, and self-check-in as well as the importance of host experience and an appropriate ratio of bedrooms and bathrooms per guest.

2 E-scooter Rebalancing with En Route Charging Capability

Xiangyu Jin[1], Yufeng Cao[2], Yu Yang[3], [1]Shanghai Jiao Tong University, Shanghai, China; [2]Shanghai Jiao Tong University, [3]University of Florida, Gainesville, FL

E-scooter sharing systems have been emerging as an important part of shared mobility services. However, the growing fleet in an e-scooter sharing system imposes great challenges in the rebalancing and recharging for the system operator. In this work, we consider a novel approach to handle this issue and propose a mathematical optimization model to solve the problem. Using a truck equipped with battery charging capability, the system operator jointly makes the routing, waiting, and handling decisions in an e-scooter network. We formulate the integrated decision problem as a two-stage mixed-integer linear program. We show that the second stage of the problem can be solved efficiently by solving a linear program. We propose an effective algorithm to solve the integrated decision problem based on Benders decomposition. We validate our framework with numerical experiments.

3 The Impact of the Epidemic on China Sharing Accommodation-Based on Empirical Analysis of Beijing Airbnb

Jialing Zhao[1], Hongwei Wang[1], Yuxin Huang[2], [1]Tongji University, Shanghai, China; [2]Soochow University, SZ, China.

The sudden arrival of Covid-19 has caused a huge impact on the tourism industry. This article uses the tracking data of listings on the Airbnb platform in Beijing, China from January 2019 to June 2020, combined with survival functions and fixed effects to analyze the behavior changes of host and consumers in China's sharing accommodation market during the outbreak. The study found that after the outbreak, the probability of host withdrawing from the market has increased by nearly 10 times; with the "Superhost" badge and entire rentals have also withdrawn from the market significantly; but the more experienced host are, the probability of withdrawing from the market is relatively lower.

Tuesday, 8AM–9:30AM

TA09

CC - Room 109
DAS Flash-Talks I
Flash Session

Session Chair
Eric Specking, University of Arkansas College of Engineering, Fayetteville

1 High Conflict or Uncertainty? D.E.C.I.D.E. with Confidence

Jen McIntosh, US DoD, Washington, DC

Senior leaders from the public and private sectors alike make critical decisions in highly uncertain environments, often facing paralyzing contexts of interpersonal conflict, change fatigue, competing stakeholder interests, hard-to-measure priorities/values, and more. We explore a ***decision quality model adapted for high conflict scenarios*** that will: get everyone clear on the appropriate frame/scope; open up creative and optimistic options; uncover shared values / priorities; and help decision-makers *get unstuck* and confident to move forward.

2 Environmentally Conscious Consumers and Retail Return Behavior

Amy Williams, L. Robin Keller, University of California, Irvine, Irvine, CA, Contact: lrkeller@uci.edu

As product returns increase, so does the environmental impact of those returns, a concern for both retailers and consumers. Through a lab study, we found that participants who were more (vs. less) environmentally conscious were more likely to buy multiple sizes of the same item at once and return more frequently. Modeling this analytically, we confirmed that this purchasing behavior is less environmentally friendly.

3 An Influence Diagram for a Data Analytics Decision

Gregory S. Parnell, University of Arkansas, Fayetteville, AR, Contact: gparnell@uark.edu

We use influence diagrams to identify available data, relationships, decisions, and values for Army Smart Base decision making. Using the influence diagram, we develop an integrated Bayesian Net using data sources, machine learning, and decisions to analyze a large decision space. We illustrate with the Fort Carson weather warning decision.

4 Value-focused Thinking is An Idea Generation Tool for Conservation Planning

David Martin[1], Josh Goldstein[2], David R. Smith[3], Jessica Musengezi[2], Jessie G. Rountree[4], Pabodha Galgamuwe[1], Aileen Craig[1], Michelle Dietz[1], Caitlin Kerr[1], [1]The Nature Conservancy, Bethesda, MD, [2]The Nature Conservancy, Arlington, VA, [3]United States Geological Survey, Kearneysville, WV, [4]Pathfinder International, Watertown, MA, Contact: david.martin@tnc.org

We present a module for strategy development based on value-focused thinking. The module is a package of materials with the intent to create alternative courses of action that directly respond to values of a decision-making group. It can be used by a trained facilitator or as a guide to self-train professionals to facilitate its proper use with a decision-making group. The module includes a participant overview, a virtual Mural board template, a facilitator's guide, and evaluation surveys. Early testing at The Nature Conservancy provided evaluations on the assumptions that value-focused thinking results in a complete set of strategies, leads to satisfaction among users, and is scalable.

5 Point Forecasts from Experience: An Empirical Examination of Judgmental Forecasting

Neslihan Özlü, Stockholm University-Business School, STOCKHOLM, Sweden.

The forecasts of professionals with similar backgrounds are heterogeneous. How much of the heterogeneity in the forecasts come from lifetime experiences versus available information? Specifically, we analyse a data set with the individual monthly forecasts of inflation of 26 professional forecasters, over 13 years. Using clustering analysis, we find that forecasters rely more on available information for cyclical categories whereas, for the non-cyclical categories, cohorts with the lowest self-experienced inflation have consistently lower forecasts than cohorts with higher self-experience.

6 Flash Paper

Ian Unson, SUNY University at Buffalo, Rochester, NY

When defending soft targets, such as airports, sports venues and houses of worship, it is critical to optimally allocate resources across the different security layers. The goal of the defender is to allocate resources amongst multiple targets throughout the respective security layers to decrease the expected damages, decrease the probability of a successful attack and potentially deter the adversary from executing an attack plan on any target. This project expands on past resource allocation problems by focusing on different security layers across multiple targets to protect soft targets against adversarial threats through the development of stakeholder-informed game-theoretic models.

8 Data-driven Method to Learn Multi-attribute Value Function with Reference Effect

Ying He[1], Haiming Liang[2], Yucheng Dong[3], [1]University of Southern Denmark, Odense, Denmark; [2]Sichuan University, Chengdu, China; [3]Business School, Sichuan University, Chengdu, China. Contact: yinghe@sam.sdu.dk

In this paper, we propose a data-driven method to learn multiattribute value function in which two kinds of data are used: the attribute-specific evaluation data, and the classification data of alternatives. Specifically, we firstly formulate multiplicative multi-attribute value function with reference effect. Then, we develop ta learning model and a prediction model, and show their desired properties in theoretical aspects. Furthermore, we compare the performances of our learning and prediction models with a few common models in the literature; and show that our learning and prediction models have a competitive advantage over these models. Finally, we also present a numerical study to illustrate how to apply our data driven model in an optimal multi-attribute product design problem.

Tuesday, 8AM–9:15AM

TA10

CC - Room 110

Reinforcement Learning in Revenue Management

General Session

Session Chair

Zhengyuan Zhou, Stern School of Business, New York University, New York, NY

Session Chair

Divya Singhvi, IBM Research, Drayton, SC

1 Sensitivity Analysis Under The F-sensitivity Models: Definition, Estimation and Inference

Zhimei Ren, University of Chicago, Chicago, IL, Contact: zmren@uchicago.edu

In this work, we propose a new sensitivity model where, in contrast to uniform bounds on the selection bias in the literature, we assume the selection bias is bounded "on average". We study the partial identification of treatment effects under the new sensitivity model. From a distributional-shift perspective, we represent the bounds on counterfactual means via certain distributionally robust optimization programs. We then design procedures to estimate these bounds and show that our procedure is doubly robust to the estimation error of nuisance components and remains valid even when the optimization step is off. In addition, we establish the Wald-type inference guarantee of our procedure that is again robust to the optimization step. Finally, we demonstrate our method and verify its validity with numerical experiments.

2 Dynamic Exploration and Exploitation -- The Case of Online Lending

Mingxi Zhu, Haim Mendelson, Stanford University, Stanford, CA, Contact: mingxiz@stanford.edu

This paper studies exploration/exploitation trade-offs in the context of online lending. In the case of unsecured online lending, the lender effectively gives away money in order to learn about the borrower's ability to repay. In our model, the lender maximizes the expected net present value of the cash flow she receives by dynamically adjusting the loan amounts and the interest rate as she learns about the borrower's unknown income. The lender has to carefully balance the trade-offs between earning more interest when she lends more and the risk of delinquency. We consider the cases of both the exogenous interest rate and endogenous interest rate and provide closed-form solutions to the optimal policies. Under the optimal policy, we examine the problem's key performance characteristics and study how the income distribution affects those performances.

3 Bayesian Design Principles for Frequentist Bandit and Reinforcement Learning

Yunbei Xu, Columbia University Graduate School of Business, New York, NY, Contact: yunbei.xu@gsb.columbia.edu

We propose a general framework to study frequentist bandit and reinforcement learning, where concepts from Bayesian inference are essential for algorithm design and regret analysis. We develop general algorithm design principles and study related complexity measures that apply in various bandit and reinforcement learning problems. In particular, we propose to design "algorithmic priors" instead of frequentist estimators; and rely on posterior updates instead of traditional frequentist decision rules. Regret behavior for this class of algorithms can often be shown to be best possible. Moreover, the algorithms are simple and often efficient to implement.

4 Provably Optimal Reinforcement Learning for Online Inventory Models with Cyclic Demands

Xiao-Yue Gong[1], David Simchi-Levi[2], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: xygong@mit.edu

We are interested in designing reinforcement learning by embedding problem structures. In this project, we tackle online inventory models with unknown cyclic demand distributions using our specifically-designed RL. We apply the standard performance measure in online learning literature, regret, defined as the difference between the total expected cost of our policy and that of the clairvoyant optimal policy that has full knowledge of the demand distributions a priori. Our policies remove the regret dependence on the cardinality of the state-action space for inventory problems. We conducted experiments with a real sales dataset.

Tuesday, 8AM–9:15AM

TA11

CC - Room 111

Interpretable Machine Learning for Social Good

General Session

Session Chair

Shixiang Zhu, Georgia Institute of Technology, Marietta, GA

1 Data-Driven Optimization for Overlapping Police Beat Design

Sarah Huestis-Mitchell[1], Shixiang Zhu[2], Yao Xie[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]Carnegie Mellon University, Marietta, GA, Contact: shuestis3@gatech.edu

We present both a data-driven, simulation-based framework and stylized theoretical model for including overlapping police patrol beats with joint primary response units in the police zone design of a city. Our objective is to decrease mean response time while subject to the resource constraints of the current system. We use both a simulation-based Bayesian optimization and a theoretical analysis using a hypercube queueing model with multi-type jobs and multi-type servers to show that introducing these overlaps between police beats can make the system more efficient without requiring additional resources or personnel.

2 Assets Bundling and Scenario Generations for Renewable Energy in Power Systems

Hanyu Zhang, Georgia Institute of Technology, Atlanta, GA, Contact: hzhang747@gatech.edu

With the increasing capacity of renewable generation in power systems, reliable forecasts and scenarios on renewable energy are essential for solving the subsequent energy dispatch optimization problem. Variance and Intermittency Index Minimization algorithms are developed to aggregate renewable generation time series to reduce the dimension for forecasting. Probabilistic models are developed to achieve renewable generation multi-step forecasting as well as its uncertainty quantification. Lastly, the support points technique is introduced to select representing scenarios from the monte-carol scenarios or empirical distribution generated by the forecasting model.

3 Learning Optimal Fair Decision Trees

Nathanael Jo[1], sina Aghaei[2], Andres Gomez[1], Phebe Vayanos[1], [1]University of Southern California, Los Angeles, CA, [2]USC, Los Angeles, CA, Contact: phebe.vayanos@usc.edu

The increasing use of machine learning in high-stakes domains creates an urgent need for interpretable and fair algorithms. In these settings it is also critical for such algorithms to be accurate. With these needs in mind, we propose a mixed integer optimization (MIO) framework for learning optimal classification trees of fixed depth that can be conveniently augmented with arbitrary domain specific fairness constraints. We benchmark our method against state-of-the-art approaches; given a fixed discrimination threshold, our approach improves out-of-sample (OOS) accuracy by 2 percentage points on average and obtains a higher OOS accuracy on 100% of the experiments. We also incorporate various algorithmic fairness notions into our method, showcasing its versatile modeling power that allows decision makers to fine-tune the trade-off between accuracy and fairness.

4 Interpretable Evaluation of Machine Learning Algorithms: A Healthcare Case Study

Michael Lingzhi Li[1], Dimitris Bertsimas[1], Kosuke Imai[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Harvard University, Cambridge, MA, Contact: mlli@mit.edu

The increasing availability of individual-level data has led to an explosion of new machine learning (ML) algorithms for personalized medicine. Given the high-stakes nature, it is important to evaluate the performance of these ML algorithms in an interpretable and rigorous way before implementation. We propose a new evaluation framework that combines causal inference with robust distributional optimization to evaluate machine learning algorithms rigorously and interpretably under both experimental and observational data. Importantly, our approach carries little-to-no modeling assumptions, making them interpretable and applicable to almost any ML algorithm. We demonstrate an application of this framework in the Boston Children's Hospital (BCH) that is resulting in the first-ever application of machine learning in the hospital.

Tuesday, 8AM–9:15AM

TA12

CC - Room 113

Predictive Analytics and Modeling to Inform Decisions

General Session

Session Chair

Michael Yankovich, US Military Academy, West Point, NY

1 US Army Aviation Air Movement Operations Planning Model

Russell Nelson, North Carolina State University, Raleigh, NC, Contact: russnelson82@gmail.com

Air movement operations comprise a majority of Army utility and cargo helicopter combat aviation operations in terms of volume of customers and aircraft resource requirements. For routine air movement operations, planning is conducted manually. Planning inefficiencies put a greater resource burden on aviation units and reduce lift capacity to the supported units. We propose an Army aviation air movement mission planning model that rapidly provides courses of action based on the commander's priorities. Features of the problem include priority demand, multi-node refueling, and the minimization of unsupported demand, aircraft utilization, and total flight time. The mathematical model is an extension of the dial-a-ride problem (DARP). Additional work includes an assignment and improvement heuristic required to generate feasible solutions in near real-time.

2 Assessing The Value of Integrating Predictive Analytics into a Decision Process

Jonathan Paynter, United States Military Academy, West Point, NY

How useful is your predictive analytics model for your organization? Predictive models (usually!) aren't perfect, and military organizations must address the impact of both successful predictions and model errors on organizational performance. In application, and in academic research, there is frequently a gap between how a data science or analytics team evaluates a predictive model, and the practical utility of that model. As an illustrative example, we will discuss a military unit implementing a machine learning model that predicts an impending part failure for an aircraft. We will connect common binary prediction model effectiveness measures to the unit's performance measure of aircraft Fully Mission Capable time. The talk will then outline generalizations to other use-cases and prediction models.

3 Spatial Aggregation and Inference for Infectious Disease Modeling

Delante Moore, Emory University, Atlanta, GA, Contact: delante.moore@gmail.com

Researchers commonly aggregate infectious disease surveillance data over space and time. However, if they are not careful, using such data can lead to biased results of individual level parameters. This work utilized surveillance data for several infectious diseases to investigate the impact of using traditional compartment models to estimate the estimate the effects of disease spread on non-homogeneous populations. We found that as a population becomes more heterogeneous, compartment models such and the SIR and it's extensions become the less and less likely to accurately forecast epidemic peaks. This work also uses simulation to demonstrate methods to account for bias inherent in compartment models for non-homogenous populations with a goal of aiding decision makers such as military commanders to better understand how impacts of epidemics on their organizations.

4 Intruder Detection and Interdiction Modeling: A Bilevel Programming Approach for Ballistic Missile Defense Asset Location

Adam B. Haywood[1], Brian J. Lunday[2], Matthew JD Robbins[3], [1]HQ USAF, Pentagon, DC, [2]Air Force Institute of Technology, Beavercreek, OH, [3]Air Force Institute of Technology, Wpafb, OH, Contact: adamhaywood307@gmail.com

A relevant analysis problem is the effective location and allocation of resources to interdict intruders. The adversary is assumed to observe defensive asset locations and respond with a targeting strategy that maximizes the expected damage of an attack. This research presents a bilevel programming model and identifies an equivalent single-objective mixed-integer nonlinear program. Upon proving the convexity of the resulting formulation to assure reported solutions are globally optimal, further testing identifies a preferable commercial solver for instances of the underlying problem. Empirical testing examines which scenario features of the underlying problem are most significant for predicting the required computational effort to solve problem instances, yielding insight into the practical nature of this research to address instances of increasing size.

Tuesday, 8AM–9:15AM

TA13

CC - Room 114

Advanced Methods for Network Optimization and Analytics

General Session

Session Chair

The-Duong Do, 1</sup

Session Chair

Duong Nguyen, Lafayette

1 Leveraging Quantum Computing for Optimal Multi-service Provisioning in Edge Computing

Duong Do[1], Duong Tung Nguyen[2], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Chandler, AZ, Contact: dtdo4@asu.edu

We present a mixed-integer linear programming (MILP) model for optimal service placement and workload allocation in edge computing. To tackle this challenging NP-hard problem, we propose a novel hybrid quantum-classical approach by decomposing the MILP into a Quadratic Unconstrained Binary Optimization (QUBO) problem that can be solved by a quantum computer and a linear program that can be solved by a classical computer. This approach leverages the Benders decomposition method and linearization techniques. Extensive numerical results demonstrate the efficacy of the proposed approach.

2 Optimizing Cooperative Interdependent Attack Graphs to Compromise Cyberinfrastructures

Joseph Alameda[1], Carlos A. Zetina[2], Robert Curry[1], [1]United States Naval Academy, Annapolis, MD, [2]Concordia University, Montréal, Canada. Contact: alameda@usna.edu

As infrastructures in our society become increasingly interdependent on one another, the possibility of attacks on these infrastructures utilizing these interdependencies also increases. In this paper, we consider attacks from multiple attackers working cooperatively to reach their goals. Moreover, we model the possibility that more than one exploit may have to be used by an attacker to reach their objective. We provide a mixed-integer program for this attacker model, and we provide a bounding algorithm that iteratively improves a series of upper and lower bounds. Furthermore, we provide preliminary analysis showing the computational effectiveness of our algorithm when compared to the MIP.

Tuesday, 8AM–9:15AM

TA14

CC - Room 115
Last Mile Delivery
Contributed Session

Session Chair
Mingwei Guo, North Dakota State University, Fargo, ND

1 **Strategic Decision-making Tool for The Last Mile Delivery Using Stochastic Programming**
Joseph Gerard Szmerekovsky, Raghavan Srinivasan, North Dakota State University, Fargo, ND
We consider the problem of determining an aggregate delivery capacity plan using a combination of fulltime, seasonal, and crowdsourcing capacity with seasonal demand. We characterize the structure of an optimal solution with known crowdsourcing capacity and use stochastic programming to find the optimal solution with random crowdsourcing capacity. We find that crowdsourcing is a valid substitute for fulltime capacity, but may result in increased or decreased seasonal capacity. Further, we observe that the cost savings from crowdsourcing may come at the cost of lower service levels for customers.

2 **Modeling TNC-Transit Partnership Under Pure Collaboration to Address First-and-Last Mile Problem and Fill Gaps in Transit Networks**
Gulam Kibria[1], Srinivas Peeta[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: mkibria7@gatech.edu
Qualitative studies suggest that TNCs can enhance transit quality through partnerships by: (i) addressing the first-and-last mile problem, and (ii) filling gaps (i.e., areas with no transit service) in existing transit networks. This study explores how these two issues can be addressed under pure collaboration (i.e., no competition) between TNCs and transit agencies. We propose mathematical models to maximize societal benefit in an integrated system in which TNCs provide first-and-last mile connections where transit service is available, and fill gaps by providing point-to-point services in regions where transit service is unavailable.

3 **Parcel Locker Location Problem with Customer Pickup and Crowd-shipping**
Kianoush Mousavi, Merve Bodur, Matthew Roorda, University of Toronto, Toronto, ON, Canada. Contact: kianoush.mousavichashmi@mail.utoronto.ca
Parcel lockers are usually used as customer order pickup points. In the presence of crowd-shipping, parcel lockers can also be used as pickup points by crowd-shippers. Therefore, we present the parcel locker location problem with customer pickup and crowd-shipping by incorporating customer and crowd-shipper behavioural models as parameters to capture interdependency between customer demand, crowd-shipper supply, and parcel locker locations. We formulate the problem as a bi-level optimization model, where the upper level set the crowd-shippers compensation per order, and the lower level decides on the location of parcel lockers. Our numerical experiments show (1) the benefit of incorporating both crowd-shipping and customer pickup, and (2) the value of the parcel locker location solution obtained from the proposed model compared to a simpler alternative model.

4 **Cost and Benefit Analysis on Crowdsourced LMD Practitioners Under Inflation and Fuel Crisis**
Mingwei Guo, Joseph Gerard Szmerekovsky, North Dakota State University, Fargo, ND
The combination of inflation, pandemic and soaring fuel prices has been impacting the gig economy and Last Mile Delivery (LMD). Platforms such as Uber, Lyft and DoorDash have been struggling to attract citizen workers. Higher sign-on bonus and better per-trip pay have made it look good. However, with an inflated economy, the actual profit level of practitioners(drivers) is not addressed. This research comes from an individual project budgeting perspective to provide an analysis of current process on citizen participants, trying to evaluate the profitability of practitioners under the current pay model with impact from both inflation and fuel crisis. In terms of methodology, focus group, hypothesis testing, NPV analysis and modified payback analysis will be conducted.

Tuesday, 8AM–9:15AM

TA15

CC - Room 120
Learning in Healthcare and Service Systems

General Session

Session Chair
Pengyi Shi, Purdue University, West Lafayette

1 **Federated Reinforcement Learning: Linear Speedup Under Markovian Sampling**
sajad Khodadadian, Georgia Institute of Technology
In this talk, we consider a federated reinforcement learning framework where multiple agents collaboratively learn a global model, without sharing their individual data and policies. Although having N agents enables the sampling of N times more data, it is not clear if it leads to proportional convergence speed-up. We propose federated versions of on-policy TD, off-policy TD and Q-learning, and analyze their convergence. For all these algorithms we are the first to consider Markovian noise and multiple local updates, and prove a linear convergence speed-up with respect to the number of agents. To obtain these results, we show that federated TD and Q-learning are special cases of a general framework for federated stochastic approximation with Markovian noise, and we leverage this framework to provide a unified convergence analysis that applies to all the algorithms.

2 **Small Area Estimation of Case Growths for Timely Covid-19 Outbreak Detection**
Zilong Wang[1], Zhaowei She[2], Jagpreet Chhatwal[3], Turgay Ayer[4], [1]Georgia Institute of Technology, Atlanta, GA, [2]Singapore Management University, Singapore, Singapore; [3]Harvard Medical School, Mass General Hospital, Boston, MA, [4]ISyE Georgia Tech, Atlanta, GA, Contact: zwang937@gatech.edu
Rapid and accurate detection of local outbreaks is critical to tackle resurgent waves of COVID-19. A fundamental challenge in case growth rate estimation, a key epidemiological parameter, is balancing the accuracy vs. speed tradeoff for small sample sizes of counties. We develop an algorithm, Transfer Learning Generalized Random Forest (TLGRF), that balances this tradeoff. Through transfer learning, TLGRF can accurately estimate case growth rates for counties with small sample sizes based on relevant day and county-level features affecting the disease spread. TLGRF outperforms established growth rate estimation methods and demonstrated that it can greatly improve the timely detection of outbreaks. We thus developed a open source tool for timely detection of COVID-19 outbreaks in each U.S. county, which received substantial attention by policymakers.

3 **Switch Scheduling Via Reinforcement Learning**
Lucy Huo[1], Qiaomin Xie[2], [1]Cornell University, Ithaca, NY, [2]University of Wisconsin-Madison, Madison, WI
We studied the performance of the PPO algorithm, which is a popular RL algorithm, in the input-queued switch network scheduling problem, aiming to provide a scalable and robust alternative to current heuristics. We compared our numerical results with several state-of-the-art policies and have observed promising results. We further investigated a decomposition of the large action space of the switch scheduling problem, which would allow the algorithm to be scalable for large switch networks, and demonstrated the benefit and success of such a decomposition via numerical experiments.

4 **Data-pooling Reinforcement Learning for Personalized Healthcare Intervention**
Xinyun Chen[1], Pengyi Shi[2], [1]CUHK Shenzhen, Shenzhen, China; [2]Purdue University, West Lafayette, IN, Contact: shi178@purdue.edu
Personalized intervention management in healthcare has received a rapidly growing interest in the big-data era yet still is a burgeoning field. A key challenge for personalization in healthcare is data scarcity. This small sample issue makes standard learning methods hard to learn the right policy and/or suffer from large variances. In this research, we extend the data-pooling technique from the bandit setting to the reinforcement learning (RL) context. RL models explicitly account for future cost/reward and are more suitable for healthcare management problems. We develop a novel data-pooling estimator in the RL context, and establish theoretical performance guarantee for RL with data-pooling. We demonstrate its empirical success on a real hospital dataset with an application to reduce 30-day hospital readmission rate.

Tuesday, 8AM–9:15AM

TA16

CC - Room 121
Health Data in Optimization and Decision-Making
General Session

Session Chair
Michelle M. Alvarado, University of Florida, Gainesville, FL

Session Chair
Coralys M. Colon-Morales, University of Florida, Gainesville, FL

1 Skin Cancer Surgical Scheduling Using Stochastic Programming

Coralys M. Colon-Morales[1], Michelle M. Alvarado[2], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL, Contact: ccolonmorales@ufl.edu

Mohs Micrographic Surgery is an iterative outpatient surgery for the treatment of skin cancer. At each iteration, a layer of skin tissue is examined for the presence of cancer cells, and this continues until a cancer-free layer is identified. This reentrance aspect, which occurs when a patient requires another iteration, can potentially add hours to the procedure, leading to long patient waiting times and clinic overtime. Therefore, it is important to consider the randomness when scheduling patients to minimize costs. This work applies stochastic programming to provide optimal surgical schedules.

2 Detecting Drug Discontinuation Events in Comments Posted on Medhelp.org

William Trevena, Xiang Zhong, Michelle M. Alvarado, University of Florida, Gainesville, FL, Contact: wtrevena@ufl.edu

Comments posted on Medhelp.org are analyzed to detect drug discontinuation events using transformer-based models for natural language processing trained using zero-shot learning.

3 Stochastic Modeling of Vaccine Supply Chain

Michelle M. Alvarado, University of Florida, Gainesville, FL

In this paper we develop a regional two-stage stochastic integer model of the vaccine supply chain for Brazil. The annual production of the federal vaccine stock is determined in advance, whereas the decision of where to allocate vaccines month-to-month is robust. We consider stochastic demand scenarios while minimizing production and transportation costs, as well as the cost of unmet demand. We use real demand data from Brazil and solve the model using sample average approximation. Results and insights are given for different planning periods and regional sizes.

Tuesday, 8AM–9:15AM

TA18

CC - Room 123

Student to Faculty Transition

Panel Session

1 Student to Faculty Transition

Carolina Vivas-Valencia, Harvard University, Boston, MA, Contact: cvivas-valencia@mgh.harvard.edu

In this panel session, we will discuss how to successfully navigate the transition to becoming faculty members and learn strategies to grow our network. With a focus on healthcare applications, we will spend some time learning from the experts about how to find interesting health-related problems to work on. Finally, we will discuss the experiences our panelists had in identifying and building interdisciplinary teams and collaborations.

Session Chair

Carolina Vivas-Valencia, Harvard Medical School, San Antonio, TX

2 Panelist

Mark P. Van Oyen, University of Michigan, Ann Arbor, MI

3 Panelist

Hari Balasubramanian, Univ of Massachusetts- Amherst, Amherst, MA

4 Panelist

Maria Esther Mayorga, North Carolina State University, Raleigh, NC

5 Panelist

Margret Bjarnadóttir, 1</sup

Tuesday, 8AM–9:15AM

TA20

CC - Room 125

Decision Analysis for Security and Defense: Models and Analytics

General Session

Session Chair

Kyle J. Hunt, University at Buffalo, Buffalo, NY

1 Technology Deployment and Information Disclosure in The Face of a Strategic Threat

Kyle J. Hunt[1], Jun Zhuang[2], [1]University at Buffalo, Buffalo, NY, [2]University at Buffalo, SUNY, Buffalo, NY, Contact: kylehunt@buffalo.edu

Security and defense agencies throughout the world continue to invest in new technologies to detect and counteract threats. Releasing information about new technologies is a complicated problem that can have enormous security implications. In this study, we model this information disclosure problem in an attacker-defender signaling game, where the defender has private information regarding the targets (e.g., airports) where the new technology is going to be (or already is) deployed. The defender selects which targets to include in her information disclosure, where she is able to practice truthful disclose, secrecy, and deception. The attacker selects which target(s) to attack, if any, after observing the defender's signal and updating his beliefs regarding the technology's deployment posture.

2 Coordinating Followers to Reach Better Equilibria: End-to-end Gradient Descent for Stackelberg Games

Kai Wang[1], Lily Xu[1], Andrew Perrault[2], Michael K. Reiter[3], Milind Tambe[1], [1]Harvard University, Cambridge, MA, [2]The Ohio State University, Columbus, OH, [3]Duke University, Durham, NC, Contact: kaiwang@g.harvard.edu

A growing body of work in game theory extends the traditional Stackelberg game to settings with one leader and multiple followers who play a Nash equilibrium. Standard approaches for computing equilibria in these games reformulate the followers' best response as constraints in the leader's optimization problem. These reformulation approaches can sometimes be effective, but require assumptions on the objectives and the equilibrium reached by followers. To overcome these limitations, we propose running gradient descent to update the leader's strategy by differentiating through the equilibrium reached by followers. Our approach generalizes to any stochastic equilibrium selection procedure that chooses from multiple equilibria stochastically. Empirically, we implement the gradient-based approach to solve three Stackelberg problems with multiple followers.

3 Dynamic Model of Conflict with Endogenous Destruction: The Role of Motivation

Aniruddha Bagchi, Kennesaw State University, Kennesaw, GA

We consider a contest for a territory between two countries with different motivations. Suppose country 1 wants to win the territory for ideological reasons, and country 2 wants to win for economic reasons. These countries are otherwise similar in all other aspects. In this case, country 1's subjective valuation of the territory stays the same, while country 2's valuation decreases over time. As a result, country 1 is more likely to win the war for at least two reasons. First, country 2 does not want to fight hard because that will reduce the value of the territory. Second, if the war continues, country 2 quits much earlier. We also compute the impact on the payoff of each country due to a change in its own motivation, and the motivation of the other country.

4 Misinformation and Disinformation in Modern Warfare

Yanling Chang, Texas A&M University, College Station, TX, Contact: yanling.chang@tamu.edu

This paper examines the value of misinformation and disinformation to a military leader who is able to affect the accuracy of information communicated between other actors. We model the problem as a partially observable stochastic game with three agents, a leader and two followers. We determine the value to the leader of misinformation or disinformation being communicated between two: (i) adversarial and, (ii) allied followers. We demonstrate that only under certain conditions}, the prevalent intuition that the leader would benefit from less (more) accurate communication between adversarial (allied) followers is valid. We discuss why the intuition may fail and show the necessity of embracing both the reward structures and policies of agents to correctly manage information. We demonstrate the application of the method to warfare situations in the Battle of Mosul.

Tuesday, 8AM–9:15AM

TA22

CC - Room 127

Applications of OR/MS in the Public Sector

Contributed Session

Session Chair

Jamie R. Wieland, Illinois State University, Normal, IL

1 Assessment of Preparedness and Vulnerability of Countries from Emerging and Re-emerging Public Health Threats

Yuka Jinnai[1], Jennifer L. Mendoza-Alonzo[2], Anthony Bennici[3], Stephanie Young[4], Curtis Blanton[2], Michael Mahar[2], Cynthia H. Cassell[2], [1]Centers for Disease Control and Prevention, Atlanta, GA, [2]Centers for Disease Control and Prevention, Atlanta, GA, [3]Metro Public Health Department, Nashville, TN, [4]11TEN Innovation Partners, Atlanta, GA, Contact: JMendoza2@cdc.gov

We examined selected World Health Organization's Joint External Evaluation (JEE) indicators and the RAND Infectious Disease Vulnerability Index to determine susceptibility and preparedness against public health threats. We created a composite indicator using weights of 26 JEE indicators. We estimated those weights using exploratory factor analysis and data from 79 countries that completed and published their JEEs between 2016 and 2018. Analysis of 16 US

Centers for Disease Control and Prevention (CDC) partner countries revealed that Mali, Guinea, and Burkina Faso were the most vulnerable and less prepared for public health threats compared to the other 13 CDC partner countries. This analysis may help inform countries in their efforts to strengthen capacities within some technical areas to improve global health security.

2 Resource Allocation for Crime Deterrence in Urban Policing

Yue Zhao[1], Long He[1,2], Xiaobo Li[1], [1]National University of Singapore, Singapore, Singapore; [2]George Washington University, Washington, D.C., DC, Contact: zhaoyue6174@gmail.com

We study the problem of urban policing resource allocation among several locations in order to minimize the total social cost of crimes. The policing resource allocation problem is an essential problem in public sector operations research that closely relates to social well-being. To explicitly consider the deterrence of policing resources to potential crimes, we utilize the discrete choice model to predict crime locations. The resulting resource allocation optimization problem can be reformulated as a tractable mix-integer conic program which can be solved using over-the-shelf optimization solvers. The analysis from our model also helps explain the observation and phenomenon from the economics and criminology study of modern crime patterns. Finally, we conduct a case study of surveillance camera deployment in New York City to demonstrate the merits of our model.

3 Digital Transparency for Strategy Execution and Moral Hazard Mitigation: A Difference-in-differences Natural Experiment

Biagio Ciao, University of Milano-Bicocca, Milano, Italy. Contact: biagio.ciao@unimib.it

We have schools which belong to two different universities. The first university implemented a "transparency policy" which made the course valuations public in 2013 by showing the valuations on the web. The second university did not. It was possible to run a difference-in-differences natural experiment. We got two opposite results. First, the "transparency policy" raises both the "teacher's ability to arose the students' interest" and the "clarity about the form of the exam". The digital era tools help to implement the organizational strategy. Second, the "transparency policy" decreases the "background appropriateness to learn from the class" that depends on previous courses. Once teachers realize that their performance becomes public they put more efforts on what they can control and drains efforts from what they cannot control effectively.

4 SWGDRUG Standards: Implications and Cost Analysis for Field Identification of Drug Evidence in The Criminal Justice System

Jamie R. Wieland[1], C. C. Mulligan[2], J. D. Driskell[3], J.-H. Kim[3], [1]Illinois State University, Normal, IL, [2]Illinois State University, Normal, IL, [3]Illinois State University, Normal, IL, Contact: jwiela2@ilstu.edu

SWGDRUG (Scientific Working Group for the Analysis of Seized Drugs) recommendations provide standards to improve the quality of the forensic examination for seized drugs. We look at the implications of imposing these standards to new technologies proposed for identifying drug evidence in the field, which eliminates the need for samples to be sent to off-site laboratories for processing. Monte Carlo simulation is used to estimate the potential reduction in logistics costs associated with the proposed technologies.

Tuesday, 8AM–9:15AM

TA23

CC - Room 128

Equity, Fairness, and Improving Access to Public Services

General Session

Session Chair

Yaren Bilge Kaya, Northeastern University, Jamaica Plain/Boston, MA

Session Chair

Nathan Adeyemi, Boston, MA

1 Diversity, Equity and Inclusion in Operations Research and Analytics University Programs

Michael P. Johnson[1], Tayo Fabusuyi[2], Jamie Lannon[1], Shengli Chu[1], [1]University of Massachusetts Boston, Boston, MA, [2]University of Michigan, Ann Arbor, MI, Contact: michael.johnson@umb.edu

We present findings from a survey of over 100 OR/analytics university programs in the US to to better understand the level of diversity in OR/analytics education, in particular the presence of traditionally underrepresented groups among students, faculty and administrators, the presence of DEI themes in coursework, and the institutional orientation and commitment to DEI. To the best of our knowledge this is the first such study in our field and will support goal-setting within the profession to set goals regarding increased diversity and inclusion, as well as meaningful comparisons between OR/analytics and other disciplines regarding progress towards increased diversity and inclusion.

2 Priority Thresholds for Equitable Housing Service Coordination

Yaren Bilge Kaya, Kayse Lee Maass, Northeastern University, Boston, MA, Contact: kaya.y@northeastern.edu

Approximately 4.2 million youth and young adults (RHY) experience homelessness each year in the United States; and lack of basic necessities puts this population at high risk of being trafficked. Although all RHY experience the risk of being victims of trafficking; racial, ethnic, and gender disparities in trafficking rates still exist. Our goal is to improve equitable access to housing resources for RHY in New York City by expanding the current housing capacity, while utilizing priority thresholds that decide who can start receiving service based on the number of idle beds in the system. We propose a queuing model that allows us to: (1) investigate the demographics that are facing access barriers, (2) project the minimum number of beds required to provide a certain global service quality level, and (3) use priority thresholds while matching RHY with the beds to promote equity.

3 Gravity-based Models for Predicting Births at Rural Hospitals

Andreas Holger Thorsen[1], Sean Harris[2], Ronald McGarvey[3], Maggie Thorsen[4], [1]Montana State University, Bozeman, MT, [2]Jake Jabs College of Business and Entrepreneurship, Bozeman, MT, [3]University of Missouri, IMSE and TSPA, Columbia, MO, [4]Montana State University, Bozeman, MT, Contact: andreas.thorsen@montana.edu

We develop gravity models to forecast birth volume at hospitals in Montana, the third least-densely populated US state. We calculate a gravity ratio (actual births/expected births) for each hospital. As a result of birthers bypassing local hospitals, some hospitals become “high gravity” (i.e., attracting patients who bypass other hospitals) and others become “low gravity” (i.e., bypassed by patients). We investigate facility-level and birther-level factors that are associated with hospital gravity. Finally we discuss how this research contributes to new knowledge about equity in access to obstetric care.

4 Designing Data-driven and Equitable Housing Allocation Policies with An Application to Homeless Services Delivery

Aida Rahmattalabi, Phebe Vayanos, Kathryn Dullerud, Eric Rice, University of Southern California, Los Angeles, CA, Contact: rahmatta@usc.edu

We study the problem of learning, from observational data, fair and interpretable policies to effectively match heterogeneous individuals and resources that arrive stochastically over time. Upon arrival, each individual is assigned to a queue where they wait to receive a resource. The resources are assigned in a first come first served (FCFS) fashion subject to an eligibility structure that encodes the resource types that serve each queue. We propose a methodology based on techniques in modern causal inference and mixed-integer programming to optimize the eligibility structure. We evaluate our framework using data from the U.S. Homeless Management Information System. We obtain wait times as low as an FCFS policy while improving rate of exit from homelessness for underserved or vulnerable groups (7% higher for the Black individuals and 15% higher for those below age 17).

Tuesday, 8AM–9:15AM

TA24

CC - Wabash 1
/ GAMS
Technology Tutorial

2 Turning Models into Applications- GAMS Engine, GAMS Connect, and GAMS Transfer

Steven P. Dirkse, Atharv Bhosekar, GAMS Development Corporation, Fairfax, VA, Contact: sdirkse@gams.com

The right tools help you deploy your GAMS model and maximize the impact of your decision support application. If your model requires significant computational resources to solve, you may benefit from GAMS Engine, a powerful tool for solving GAMS models either on-prem or in the cloud. Engine acts as a broker between applications or users with GAMS models to solve and the computational resources used for this task. Central to Engine is a modern REST API that provides an interface to a scalable containerized system of services, providing API, database, queue, and a configurable number of GAMS workers.
If you are working with data stored in different formats, or you are working with an environment such as Python, Matlab, and R, you will benefit from the GAMS Connect framework and GAMS Transfer API. GAMS Connect provides unified and platform-independent data exchange between different formats (CSV and Excel). GAMS Transfer API (available in Python, Matlab, and R) makes moving data between GAMS and your computational environment fast and easy.

Tuesday, 8AM–9:15AM

TA25

CC - Wabash 2
Advances for Quantum-inspired Optimization
Tutorial Session

Session Chair
Douglas R. Shier, Clemson University, Pittsboro, NC

1 **Advances for Quantum-Inspired Optimization**
Fred W. Glover[1], Gary A. Kochenberger[2], [1]University of Colorado, Boulder, CO, [2]University of Colorado, Denver, CO
In recent years we have discovered that a mathematical formulation known as QUBO, an acronym for a Quadratic Unconstrained Binary Optimization problem, can embrace an exceptional variety of important optimization problems found in industry, science, and government. The QUBO model has emerged as an underpinning of the quantum computing areas known as quantum annealing and digital annealing and has become a subject of study in neuromorphic computing. Through these connections, QUBO models lie at the heart of experimentation carried out with quantum computers developed by D-Wave Systems and neuromorphic computers developed by IBM. New discoveries linking QUBO models to quantum computing are being explored in initiatives by organizations such as IBM, Google, Amazon, Microsoft, D-Wave and Lockheed Martin in the commercial realm and Los Alamos National Laboratory, Oak Ridge National Laboratory, Lawrence Livermore National Laboratory and NASA's Ames Research Center in the public sector. Computational experience is being amassed by both the classical and the quantum computing communities that highlights not only the potential of the QUBO model but also its effectiveness as an alternative to traditional modeling and solution methodologies. The significance of the ability of the QUBO model to encompass many models in combinatorial optimization is enhanced by the fact that the QUBO model can be shown to be equivalent to the Ising model that plays a prominent role in physics. Consequently, the broad range of optimization problems solved effectively by state-of-the-art QUBO solution methods are joined by an important domain of problems arising in physics applications. We illustrate the process of reformulating important optimization problems as QUBO models through a series of explicit examples. We disclose the unexpected advantages of modeling a wide range of problems in a form that differs from the linear models classically adopted in the optimization community. We then go farther by describing important QUBO-Plus and PUBO models (where "P" stands for "Polynomial") that go beyond QUBO models to embrace a wide range of additional important applications. Each step of generating such models is illustrated in detail by simple numerical examples, to highlight the convenience of using these models in numerous settings. Beyond the modeling component, an extremely significant dimension lies in the development of powerful algorithms and efficient computer implementations. We describe recent algorithmic innovations that offer a fertile avenue for integrating classical and quantum computing and for applying these models. These innovations, embodied in software made available through Entanglement, Inc., have produced an ability to solve dramatically larger problems and to obtain significantly better solutions than software being offered through D-Wave, IBM, Microsoft, Fujitsu and other groups pursuing this area. Some of the major applications addressed with these innovations include those in: • Classical Combinatorial Optimization • Financial Services • Transportation • Manufacturing • Pharmaceuticals and Related • Network and Energy • Machine learning

Tuesday, 8AM–9:15AM

TA26

CC - Wabash 3
Applications of Facility Location
General Session

Session Chair
Lawrence V. Snyder, Lehigh University, Bethlehem, PA

Session Chair
Karmel S. Shehadeh, Lehigh University, Bethlehem, PA

1 **A Multiobjective Heuristic for Political Redistricting Under a Similarity Metric**
Brendan Ruskey, Lehigh University, Bethlehem, PA, Contact: bjr221@lehigh.edu
In the United States, congressional districts divide the citizens of each state into groups of roughly equal population in what is called a "redistricting plan". Because voters' representation depends on the quality of these plans, and the scale of the political redistricting problem is often too large for traditional optimization methods, it is necessary to develop heuristic methods which generate equitable redistricting plans. This presentation proposes a new similarity metric that measures the difference between two redistricting plans, e.g., the current plan and a proposed decennial plan. The metric is then embedded within a multiobjective genetic algorithm

which balances similarity with other objectives, such as population equity, compactness, and partisan fairness. Results on real U.S. redistricting problems will be presented.

2 Data Center Network Design

Yong Liang[1], Mengshi Lu[2], Zuo-Jun Shen[3], Runyu Tang[1], [1]Tsinghua University, Beijing, China; [2]Purdue University, West Lafayette, IN, [3]University of California Berkeley, Berkeley, CA, Contact: mengshilu@purdue.edu

We present a data center network design model that optimizes location, computation footprint allocation, and resource provisioning decisions, while incorporating essential features, such as latency, power consumption, multiple computational resources, configuration limits, and interdependent services. We employ a queueing model to approximate the service latency and provide tractable reformulations. To enhance computational efficiency for large-scale problems, we further develop Lagrangian relaxation methods and generate strengthening cuts. Our numerical studies demonstrate that the proposed model, which jointly optimizes location, allocation, and resource provisioning, can achieve significant cost reductions and improvements in service quality compared with a hierarchical approach that optimizes these decisions sequentially.

3 Automating Insights in The Burrito Optimization Game

Alison Cozad[1], Lawrence V. Snyder[2], [1]Gurobi Optimization, Beaverton, OR, [2]Lehigh University, Bethlehem, PA, Contact: cozad@gurobi.com

In this talk, we showcase several methods to generate insights in Gurobi's Burrito Optimization Game --- a facility location optimization game. These automatically generated insights mimic how an expert in the game would compare their proposed solution to the optimized solution. By teaching how to assess the quality of their decisions, we encourage players to think critically about both their own decisions and the optimal solution. While these insights are aimed at teaching optimization concepts to those new to the field, we will use this as a foundation to discuss how to extend these ideas to industrial applications. By incorporating thoughtful post-solution analysis, we can help the users of our optimization applications understand solutions, gain insights into the physical system, and gain confidence in the results.

4 Location Optimization of Contiguous Areas

Alan T. Murray[1], Richard Church[2], [1]University of California at Santa Barbara, Santa Barbara, CA, [2]University of California, Santa Barbara, Santa Barbara, CA, Contact: amurray@ucsb.edu

Land acquisition involves the selection of spatial planning units to form independent areas, with each required to be contiguous and limited in size. Identifying the best configuration of units satisfying contiguity and maximum size stipulations has proven to be a challenging task. Simplifying assumptions have often been necessary in application, such as identifying only a single area and/or considering only planar neighbor conditions. This paper introduces a new model formulation without restrictive assumptions that can be solved by exact methods. Highlighted in this paper are capabilities to address the selection of multiple areas, contiguity constraints that are self-contained and complete, any interpretation of neighbor (or adjacency) relationships and the ability to consider application problem sizes involving tens of thousands of spatial planning units.

Tuesday, 8AM–9:15AM

TA27

CC - Room 138

Equilibrium Analysis in Service Systems

General Session

Session Chair

Laurens G. Debo, Dartmouth College, Hanover, NH

Session Chair

Ran Snitkovsky, Tel Aviv University, Tel Aviv - Jaffa, Israel.

1 List Now or Later? An Equilibrium Analysis of Advance-booking Platforms

Neha Sharma[1], Achal Bassamboo[2], Sumanta Singha[3], Milind Sohoni[3], [1]Kellogg School of Management, EVANSTON, IL, [2]Northwestern University, Evanston, IL, [3]Indian School of Business, Hyderabad, India. Contact: a-bassamboo@northwestern.edu

We study sharing platforms that allow guests to reserve assets ahead of service. On such platforms, 'hosts', asset owners who rent their assets, *commit to the assets' availability* by 'listing' it for a future time. We find *empirical evidence* of hosts' strategic decision regarding whether to list early or later from one of the largest car-sharing platforms in India. Given that platforms use dynamic pricing and share revenue with the hosts, they may not always prefer listing early. We use a two-period game-theoretic framework to model such a platform. We first analyze the platform's equilibrium supply and service level for guests under the widely used revenue-share contract. We theoretically show that there always exists a region where no hosts list their assets early. Our results show the limitations of revenue-share contracts in sharing platforms.

2 Observable M/G/1 Queue with Service Age Information

Lin Zang[1], Ricky Roet-Green[2], Yoav Kerner[3], [1]University of Rochester, Rochester, NY, [2]University of Rochester, Pittsford, NY, [3]Ben Gurion University of the Negev, Beer Sheva, Israel. Contact: lzang@simon.rochester.edu

In this paper, we study how service age information influences customers' strategic joining decisions to an M/G/1 queue. Earlier, researchers assume that customers make joining decisions by roughly estimating the residual service time via the queue length information. In this paper, we provide the service age information to customers, which helps simplify their decision process. It is unclear how this more accurate information will influence customers' strategic behaviors and the performance of the system. We study this new system under two service time distribution families: the distribution with decreasing mean residual life (DMRL) and the distribution with increasing mean residual life (IMRL). We find that more accurate information is not always beneficial to the system in terms of throughput and social welfare compared with the no service age information system.

3 Charging More for Priority Via Two-part Tariff for Accumulating Priorities

Binyamin Oz, Shir Moshe, Hebrew University of Jerusalem, Jerusalem, Israel. Contact: b.oz@huji.ac.il

We consider an unobservable M/G/1 queue with accumulating priorities and strategic customers who bid for priority accumulation rates. We show that when affine pricing is introduced, multiple equilibria may exist. This is in contrast to the standard linear pricing case where the equilibrium bidding strategy is unique. Furthermore, a revenue-maximizing operator may generate more revenue under the optimal affine pricing than under linear pricing. In particular, we show that if the utilization level is not too high, no other combination of a priority scheme and pricing generates more revenue than the optimal affine pricing of accumulating priorities.

4 Join, Balk, or Jettison? The Effect of Flexibility and Ranking Knowledge in Systems with Batch-arrivals

Olga Bountali[1], Apostolos Burnetas[2], E. Lerzan Ormeci[3], [1]University of Toronto, Toronto, ON, Canada; [2]University of Athens, Athens, Greece; [3]Koc University, Istanbul, Turkey.

Families that visit theme parks like Disneyland are debating on two aspects when they determine whether they prefer to join an activity or would rather balk: (1) Is it better to join or balk as a group or allow the flexibility to get separated and jettison some members?, and (2) Will it make any difference if they set a ranking among themselves beforehand? We tackle the above and investigate the interplay interplay among flexibility and ranking knowledge with the group size distribution and the corresponding implications on system performance and social welfare.

Tuesday, 8AM–9:15AM

TA28

CC - Room 139

Empirical Healthcare Operations

General Session

Session Chair

Mohamad Soltani, University of Alberta, Edmonton, AB, Canada.

1 Who is An Efficient and Effective Physician? Evidence from Emergency Medicine

Raha Imanirad[1], Soroush Saghafian[2], Stephen Traub[3], [1]Schulich School of Business, Toronto, ON, Canada; [2]Harvard Univeristy, Cambridge, MA, [3]Mayo Clinic, Phoenix, AZ, Contact: raharad@schulich.yorku.ca

Improving the performance of the healthcare sector requires an understanding of the effectiveness and efficiency of care delivered by providers. Although this topic is of great interest to policymakers, researchers, and hospital managers, rigorous methods of measuring effectiveness and efficiency of care delivery have proven elusive. Through Data Envelopment Analysis (DEA), we make use of evidence from care delivered by emergency physicians, and develop scores that gauge physicians' performance in terms of effectiveness and efficiency. Using the derived scores, we carry out a second-stage Tobit analysis to identify the distinguishing behaviors of highly effective and efficient physicians.

2 What Drives Algorithm Use? An Empirical Analysis of Algorithm use in Type 1 Diabetes Self-Management

Wilson Lin[1], Song-Hee Kim[2], Jordan D. Tong[3], [1]University of Southern California, Los Angeles, CA, [2]Seoul National University, Gwanak-gu, Korea, Republic of; [3]University of Wisconsin Madison, Madison, WI, Contact: wilson.lin.phd@marshall.usc.edu

Advancements in algorithms hold promise to better operations by improving users' decision-making. However, people sometimes fail to use algorithms, which could be a barrier from achieving such improvements. Using the bolus calculator (algorithm) use behavior from a field experiment on type 1 diabetes self-management, we show that 1) previous algorithm use increases future algorithm use, 2) being out of target with self-driven decisions increases subsequent algorithm use, while being out of target with algorithm-driven decisions does not impact algorithm use, 3) increasing the number of measurements provided to the user for a single algorithm input decreases algorithm use, 4) increasing one's need for precision increases algorithm use and 5) previous deviations from algorithm recommendations decrease future algorithm use.

3 A Comparison Between Rapid Medical Assessment Vs. Fast-track in Emergency Departments

Arshya Feizi[1], Agni Orfanoudaki[2], Soroush Saghafian[3], [1]Harvard University, Cambridge, MA, [2]Saïd Business School, University of Oxford, Oxford, United Kingdom; [3]Harvard Univeristy, Cambridge, MA, Contact: afeizi@hks.harvard.edu

In order to expedite care in the emergency department (ED), one room called Rapid Medical Assessment (RMA) is dedicated to have a physician conduct an initial evaluation of certain patients in the waiting room and order their tests (e.g., lab, imaging) as they see necessary. A physician will identify a patient from the waiting room who can be seen in the RMA, and have the patient transferred for assessment. Once seen in the RMA, patients return to the waiting room, pending their test results which ultimately determine whether they need an (ordinary) ED bed or that they can be discharged. Currently, the selection of RMA patients is ad-hoc, and may be primarily based on a physician's belief on the patient's complexity. In this paper, we characterize the optimal RMA usage policy, and compare it with fast-track, which is the more ubiquitous patient routing policy.

4 Impacts of Priority in Deceased-Donor Kidney Allocation: A Regression Discontinuity Analysis

Diwas KC, Jiayi Liu, Emory University, Atlanta, GA, Contact: diwas.kc@emory.edu

Despite the efforts to improve the kidney allocation system by focusing on the supply-side policies, little is known about the demand-side response. This paper examines transplant candidates' behavioral responses to one of the most important supply-side leverages---allocation priority---based on a national policy that assigns priority based on an age cut-off.

Tuesday, 8AM–9:15AM

TA29

CC - Room 140

Operations Management in Commodity and Energy Markets

General Session

Session Chair

Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA

1 Aggregating Distributed Energy Resources: Efficiency and Market Power

Zuguang Gao[1], Khaled Alshehri[2], John R. Birge[1], [1]University of Chicago, Chicago, IL, [2]King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia. Contact: zuguang.gao@chicagobooth.edu

The rapid expansion of distributed energy resources (DERs) is one of the most significant changes to electricity systems around the world. Examples of DERs include solar panels, combined heat and power plants, etc. Due to the small supply capacities of these DERs, it is impractical for them to participate directly in the wholesale electricity market. In this talk, we discuss different aggregation models with 1) an unregulated aggregator using a differential pricing policy; 2) an unregulated aggregator using a uniform pricing policy; and 3) a regulated aggregator using a uniform pricing policy. We show that models 1) and 3) achieve full market efficiency, while model 2) has mild efficiency loss. Furthermore, we show that DER aggregation can also leads to a reduction on the market power of conventional generators. All arguments are supplemented with illustrative examples.

2 Integration of Pumped Hydro Energy Storage and Wind Energy Generation: A Structural Analysis

Emre Nadar[1], Harun Avci[2], Ece Cigdem Karakoyun[1], Ayse Selin Kocaman[1], Parinaz Toufani[1], [1]Bilkent University, Ankara, Turkey; [2]Northwestern University, Evanston, IL, Contact: emre.nadar@bilkent.edu.tr

We study the energy generation and storage problem for a hybrid energy system that includes a wind farm and a pumped hydro energy storage facility with two connected reservoirs fed by a natural inflow. We model the problem as a Markov decision process by taking into account the uncertainties in streamflow rate, wind speed, and electricity price. We characterize the optimal policy structure in the presence of positive electricity prices. Leveraging our structural results, we construct a policy-approximation algorithm as a heuristic solution method. Numerical experiments show that our heuristic method yields near-optimal solutions up to 23 times faster than the standard dynamic programming algorithm in our data-calibrated instances.

3 Self-adapting Reinforcement Learning for Financial and Real Options

Selvaprabu Nadarajah[1], Parshan Pakiman[2], [1]Information and Decision Sciences, University of Illinois at Chicago, Chicago, IL, [2]University of Illinois-Chicago, Chicago, IL, Contact: selvan@uic.edu

Least-squares Monte Carlo represents a popular method for options valuation and exercise. Its successful implementation necessitates choosing parametric models to approximate a high-dimensional MDP, which is often done using domain knowledge and some trial and error. We investigate the use of random features to mitigate this implementation burden and show simultaneous improvement in performance.

4 Quadratic Hedging of Risk Neutral Values

Nicola Secomandi, Carnegie Mellon University, Pittsburgh, PA

We apply quadratic hedging in a nonstandard fashion to approximately offset the change in the value of an asset obtained from using any chosen risk neutral measure when markets are incomplete. Consistency between valuation and hedging conditional on this value is thus ensured. Achieving this goal with standard quadratic hedging requires employing the so called variance optimal martingale measure for valuation and can be problematic in general because this measure can fail to be a risk neutral one. The proposed methodology also applies to fully risk neutral valuation of assets with cash flows that depend on both market and private risks, reducing to quadratic hedging if markets are partially complete, which we show provides a novel justification for this valuation strategy in this case.

Tuesday, 8AM–9:15AM

TA31

CC - Room 142

Strategic Interactions in the Interface of Retailing and Operations Management

General Session

Session Chair

Hongseok Jang, Tulane University, New Orleans, LA

Session Chair

Quan Zheng, University of Science and Technology of China, Pittsburgh

1 Supplier Encroachment Through Online Retail Marketplaces

Hongseok Jang[1], Quan Zheng[2], Xiajun Amy Pan[3], [1]Tulane University, New Orleans, LA, [2]University of Science and Technology of China, Pittsburgh, [3]University of Florida, Gainesville, FL, Contact: hjang@tulane.edu

We study whether a supplier should encroach on an online retail marketplace where both reselling and agency channels are available and its impact on stakeholders in e-commerce. We show that agency encroachment could lead to different results and managerial insights, comparing with traditional supplier encroachment through a direct channel.

2 Online Seller Competition on E-commerce Platforms with Blockchain Technology

Yonghua Ji[1], Yu Jiang[2], [1]University of Alberta, Edmonton, AB, Canada; [2]University of Science and Technology of China, Hefei, Contact: yji@ualberta.ca

Blockchain technology has been increasingly used in supply chain management. It can be used in several aspects such as product authentication. However use of blockchain technology also causes the concern of information leakage. We study a setting where a brand-name seller and a non-brand-name seller compete on an online platform. A game theoretical model is used to study the sellers' incentives in adopting blockchain technology and the impact of blockchain technology on supply chain participants.

3 Freemium Pricing of Conspicuous Digital Goods in Free-to-play Multiplayer Games

Esma Koca[1], Ioannis Bellos[2], Hang Ren[2], [1]Imperial College London, [2]George Mason University, Fairfax, VA

Many popular free-to-play (F2P) multiplayer games offer digital goods at a monetary price and a price in virtual currency which is earned with playtime. These goods (e.g., so-called "skins") do not provide any gameplay advantages but furnish unique cosmetics to a player's in-game appearance; hence, players seek exclusivity from purchasing them. Given such exclusivity-seeking behavior, the widespread practice of offering skins for free seems puzzling, especially considering that game publishers do not monetize playtime through activities such as in-game advertising. In this paper, we analyze a game publisher's optimal freemium pricing strategy for a digital conspicuous good in a F2P multiplayer game. We find that players' exclusivity-seeking behavior can support the publisher's freemium offering.

Tuesday, 8AM–9:15AM

TA32

CC - Room 143
Renewable Energy and Storage Operations
General Session

Session Chair
Karthik Murali, Oregon State University, Corvallis, OR

1 Does Renewable Energy Renew The Endeavor in Energy Efficiency?
Amrou Awaysheh[1], Christopher J. Chen[2], Owen Wu[3], [1]Indiana University, Indianapolis, IN, [2]Indiana University Kelley School of Business, Bloomington, IN, [3]Indiana University, Bloomington, IN
We examine whether and how renewable energy (RE) adoption can increase or decrease energy efficiency (EE) improvement. Using site-level data from an industrial conglomerate, we estimate the impact of changes in RE usage and in the acquisition approach on the EE of 183 sites across the globe from 2015 to 2020. We find that using RE to meet 10% more of a site's energy demand led to an additional 2.0% improvement in EE. However, there is significant heterogeneity in the effects depending on the acquisition approach: while purchasing RE credits or entering into power purchase agreements led to gains in EE, installing on-site RE generators had no effect.

2 Optimal Management of Renewable Energy Certificates (REC): A Reinforcement Learning Approach
Daeho Kim[1], Dong Gu Choi[1], Michael Lim[2], [1]Pohang University of Science and Technology (POSTECH), Pohang, Korea, Republic of; [2]Seoul National University, Seoul, Korea, Republic of.
Several countries have adopted regulations that require electricity suppliers the increased production of electricity from renewable energy resources. To comply with the requirements, the suppliers purchase renewable energy from generators through a market-based instrument called Renewable Energy Certificate (REC). The price volatility and lofty requirements for participation in the REC market have led to the emergence of a brokerage service for renewable energy generators. This research aims to study the optimal REC management for a brokerage service provider. We formulate the problem in Markov Decision Process and characterize key structural properties of the optimal policy. Then, we develop a deep reinforcement learning (DRL) algorithm exploiting the structural properties. Lastly, we verify the performance of the algorithm through the real market data.

3 An Efficient Heuristic for Energy Storage Management Under Time-of-use Pricing
Na Rea Cho[1], Karthik Murali[2], Youngsoo Kim[1], Mesut Yavuz[1], [1]University of Alabama, Tuscaloosa, AL, [2]Oregon State University, Corvallis, OR, Contact: myavuz@cba.ua.edu
We develop an efficient heuristic to identify a time-independent home energy storage operation policy for a residential user with a paired solar array. We quantify the benefits of good energy storage management and provide managerial implications to guide users on how to make simple and cost-effective battery operation decisions when faced with time-varying demands, energy generation, and electricity prices.

Tuesday, 8AM–9:15AM

TA33

CC - Room 144
Inventory and Supply Chain Management
Contributed Session

Session Chair
Zuochun Tang, IBM, san francisco, CA

1 Inventory Placement Optimization in E-commerce: The Need for Speed
Gowtham Bellala, Vikas Goel, Flipkart, Bangalore, India. Contact: gowtham.bellala@gmail.com
We discuss Inventory placement for the largest e-commerce company in India. Speed is a critical factor for success in e-commerce. To enable speed, we adopted a 2-tier network consisting of Forward and Deep reserves (FRs & DRs). DRs are big warehouses that serve a large geography. FRs are small warehouses that serve a smaller geography, thus providing better speed. Inventory at FRs are periodically replenished from the DRs. We address the following questions, (i) which products must be moved to an FR, (ii) how much quantity to move, and (iii) which DRs to move it from? This problem can be formulated as MILP. Solving

it to optimality is infeasible due to its sheer scale (~400M variables). In this work, we propose a highly scalable and efficient algorithm. The proposed algorithm showed significant uplift in FR in-stock (>1000 bps) and regional fulfillment (>300 bps) at a 50% lower cost.

2 Scattered Storage Assignment in a Mixed-shelves Warehouse Based on a Two-phase Surrogate Method

Xuefei Liu[1], Ek Peng Chew[2], Haobin Li[2], Kok Choon Tan[2], [1]National University of Singapore, Singapore, Singapore; [2]National University of Singapore, Singapore, Singapore.

The scattered storage strategy has been used in third-party logistics warehouses that provide services to retail chain stores. For this storage strategy, incoming items are broken down into individual units, and items of the same stock-keeping unit (SKU) can be stored in multiple locations. In this scenario, the probability of storing different SKUs with high correlations in nearby storage units will increase. This research proposes a two-phase surrogate method to optimize the scattered storage assignment in a mixed-shelves warehouse with uncertain orders. Phase 1 adopts a multi-objective mixed-integer programming model to minimize the weighted average distance based on both the SKUs' demands and their summarized correlations. Phase 2 introduces an object-oriented discrete-event simulation framework as the core engine to find the most efficient storage strategy.

3 Scattered Storage Assignment: Mathematical Model and Vns Meta-heuristic to Optimize The Intra-order Item Distances

Harol Mauricio Gamez Alban[1], Trijntje Cornelissens[2], Kenneth Sörensen[1], [1]University of Antwerp, Antwerp, Belgium; [2]University of Antwerp, Antwerp, Belgium. Contact: mauricio.gamezalban@uantwerpen.be

In scattered storage, individual items are intentionally distributed across multiple positions in the picking area. Especially in e-commerce environments, where orders typically consist of a few items in small quantities, such a storage policy can reduce picking travel times by increasing the likelihood that items belonging to the same order can be found in nearby positions. We propose a scattered storage policy that, when determining the positions where each replenished item should be stored, attempts to minimize the sum of pairwise distances between all items that belong to the same order. We propose a VNS metaheuristic to obtain good solutions in reasonable computation time. We tested our policy by implementing a routing algorithm. The results show that our policy helps to reduce the distances in picking compared to a volume-based and a random scattering policy.

4 Two-step Optimization for Product Availability in Inventory Management

Zuochun Tang[1], Yihua Li[1], Xiaowei Bao[2], [1]IBM, San Francisco, CA, [2]IBM, Portland, OR

In retail, businesses need to decide what is the amount of inventory level that is available for various business operations, such as sales operations, fulfill operations. This product availability has significantly impact on many business objectives. Our method seeks to find an optimal product availability at both network level and item-location-channel level for omni-channel inventory management. We have developed a two-step optimization mechanism to forward the solution from higher level to the lower level so that the problem size is manageable, and the optimal product availability at different level are consistent, which also provides the benefit of decomposing a complex problem into many small subproblems that can be easily parallelized.

Tuesday, 8AM–9:15AM

TA34

CC - Room 145

Sustainability in Manufacturing and Cluster Best Student Paper Talks

Flash Session

Session Chair

Zijun Zhang, City University of Hong Kong, Hong Kong, Hong Kong.

Session Chair

Li Zeng, Hong Kong.

Session Chair

Yuxin Wen, Chapman University, Orange, CA

1 Ontology-based Attribute Learning to Accelerate Certification for New Printing Processes

Hui Wang[1], Tsegai Yhdego[2], [1]Florida A&M University - Florida State University College of Engineering, Tallahassee, FL, [2]Florida A&M University- Florida State University College of Engineering, Tallahassee, FL, Contact: hwang10@fsu.edu

As new printing technologies are being developed, process certification is important to determine if printed structures are defect-free. However, such process certification entails extensive measurements. This research learns defects unseen in the training dataset by imitating how a human learns new concepts by recognizing a combination of attributes. The work formulates a joint optimization problem for learning defect class embedding and ontology structures and solves it by integrating natural language processing, metaheuristics, and stochastic gradient descent. The optimized ontology can identify defects that are not included in training data. A case study for printing nanocomposites demonstrated the methodology. This work is among the first attempts to learn defects unseen in training data so that measurements for process certification can be reduced.

2 A Hybrid Deep Generative Network for Porosity Prediction in Metal Additive Manufacturing

Zheren Song, Peking University, Beijing, China.

Metal additive manufacturing technique has shown promising application prospect in various industrial sectors. However, various defects, especially porosity, significantly impact the mechanical properties of the final products. This urges a deeper insight into the relationship between porosity microstructure and processing parameters for quality control. In this work, we present a novel hybrid deep generative porosity prediction (HDGPP) framework that leverages deep generative models to systematically characterize the relationship between pore microstructure and processing parameters. The effectiveness of the proposed HDGPP is validated through case study of a laser powder bed fusion process.

3 A Deep Mixed-effects Modeling Approach for Real-time Monitoring of Metal Additive Manufacturing Process

Ruiyu Xu, Peking University, China.

We propose a deep mixed effects modeling approach to monitor the melt pool temperature for anomaly detection. It consists of a deep neural network (DNN) capturing the relationship between the temperature and other sensing data, a random-effect term accounting for the random variation of mean temperature, and a measurement error term modeling the spatio-temporal correlation. An efficient optimization algorithm is developed which iteratively optimizes the model parameters. A T^2 control chart and a Generalized Likelihood Ratio (GLR) control chart are developed to timely detect the process anomalies. The asymptotic consistency of the T^2 and GLR statistics are further established.

4 Generativewind Power Curve Modeling Via Machine Vision: A Deep Convolutional Network Method with Data-synthesis-informed-training

Luoxiao Yang, City University of Hong Kong, Hong Kong.

A wind power curve (WPC) directly pictures the wind speed and power output relationship and is useful to help address many issues in the wind energy domain. In this talk, I will present our work that develops a novel data-synthesis-informed-training U-net based method to automate the WPC modeling without data pre-processing. Specifically, we renovate the WPC modeling formulation from a machine vision aspect and synthesize diversified training samples. Next, we develop a deep generative model to approximate the projection recovering the synthesized neat WPC from the synthesized SCADA WPC. The proposed method only needs to train once and does not require any data preprocessing in applications.

5 Airu-wrf: A Physics-guided Spatio-temporal Wind Speed Forecasting Model and Its Application to The U.s. North Atlantic Offshore Wind Energy Areas

Feng Ye, Joseph Brodie, Ahmed Aziz, Rutgers University, Piscataway, NJ

Accurate wind forecasts are instrumental for cost-effective wind farm operation. In order to make accurate, short-term, spatio-temporal wind speed forecasts, we propose a physically motivated statistical model which integrates two multi-resolution data streams: a set of numerical weather predictions, and co-located set of weather measurements. The proposed model is "physics-guided", which statistically captures salient physical features of the offshore wind field, without the need to explicitly model physics. Exhaustive numerical experiments using data from the NY Bight, suggest that the proposed model outperforms prevalent benchmarks in the wind forecasting literature and practice.

6 An Explainable Machine Learning (eml) Approach for Process Anomalies Characterizations Towards Improving Sustainable Materials' Manufacturing

Qiyang Ma[1], Zimo Wang[2], [1]SUNY at Binghamton, Binghamton, NY, [2]SUNY Binghamton, Binghamton, NY

Natural fiber reinforced plastic (NFRP) composites are ecofriendly and biodegradable materials that can be applied as alternatives to conventional synthetic fibers for sustainable manufacturing. However, critical issues reside in the machinability of such materials due to their heterogeneous microstructures. We report a model-agnostic explainable machine learning approach to unravel the fundamental understanding of the relationships between material microstructure and the in-situ machining dynamics. The investigations suggest that the presented approach can provide guidance on material structure optimizations and process improvements during sustainable material machining.

Tuesday, 8AM–9:15AM

TA37

CC - Sagamore 6

Stochastic and Robust Integer Programming

General Session

Session Chair

Xian Yu, University of Michigan, Okemos, MI

1 Constrained Network Flow Models for Two-stage Robust Binary Optimization

Ian Yihang Zhu, Merve Bodur, Timothy Chan, University of Toronto, Toronto, ON, Canada. Contact: i.zhu@mail.utoronto.ca

In this talk, we examine two-stage robust binary optimization problems with objective uncertainty, which are notoriously difficult to solve exactly. We show how a specific condition, termed "selective adaptability", between first-stage and second-stage decisions facilitates a reformulation of the robust problem into a single MIP formulation representing a constrained network flow model. Our network flow model builds upon concepts from the decision diagram literature. We show the advantages of the new models through a comprehensive set of computational experiments.

2 Wasserstein-based Distributionally Robust Nonlinear, Discrete Optimization with Multiple Sources of Uncertainty: Reformulation and Algorithm

Niloufar Izadinia, Andreas Waechter, David Morton, Northwestern University, Evanston, IL, Contact: niloufarizadinia2020@u.northwestern.edu

We present an optimization framework for a distributionally robust optimization model that captures nonlinearities in the model structure as well as the supply chain for material procurement under uncertain demand and outsourcing prices. A novel algorithm and numerical results will be presented.

3 Data-driven Unit Commitment Problem Under Uncertainty with Fairness Considerations

Yutong Wu, Grani Adiwena Hanasusanto, The University of Texas at Austin, Austin, TX, Contact: yutong.wu@utexas.edu

Unit Commitment (UC) is one of the most important and crucial tasks in the power system. The UC problem aims to find an optimal schedule of power generation and dispatch to meet the system load subject to various operational constraints while minimizing the total cost. In this paper, we model the UC problem as a two-stage distributionally robust optimization problem while addressing uncertainty in renewable output and network topology. Meanwhile, we introduce nonlinear fairness constraints to ensure that the proportion of the shedded load is consistent within the system. We provide tractable reformulations of the problem using linear decision rules and copositive programming. Numerical experiments on IEEE test cases show that our framework effectively guarantees fairness across different regions while reducing the generation and dispatch cost.

4 On The Value of Multistage Risk-averse Stochastic Facility Location with or Without Prioritization

Xian Yu[1], Siqian Shen[2], [1]The Ohio State University, Columbus, OH, [2]University of Michigan, Ann Arbor, MI, Contact: yu.3610@osu.edu

We consider a multi-period capacitated facility location problem under uncertain demand and budget. We formulate a multistage stochastic integer program and compare it with a two-stage approach that determines a part of the decisions up front. In the multistage model, after realizing the demand, a decision maker optimizes facility locations and recourse flows. When the budget is also uncertain, a modeling framework is to prioritize the candidate sites. In a two-stage model, the priority list is decided in advance, while in a multistage model, the priority list can change adaptively. Using expected conditional risk measures, we provide *tight* lower bounds for the gaps between optimal objective values of risk-averse multistage models and their two-stage counterparts. Moreover, we propose approximation algorithms and cutting planes to efficiently solve these two models.

Tuesday, 8AM–9:15AM

TA38

CC - Sagamore 7

Network Optimization Problems Under Uncertainty

General Session

Session Chair

Aliaa Alnaggar, 1</sup

1 A Multi-stage Stochastic Integer Programming Approach for Last-mile Delivery with Crowdshipping: Optimizing Profitability & Service Level

Akshit Goyal[1], Yiling Zhang[2], Saif Benjaafar[2], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, Contact: goyal080@umn.edu

We study a last-mile delivery system where both crowdsourced and full-time drivers are employed and explore the opportunity of hiring crowdsourcing drivers. Under uncertain crowdsourced drivers' availability and demand, the problem is formulated as a multi-stage stochastic integer programming model, where in the planning stage the decision of hiring full-time drivers is optimized. Each of the remaining stages corresponds to a delivery time window for which a time-and-capacity-status transportation network is constructed to optimize operations of vehicle fleet of both types of drivers. Using value function approximations, an approximate dynamic programming algorithm is developed to solve the model. We conduct extensive computational studies based on the city of Minneapolis.

2 Stochastic Programming for Dynamic Inventory Optimization Under Downward Substitution

Mahsa sheikhihafshejani, Harsha Gangammanavar, Sila Cetinkaya, Southern Methodist University, Dallas, TX

Ensuring product availability while eliminating excess inventory is an important supply chain challenge in today's volatile markets with supply shortages and panic-buying behavior. Product substitution is indeed a means for managing product availability in such volatility. We investigate a multi-product dynamic inventory optimization problem with one-way substitution and stochastic demands. Our goal is to compute cost-optimal inventory control policies prescribing order and substitution quantities for both two-stage and multi-stage settings. The resulting optimization formulations lead to computationally challenging stochastic programming problems with network representations for which we explore alternative methodologies, including stochastic decomposition and stochastic dual dynamic programming, and document their relative performance.

3 Optimizing Car Sharing Services Under Demand Substitution and Uncertainty

Sinan Emre Kosunda[1], Beste Basciftci[2], Esra Koca[1], [1]Sabanci University, Istanbul, Turkey; [2]University of Iowa, Iowa City, IA, Contact: beste-basciftci@uiowa.edu

To optimize the strategic and operational decisions of car sharing systems under demand uncertainty with a mix fleet of vehicles including gasoline-powered and electric, we propose a two-stage stochastic mixed-integer program with spatial-temporal networks. We optimize the location decisions of zones with their parking capacities while satisfying trips and relocating cars between open zones under each demand realization. We introduce demand substitution to this problem by extending it to a multi-commodity setting and prove that its second-stage problem has a totally unimodular constraint matrix. As our solution approach, we provide a Benders-based decomposition algorithm with enhancements. Our computational study demonstrates the benefits of incorporating demand substitution and provides insights for fleet allocation decisions under demand uncertainty.

4 Two-stage Distributionally Robust Optimization for Network Balancing Problems

Aliaa Alnaggar[1], Andre Augusto Cire[2], Adam Diamant[3], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada; [3]Schulich School of Business, Toronto, ON, Canada. Contact: aliaa.alnaggar@utoronto.ca

We propose a two-stage distributionally robust optimization problem for capacity rebalancing where resources are located at nodes of a network. The first stage establishes node capacities, while the second stage transfers resources across network links after observing demand. We show that, for partial moment ambiguity sets, the problem may be solved exactly for general second-stage networks via a separation algorithm, where the subproblem is a mixed integer second order cone program. Using publicly available data, we illustrate the benefits of the approach for repositioning ICU beds across hospitals.

Tuesday, 8AM–9:15AM

TA39

CC - Room 201

Global Optimization of Stochastic and Semi-Infinite Programs

General Session

Session Chair

Rohit Kannan, Los Alamos National Laboratory, Los Alamos, NM

1 **Piecewise Linear Decision Rules Via Adaptive Partition for Two Stage Stochastic Mixed Integer Linear Programs**
Can Li[1], Kibaek Kim[2], [1]Purdue University, West Lafayette, IN, [2]Argonne National Laboratory, Lemont, IL, Contact: canli.pse@gmail.com
We propose an algorithm based on piecewise linear decision rules for TS-SMILP with continuous distributions. The domain of the uncertainty parameter is partitioned into several subsets. In each subset, the second stage continuous variables adopt a linear decision rule with respect to the uncertain parameters and the second-stage binary variables are constant. Several theoretical properties are proved. First, we prove that there exists a piecewise decision rule that is optimal for TS-SMILP. Second, under uniform partition, the convergence rate of the piecewise decision rule is proved and compared with the convergence rate of sample average approximation. In the proposed algorithm, the partition of the uncertainty set is adaptively updated. Several adaptive partition schemes including uniform partition, strong partition, and reliability partition, are proposed.

2 **Stage-t Scenario Dominance for Risk-averse Multi-stage Stochastic Mixed-integer Programs**
Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Newark, NJ
We present a new and general approach, named ``Scenario Dominance,'' to solve the risk-averse multi-stage stochastic mixed-integer programming (M-SMIP) problems. We derive bounds and cutting planes from the stage-*t* scenario dominance, using the partial ordering of scenarios, and solving a subset of individual scenario sub-problems to tackle the computational difficulty of risk-averse M-SMIPs. We demonstrate the use of this methodology on a stochastic version of the mean-Conditional Value-at-Risk (CVaR) dynamic knapsack problem. Computational results show that our ``scenario dominance"-based method can substantially reduce the solution time for risk-averse stochastic multi-stage knapsack problems by one-to-two orders of magnitude.

3 **CoMirror with Random Constraint Sampling for Semi-infinite Programming**
Wei Bo[1], William Haskell[2], Sixiang Zhao[3], [1]Bilkent University, Ankara, Turkey; [2]Purdue University, West Lafayette, IN, [3]SJTU, Shanghai, China.
In this paper, we combine the CoMirror algorithm with inexact cut generation to create the SIP-CoM algorithm for solving semi-infinite programming (SIP) problems. First, we provide general error bounds for SIP-CoM. Then, we propose two specific random constraint sampling schemes to approximately solve the cut generation problem for generic SIP. When the objective and constraint functions are generally convex, randomized SIP-CoM achieves an O(1/sqrt(*N*)) convergence rate in expectation (in terms of the optimality gap and SIP constraint violation). When the objective and constraint functions are all strongly convex, this rate can be improved to O(1/*N*).

4 **Improved Lower Bounding Method for Semi-infinite Programming**
Evren M. Turan[1], Johannes Jäschke[1], Rohit Kannan[2], [1]Norwegian University of Science and Technology, Trondheim, Norway; [2]Los Alamos National Laboratory, Los Alamos, NM, Contact: evren.m.turan@ntnu.no
Semi-infinite programs (SIPs) are optimization problems with finitely many decision variables and infinitely many constraints, typically parameterized. Most recent methods for the global minimization of SIPs use an adaptive discretization method developed by Blankenship and Falk (1976) to guarantee convergence of the lower bounds.
We propose a new discretization method for SIPs in which the parameter values that yield the highest lowest bound at incumbent solutions populate the discretization. This is formulated as a max-min problem, which we solve to local optimality using results from parametric sensitivity theory. Numerical results show that our approach can significantly reduce the number of iterations for the lower bound to converge compare.

Tuesday, 8AM–9:15AM

TA40

CC - Room 202
Linear and Conic Optimization/Quantum Optimization
General Session

Session Chair
Rodolfo Quintero, Lehigh University

1 **The Set Partitioning Problem on Quantum Computers**
Rafael Farias Cação[1], Lucas R. C. T. Cortez[1], Jackson Forner[2], Hamidreza Validi[3], Ismael Regis De Farias[1], Illya V. Hicks[4], [1]Texas Tech University, Lubbock, TX, [2]Southern Methodist University, Dallas, TX, [3]Texas Tech University, Lubbock, TX, [4]Rice University, Houston, TX, Contact: rafael.cacao@ttu.edu

The set partitioning problem and its decision variant (i.e., the exact cover problem) are combinatorial optimization problems that were historically crucial in the quantum optimization community. The set partitioning problem is also employed in the main problem of many real-world optimization problems, including, but not limited to, districting and scheduling. Motivated by this, we propose quadratic unconstrained binary optimization (QUBO) models with tight penalty coefficients for the problem. Furthermore, we employ five classical reductions of Garfinkel and Nemhauser (Operations Research, 1969) to reduce the size of random and existing instances substantially. We finally use Variational Quantum Eigensolver (VQE) for solving the set partitioning problem on two sets of existing and random instances.

2 Filtering Variational Quantum Algorithms for Combinatorial Optimization

Gabriel Marin Sanchez, David Amaro, Quantinuum, London, United Kingdom. Contact: gabriel.marin@cambridgequantum.com

Combinatorial optimization is highly relevant in industry and research but can be computationally intractable even with the best classical algorithms. Quantum computing uses genuine quantum properties to provide a fundamentally different approach. Variational quantum algorithms like VQE and QAOA complement the limited resources of current quantum hardware with classical algorithms like gradient descent, but suffer from bad convergence. We present F-VQE, a variational quantum algorithm that filters-in the candidate solutions closer to the optimum. The convergence outperforms that of VQE and QAOA on MaxCut and on a job-shop scheduling problem on the steel industry. The hardware-efficiency is demonstrated on trapped-ion and superconducting quantum devices.

3 A Quantum Computing Approach to Discretized Traffic Assignment Problem

Tina Radvand, Alireza Talebpour, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: radvand2@illinois.edu

Recent advances in quantum computing provide a new tool to deal with the computational power needed to handle combinatorial optimization problems like traffic assignment. In this study, the multi-source multi-destination traffic assignment problem is formulated as a quadratic unconstrained binary optimization and implemented on a quantum annealer. The complexity of the algorithms and the annealing time to find the solution to the traffic assignment problem are discussed.

4 Binary Integer Formulations for Adiabatic Quantum Annealing Hardware

Toby Huskinson, Richard S. Barr, Southern Methodist University, Dallas, TX

It has been demonstrated that Binary Integer Programming (BIP) formulations can be converted to a corresponding quadratic unconstrained binary optimization (QUBO) problem. The conversion allows for BIPs to run as QUBOs on adiabatic quantum annealing hardware. Current BIP to QUBO conversion techniques propagate dense QUBO structures that are not ideal for current hardware where quantum bits, and the connections between them, are scarce. We propose a methodology for BIP to QUBO conversion that results in a sparse QUBO and reduces the physical prerequisites necessary to represent the BIP on hardware. We discuss the limitations of the technique and avenues for future improvements.

Tuesday, 8AM–9:15AM

TA41

CC - Room 203

Recent Advances in Stochastic Optimization and Variational Inequality Problems

General Session

Session Chair

Afrooz Jalilzadeh, The University of Arizona, Tucson, AZ

1 A Stochastic Level-Set Method for AUC Optimization with AUC-based Fairness Constraints

Yao Yao, Qihang Lin, Tianbao Yang, The University of Iowa, Iowa City, IA, Contact: yao-yao-2@uiowa.edu

The area under the ROC curve (AUC) is one of the most widely used performance measures for classification models in machine learning. Instead of only maximizing AUC, fairness has become a serious concern in many fields, such as criminal justice and medical diagnosis. We focus on three different types of fairness measures based on AUC and its variants. We cast the problem into min-max objective with min-max constraints problem based on perspective function, which allows us to apply a stochastic feasible level-set method that has low data complexity and emphasizes feasibility before convergence. Specifically, the level-set method solves a root-finding problem by calling stochastic mirror descent oracle that computes a stochastic upper bound on the level-set function. Finally, we numerically demonstrate the effectiveness of our proposed algorithms.

2 Alternating Direction Method of Multipliers for Quantization

Tianjian Huang, Los Angeles, CA

Quantization of the parameters of machine learning models, such as training binarized neural networks, requires solving constrained optimization problems, where the constraint set is the Cartesian product of many simple discrete sets. For such optimization problems, we study the performance of the ADMM for Quantization (ADMM-Q) algorithm, which is a variant of the widely-used ADMM method applied to our discrete optimization problem. We establish the convergence of the iterates of the ADMM-Q algorithm to certain stationary points. Based on our theory, we develop a few variants of ADMM-Q; that can handle inexact update rules, and have improved stability through "soft projection operators".

3 Homotopic Policy Mirror Descent: Policy Convergence, Implicit Regularization, and Improved Sample Complexity

Yan Li[1], Tuo Zhao[2], Guanghui Lan[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, [3]ISyE Ga Tech, Atlanta, GA, Contact: yli939@gatech.edu

We propose the homotopic policy mirror descent (HPMD) method for solving discounted, infinite horizon MDPs with finite state and action space, and study its policy convergence. We report three properties that seem to be new in the literature of policy gradient methods: (1) HPMD exhibits global linear convergence of the value optimality gap, and local superlinear convergence of the policy to the set of optimal policies with order γ^{-2}; (2) HPMD also exhibits the last-iterate convergence of the policy, with the limiting policy corresponding exactly to the optimal policy with the maximal entropy for every state; (3) For the stochastic HPMD method, we demonstrate that a better than $\mathcal{O}(\abs{\mathcal{S}} \abs{\mathcal{A}} / \epsilon^2)$ sample complexity for small optimality gap ϵ holds with high probability when assuming a generative model.

4 Accelerated Primal-dual Scheme for a Class of Nonconvex-concave Saddle Point Problems

Morteza Boroun, Zeinab Alizadeh, Afrooz Jalilzadeh, The University of Arizona, Tucson, AZ

Nonconvex-concave min-max saddle point problems appear in many machine learning problems, such as generative adversarial networks and adversarial learning. Convex-concave minimax problems have been extensively studied in literature. In this paper, we study a class of nonconvex saddle point problems where the objective of one of the playerssatisfies the Polyak-Łojasiewicz (PL) condition. We propose a novel single-loop accelerated primal-dual algorithm to find an �-gap solution in O(�^{-1}) iterations for the first time. To the best of our knowledge, this is the best-known rate for this setting. To show the behaviour of the algorithm, we applied the proposed scheme to solve Generative adversarial imitation learning.

Tuesday, 8AM–9:15AM

TA43

CC - Room 205

Large Scale Optimization

Contributed Session

Session Chair

Lucas Guerreiro, [1</sup]

1 More Practical Results on The Exactness of Trimmed Penalties for Sparse Optimization

Shotaro Yagishita, Jun-ya Gotoh, Chuo University, Bunkyo-ku, Japan. Contact: sho.stochas@gmail.com

Nonconvex sparse optimization problems with the trimmed l1 norm penalty or truncated nuclear norm penalty for sparse optimization have been actively studied. In this talk, we first introduce a unified framework that includes all the existing trimmed l1-penalized problems. We then show that under mild conditions, any d-stationary point of the generalized trimmed l1 (resp. truncated nuclear) penalized problem satisfies the corresponding cardinality (resp. rank) constraint. This property is called the "exactness" and our exactness result is superior to almost all existing results, especially from the viewpoint of practice. We also extend our results to constrained problems. Finally, algorithms based on the proximal mapping are presented and we show that they obtain a d-stationary point of the problems.

2 The Complexity of Nonconvex Minimax Optimization: Fundamental Limits and Improved Algorithms

Siqi Zhang, Johns Hopkins University, Baltimore, MD, Contact: szhan207@jhu.edu

We will study the complexity for finding approximate stationary points in Nonconvex-Strongly-Concave (NC-SC) smooth minimax optimization problems. We establish nontrivial lower complexity bounds for NC-SC problems in both general and stochastic settings, which reveal substantial gaps between these limits and best-known upper bounds in the literature. To close these gaps, we introduce a generic Catalyst acceleration scheme that deploys existing gradient-based methods to solve a sequence of crafted Strongly-Convex-Strongly-Concave (SC-SC) subproblems. We show that our proposed algorithm improves over previous algorithms and nearly matches the lower bounds. We also extend our analysis to the purely stochastic case and its corresponding generalization performances.

3 A Generation and Transmission Expansion Planning Model with Security Constraints - a Hybrid Modeling Using Transmission Network Feasibility Cuts

Lucas Guerreiro[1], Tiago Coutinho Carneiro de Andrade[2], Alessandro Junior[2], [1]PSR, Rio de Janeiro, Brazil; [2]PSR, Rio de Janeiro, Brazil. Contact: lucasaguerreiro@psr-inc.com

The classic modeling of the transmission network requires an explicit representation of angles and flows variables, which usually increases the size of the G&T expansion planning (GTEP) model. We propose a "compact formulation" of the transmission network by using the power transfer distribution factor (PTDF) matrix implicitly representing the transmission in the GTEP problem by adding feasibility cuts.
Also, since the network topology of the GTEP problem is a decision variable (it depends on the investment decision and the security constraints), the PTDF matrix will depend on the decision variables. Because of that, we discuss a "hybrid" representation for the GTEP problem by explicitly representing the network variables for the projects and adding feasibility cuts for the existing transmission lines and the N - 1 security constraints.

Tuesday, 8AM–9:15AM

TA44

CC - Room 206

AI4OPT: ML for Discrete Optimization Solvers

General Session

Session Chair

Bistra Dilkina, USC, Los Angeles, CA

1 Learning to Branch on Security-constrained Unit Commitment

Santanu Subhas Dey[1], Xiaoyi Gu[2], Feng Qiu[3], Alinson Xavier[4], [1]ISyE Georgia Tech, Atlanta, GA, [2]Georgia Tech, Atlanta, GA, [3]Argonne National Laboratory, Lemont, IL, [4]Argonne National Lab, Lemont, IL

We develop ML-based methods for improving branch-and-bound variable selection rules that exploit key features of operational problems: similarity between instances translates mathematically to solving mixed integer linear programming (MILP) instances where there are only minimal changes on the matrix, right-hand-side and the objective function coefficients. Therefore, we build one separate ML model per variable for learning to predict the strong branching score. We implement this methodology for SCUC, and show that on the test instances, we are able to obtain branch-and-bound trees whose size isclose to the size of the tree obtained by strong branching and outperforming previous machine learning schemes.

2 Ml-guided Searches for Multi-agent Path Finding

Taoan Huang[1], Bistra Dilkina[2], Sven Koenig[1], [1]University of Southern California, LOS ANGELES, CA, [2]USC, Los Angeles, CA, Contact: huangtaoan@163.com

Multi-Agent Path Finding (MAPF) is an NP-hard problem that finds collision-free paths for a set of agents. Conflict-Based Search (CBS), an optimal algorithm, and Enhanced CBS (EBCS), its suboptimal version, are state-of-the-art algorithms for MAPF. In this work, we use ML techniques to improve heuristic decisions made in CBS and ECBS. For CBS, we learn to resolve conflicts for CBS, where we learn to imitate a computationally-expensive but effective oracle. For ECBS, we learn node-selection strategies, where we apply imitation learning and curriculum learning iteratively for instances with increasing difficulties. We deploy the learned models in CBS or ECBS. Our ML-guided solvers show substantial improvement in terms of the success rates and runtimes over the state-of-the-art CBS or ECBS on several different types of grid maps from the MAPF benchmark.

Tuesday, 8AM–9:15AM

TA45

CC - Room 207

Machine Learning-optimization Interface

General Session

Session Chair

Bartolomeo Stellato, Princeton University, Princeton, NJ

1 Mean Robust Optimization

Irina Wang[1], Bartolomeo Stellato[1], Cole Becker[1], Bart Paul Gerard Van Parys[2], [1]Princeton University, Princeton, NJ, [2]MIT Sloan School of Management, Cambridge, MA,

Contact: iywang@princeton.edu
Robust optimization is an expressive technique for decision-making under uncertainty, but it can lead to overly conservative decisions due to pessimistic assumptions. Wasserstein distributionally robust optimization can reduce conservatism by being closely data-driven, but it often leads to large problems with prohibitive solution times. We introduce mean robust optimization, a general framework that combines the best of both worlds by providing a trade-off between computational effort and conservatism. Using machine learning, we define uncertainty sets and constraints around clustered data, undergoing a significant size reduction while preserving key properties. We show finite-sample performance guarantees and conditions for which clustering does not increase conservatism. Numerical examples illustrate the efficiency of our approach.

2 Performance Certification of First Order Methods for Parametric Quadratic Optimization

Vinit Ranjan, Bartolomeo Stellato, Princeton University, Princeton, NJ, Contact: vranjan@princeton.edu
Fast convergence of first order optimization is critical for real-time decision making where we solve the same problem over time with varying parameters. Common algorithm analysis techniques focus on generic worst-case convergence rates and often lead to a gap between theoretical bounds and practical convergence. We introduce a framework to certify finite step convergence of first-order methods for parametric convex quadratic optimization. Our framework is modular because we encode, through quadratic constraints, a wide range of proximal algorithms and sets where initial iterates and problem parameters live. Using semidefinite programming, we derive tractable convex relaxations to scale certification problems to high dimensions. Numerical examples show that our method significantly reduces the conservatism of common convergence analysis techniques.

3 Learning to Convexify for Fast Real-time Optimization

Rajiv Sambharya[1], Georgina Hall[2], Brandon Amos[3], Bartolomeo Stellato[1], [1]Princeton University, Princeton, NJ, [2]INSEAD, Fontainebleau, France; [3]Facebook AI Research, New York, NY, Contact: rajivs@princeton.edu
We present learn2convexify, a data-driven method to solve similar non-convex optimization problems in real-time. Solution algorithms for non-convex optimization remain prohibitively expensive. Most are general-purpose and tackle each optimization instance individually. In practice, however, we often solve very similar problems with varying data. We propose a novel neural network architecture to solve non-convex problems that come from the same family. Our method leverages common structure across the family to learn a latent variable representation, which is then used as input to a convex optimization problem whose solution approximates a solution to the original non-convex optimization problem. After training, our method consists of a feedforward network followed by a convex optimization problem which enables fast real-time decision making.

4 Learning for Optimization Under Uncertainty

Irina Wang[1], Cole Becker[2], Bart Paul Gerard Van Parys[3], Bartolomeo Stellato[4], [1]Princeton University, Princeton, [2]Princeton University, Princeton, NJ, [3]MIT Sloan School of Management, Cambridge, MA, [4]Princeton University, Princeton, NJ, Contact: bstellato@princeton.edu
We propose a data-driven method to automatically learn the uncertainty sets in robust optimization. Our technique relies on differentiating the solution of robust optimization problems with respect to the parameters of the uncertainty set. By applying gradient-based methods, we resize and reshape the uncertainty sets to better conform to the underlying distribution. Our approach is very flexible it can learn a wide variety of uncertainty sets while preserving tractability and out of sample guarantees. Numerical experiments in portfolio management, optimal control, and inventory management show that our method outperforms traditional approaches in robust optimization in terms of out of sample performance and execution time.

Tuesday, 8AM–9:15AM

TA46

CC - Room 208

Mobility on Demand in Multimodal Urban Transportation Systems

General Session

Session Chair

Kayla Spring Cummings, Massachusetts Institute of Technology, Allston, MA

1 Stable Mobility-as-a-service Market Design with Fixed-route Transit and Mobility-on-demand Services

Bingqing Liu[1], Joseph Y J Chow[2], [1]New York University, Brooklyn, NY, [2]New York University, Brooklyn, NY, Contact: bl2453@nyu.edu

Mobility-as-a-Service (MaaS) systems incorporate services with different levels of flexibility. Analytical tools are needed to help with MaaS designs: links and service regions, fares, capacities, and fleet sizes. Pantelidis et al. (2020) proposed a bilevel game-theoretic framework to model the stable matching between operators and users in MaaS considering fixed transit, in which the lower level is the matching and the upper level is the cost allocation. We consider adding dummy links with infinite capacities to incorporate options outside the MaaS system. Existence of a stable outcome is proven with the dummy links. MOD service is incorporated, whose access and operation costs are modeled with Cobb-Douglas productions, leading to a non-linear matching problem. A branch-and-price solution algorithm is proposed and tested on numerical examples and real networks.

2 System Design Optimization in On-demand Microtransit Systems

Bernardo Martin-Iradi[1], Alexandre Jacquillat[2], Kayla Spring Cummings[3], [1]Technical University of Denmark, Copenhagen, Denmark; [2]MIT Sloan School of Management, Cambridge, MA, [3]Massachusetts Institute of Technology, Allston, MA, Contact: bmair@dtu.dk

On-demand microtransit defines a middle ground between public transit (with a reference route and a reference schedule) and on-demand transportation (with real-time routing adjustments to serve on-demand requests). We formulate a two-stage stochastic program to optimize strategic network design (in the first stage) along with system operations (in the second stage). We propose an effective model representation based on a time-space-load network. This structure enables the design of a tailored Benders decomposition algorithm. Preliminary results suggest that the proposed algorithm outperforms baseline modeling and computational approaches, and that microtransit systems can provide win-win-win benefits in urban mobility—higher level of service for passengers, lower operating costs for transit operators, and a smaller environmental footprint.

3 Autonomous Vehicles in Ride-hailing and The Threat of Spatial Inequalities

Francisco Castro[1], Jian Gao[1], Sébastien Martin[2], [1]UCLA Anderson School of Management, Los Angeles, CA, [2]Kellogg School of Management, Northwestern University, Evanston, IL, Contact: jian.gao.phd@anderson.ucla.edu

When ride-hailing platforms start to adopt self-driving cars, they will likely have to manage a mixed fleet of human and autonomous vehicles (HVs and AVs). Our goal is to understand the potential consequences of this change, both on the quality of service and the equality of access to transportation. We introduce a queueing model where HVs strategically choose to join the market, and the platform aims to maximize its profit. We show that, surprisingly, the introduction of AVs may deteriorate the service level. We then reveal that the reduction of service level is not homogeneous across areas of a city: while the more profitable high-demand areas will see a high concentration of vehicles, remote areas will suffer from a drop in service level. Our work highlights potential threats when introducing AVs in the ride-hailing industry and discusses ways to prevent them.

4 Optimization and Learning-based Decision Making for Matching and Rebalancing in Autonomous Fleet Operations for Mobility-on-demand Services

Monika Filipovska, University of Connecticut, Storrs, CT, Contact: monika.filipovska@uconn.edu

Mobility-on-demand (MOD) services have the potential to promote responsive and accessible multimodal transportation. Ride-sharing services in particular, using autonomous vehicle (AV) fleets, create opportunities for significant social value, and challenges in terms of demand management and increasing vehicle-based congestion. This study combines optimization and reinforcement learning approaches for joint ride matching and vehicle rebalancing decision making in autonomous MOD systems. It proposes a framework for reactive responses to the dynamically emerging demand and proactive anticipation of future needs for travel. It demonstrates the benefit of joint consideration of the two problems for efficiency of MOD operation and the complementarity of optimization and reinforcement learning techniques for anticipatory decision-making.

Tuesday, 8AM–9:15AM

TA47

CC - Room 209

TSL and TS Best Paper Award Session

Award Session

Session Chair

Jan Fabian Ehmke, University of Vienna, Wien, Austria.

Session Chair

Vikrant Vaze, Dartmouth College, Hanover, NH

TSL Best Paper Presentation

Award Presenter, IN

The winner of the TSL Best Paper Award will present their corresponding paper. The winner will be announced at the TSL Business Meeting. More details on the award can be found here: https://connect.informs.org/tsl/awards/best-paper-application

TS Best Paper Presentation

Award Presenter, IN

The winner of the TS Best Paper Award will present their corresponding paper. The winner will be announced at the TSL Business Meeting.

Tuesday, 8AM–9:15AM

TA48

CC - Room 210

E-commerce Logistics

General Session

Session Chair

Reem Khir, Georgia Institute of Technology, Atlanta, GA

1 An Integer Programming Based Local Search Algorithm to Modify Base Load Plans for Small Package Carriers

Ritesh Ojha, Alan Erera, ISyE Georgia Tech, Atlanta, GA

Small package carriers operate terminals, equipped with sortation centers with a given capacity, and trailers to serve demand. These carriers use historical data and run simulations to develop a base package flow and load plan which is sent to the operations team for execution. Due to uncertainty in demand, the planning team updates or modifies the plan as it gets closer to the day-of-operations. Modifying the flow and load plan for the entire terminal network is very difficult due to the size of the resulting optimization models. We formulate the load plan modification problem and propose an integer-programming based local search method to solve real-life instances from a U.S.-based e-commerce partner.

2 Optimization Proxies for The Flexible Job Shop Scheduling Problem

Reem Khir[1], Wenbo Chen[1], Pascal Van Hentenryck[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: reem.khir@gatech.edu

The Flexible Job Shop Scheduling Problem (FJSP) is an important combinatorial optimization problem that arises in various facility logistics settings. In this work, we investigate the potential of using deep learning approaches to deliver fast and accurate solutions for the FSJP in a stochastic environment. The idea is to develop a deep neural network architecture that exploits the structure of FJSP and integrate it with optimization tools to generate high-quality solutions efficiently.

3 Online Shortest Path Problem: A Combinatorial Bandit Approach

Ramon Auad, Amazon, Seattle, WA, Contact: ramauad@amazon.com

Motivated by the case of a new delivery provider that does not have available data of network travel times, we study the Online Shortest Path problem that seeks to discover optimal routes over time. In particular, inspired on combinatorial bandit literature, we propose three methods with different characteristics that effectively learn the best delivery routes and illustrate the practical advantages of incorporating spatial correlation in the learning process.

4 Exact Solution Methods for An Integrated Multi-stakeholder Freight Transportation System with Stochastic Demand

Gita Taherkhani[1], Mojtaba Hosseini[2], Ali Hassanzadeh[3], Teodor Gabriel Crainic[4], [1]Loyala University, Chicago, IL, [2]Paul Merage School of Business, UCI, Irvine, CA, [3]University of Manchester, Manchester, United Kingdom; [4]Université du Québec à Montréal, Montréal, QC, Canada.

This study focuses on investigating the tactical planning of an integrated multi-stakeholder system. The system receives time-dependent requests from carriers and shippers and optimizes in time and space the operations and transportation activities through the consolidation of loads of different shippers into the same vehicles. The demand values of shippers are taken under uncertainty. The aim of tactical planning in this system is to build an efficient service network and schedule to satisfy the demand and requirements of shippers by making use of the predicted services and their capacities offered by the carriers. A two-stage stochastic program is presented and an exact decomposition-based algorithm is developed. Extensive computational analysis is performed to evaluate the impact of uncertainty on the solution of the proposed model.

Tuesday, 8AM–9:15AM

TA49

CC - Room 211

TSL Flash Session II

Flash Session

Session Chair
Sara Reed, University of Kansas, Lawrence, KS

1 Automated Guided Vehicle Recharging Scheduling Using Multi-agent Q-learning
Ek Peng Chew, National University of Singapore, Singapore, Singapore. Contact: isecep@nus.edu.sg
Decarbonization initiatives in automated container terminals have led to greater adoption of battery powered automated guided vehicles (AGVs). However, they need to be recharged during the transportation activities, which can be disruptive. The main challenges of recharging scheduling can be attributed to the limited charging station capacity and the tight job schedule. We propose a multi-agent system and reinforcement learning to resolve the recharging scheduling for large container terminals which minimizes the delay of the jobs.

2 Combinatorial Auctions for Truckload Transportation
Mohsen Emadikhiav[1], Robert Day[2], [1]Florida Atlantic University, Boca Raton, FL, [2]University of Connecticut, Storrs, CT
We present a combinatorial auction/exchange market for a truckload transportation system where carriers can use a compact bid language to express their preferences to participate in the market. We present a dual-pricing mechanism that finds (epsilon-) competitive equilibrium prices and we evaluate the market outcomes under consideration of different practical constraints. We also benchmark our proposed pricing mechanism against some of the standard pricing schemes in the literature.

3 Heterogeneous Multi-depot Collaborative Vehicle Routing Problem
Ziteng Wang, Northern Illinois Universtiy, Dekalb, IL, Contact: zwang3@niu.edu
Collaborative vehicle routing of multiple logistics providers is a critical means to achieve logistics collaboration and economic savings. Different from existing research that is limited to the setting where the logistics providers transport the same product. We investigate a heterogeneous multi-depot collaborative VRP in this paper. The key operational and computational challenge is to properly select transfer points for product transshipment between vehicles of different depots and to manage the shipment flows. A Benders-based branch-and-cut algorithm is designed to solve a mixed-integer programming formulation of HMCVRP. The proposed algorithm significantly outperforms the CPLEX solver. Additional computational study further reveals the importance of the locations of depots and having a well-designed cost savings allocation mechanism in practice.

4 Dynamic Inventory Allocation for Intermittent Demand in E-Commerce Fulfillment Networks
Katja Meuche[1], Benoit Montreuil[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: kmeuche@gatech.edu
E-commerce and fast delivery become more dominant in retail requiring retailers to decide where and how many items of infrequently ordered goods to store in their fulfillment network considering shipment and inventory costs, supplier case sizes, and service levels. We propose a novel approach for dynamic allocation of slow-moving products. Upon customer order, we reassess the network-wide inventory allocation and decide how to best reallocate inventory across the network to ensure fast delivery of next orders. The objectives of reducing fulfillment costs and the ecological footprint while ensuring fast delivery make this a promising approach for sustainable and consumer-oriented e-commerce.

5 Overview of Practical Methods for Inventory Routing Via Time-expanded Modeling Framework
Kevin C. Furman, ExxonMobil, Houston, TX
The use of time-expanded network flow models to represent routing of vehicles has been demonstrated to be an effective representation for inventory routing problems. Any path from source to sink in such a network represents a complete route schedule for a vehicle. This structure allows for use of general design schemes for large neighborhood search matheuristics. The modeling concept, examples of local search operators, and applications to real-world maritime inventory routing problems will be briefly illustrated.

6 A Social Optimal Routing and Ordering Model
Oriana Calderon, Rensselaer Polytechnic Institute, Troy, NY, Contact: caldeo@rpi.edu
This research aims to contribute to the mitigation of climate change by developing policy procedures that induce changes in the behavior of supply chain agents. A social optimal routing and ordering model is developed that uses an environmental charge to induce receivers to reduce the number of orders, and find optimal vehicle routes.

7 Data-driven Block Occupancy Analysis for Urban Rail Capacity Management
Saeid Saidi, University of Calgary, Calgary, AB, Canada. Contact: ssaidi@ucalgary.ca

Block occupancy has been extensively used in the rail operations literature to capture train schedule conflicts and for capacity analysis. Most studies considered conflict-free operations between trains. However, due to the uncertainties and interruptions in the operations, the block occupancy analysis using the historical data indicates numerous occurrences of induced delays due to train conflicts. As such, the constructed block occupancy based on real operations is very different than the one at the scheduling step. We will present the utilization of data-driven block occupancy analysis for monitoring and controlling the rail operations to improve the effective line capacity.

8 Ambulance Bus Routing in Disaster Situations

Yue Wang, Bahar Cavdar, Joseph Geunes, Xiaofeng Nie, Texas A&M University, College Station, TX, Contact: xiaofengnie@tamu.edu

We consider the aftermath of a disaster where geographically-dispersed patients require transportation to safe locations using an ambulance bus. As patients wait longer, their survivability rate decreases based on the severity of their situation. We study a multi-trip single-vehicle routing problem where an ambulance bus sequentially picks up a given number of patients in several routes. Accounting for patients' time-dependent survivability, we present a model that determines the number of routes and the number of patients on each route for uniformly dispersed patients that maximize the total survivability rate based on tour length estimation models for linear survival rates. We also present a dynamic programming model that accommodates general forms of survivability and propose heuristic solutions.

10 Optimal Parking Strategies for Last-mile Delivery

Sara Reed[1], Ann Melissa Campbell[2], Barrett Thomas[2], [1]University of Kansas, Lawrence, KS, [2]University of Iowa, Iowa City, IA, Contact: sara.reed@ku.edu

Urban environments experience shortages in curbside parking spots. Availability of parking is necessary for last-mile delivery drivers as the driver must park the vehicle to deliver packages to customers on foot. We model the delivery driver's search process for parking as a stochastic process where the driver circles blocks of parking spots near customer locations. When the delivery driver reaches an open parking spot, we define optimal parking strategies on whether the driver should park or drive on in search of a parking spot closer to customer locations.

Tuesday, 8AM–9:30AM

TA50

CC - Room 212
Digital Business and AI
General Session

Session Chair
Vandith Pamuru, Indian School of Business, Hyderabad, India.

1 Language, Status, and Persuasion Online: Evidence from a Field Experiment

Emaad Manzoor, University of Wisconsin Madison, Madison, WI

We quantify persuasive power of status in conversations online with a field experiment on the ChangeMyView platform. We randomize the visibility of ChangeMyView users' status, and exploit the availability of explicit indicators of opinion change provided by ChangeMyView users, to quantify the impact of hiding a user's status on their persuasion rate. We find that the impact of hiding status is heterogeneous: the persuasion rate of low status users is unaffected when their status is hidden, the persuasion rate of moderate status users increases when their status is hidden, and the persuasion rate of high status users decreases when their status is hidden. We further explore how the persuasive power of status varies with linguistic features of the conversation.

2 Test, Target, & Roll: Optimal Explore-first Contextual Targeting in Finite Populations

Alex P. Miller, USC, Los Angeles, CA

The task of finding an optimal personalization strategy for any given set of possible treatments requires accurately learning the best treatment for each individual given their context, while also acting on this information as quickly as possible. In this project, we propose and analyze a simplified but underexplored solution to this classic explore-exploit problem in finite populations, which is effectively an "explore-then-commit" or "epsilon first" strategy. We study the trade-offs of this strategy when considered over finite target populations and demonstrate that this approach has multiple benefits relative to dynamic policies such as contextual bandits. In particular, we derive a lower bound on the optimal exploration period under parametric conditions and demonstrate how to estimate this quantity using non-parametric methods on offline experimental data.

3 Factual Vs. Non-factual Awareness in Social Networks: Opinion Dynamics Approach

Abhishek Ray, George Mason University, VA

Any defender focusing on solving the information flow crisis has to either consider prevention or protection. By prevention, the defender can consider pro-actively preventing consumption of non-factual information by contradicting and refuting false and misleading claims from nodes on the network that may be impacting some subset or overall nodes on the network. By protection, the defender can consider pro-actively protecting some or all vulnerable nodes by disseminating the correct information to all nodes connected to it on the social network, either periodically or all at once. We model this problem as a game on a network and give insights on how to develop policies to deploy one strategy over another.

4 Market Dominance in The Digital Age

Logan Emery, Rotterdam School of Mangement, Rotterdam, Netherlands.

I document that the network structure of the online economy significantly contributes to rising industry concentration. Firms central in the online economy are aided by feedback effects that drive users to their websites, providing further benefits via economies of scale and network effects. Industries with more central firms become more concentrated and central firms have larger increases in market share during the sample period. This result appears to be due to firms' ability to generate revenue, as central firms earn higher risk-adjusted returns and have more positive earnings surprises. Finally, centrality is more strongly associated with increasing productivity than decreasing competition, providing generally positive welfare implications.

Tuesday, 8AM–9:15AM

TA51

M - Santa Fe

Equitable Building Systems under a Changing Climate

General Session

Session Chair

Rebecca Ciez, Murrysville

1 An Equitable Transition to Clean Heating for US Cold Climates

Vaishnav Parth[1], Claire McKenna[1], Carina Gronlund[2], Shagun Parekh[1], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: parthtv@umich.edu

Electrifying residential space heating is a key decarbonization strategy, but it may raise energy bills for existing homes in cold regions. We gather data on household behavior and physical housing characteristics from 50 households, half of which have incomes below the regional median, and around 40% of which are energy-insecure, in Southeast Michigan. We integrate these data with physics-based energy models to estimate energy use and heating bills, and validate these models against empirically-observed energy use. We then test a suite of envelope upgrades along with air source heat pumps and expect to identify a package of strategies that reduce the bills for each home under dynamic utility pricing scenarios. We present building upgrade cost estimates. We juxtapose these data with data on income and housing values to assess the environmental justice implications.

2 Geospatial and Social Factors Affecting Equitable U.S. Heating Electrification

Kelsey Biscocho[1], Mohammad Rezqalla[1], Davide Ziviani[1], Rebecca Ciez[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN, Contact: kbiscoch@purdue.edu

Heat pumps (HPs) are key to electrifying heating, growing the renewable energy sector, and minimizing energy expenses. Complex barriers-including cost, climate, and housing-hinder adoption. This study involves a literature review of sociotechnical and geospatial obstacles in U.S. residential heating electrification. Linear regression techniques are used with high resolution temporal and spatial data to characterize the effects of varying heat pump technology on residential energy consumption and cost in California and Colorado. Heat pump models were based on laboratory test data and manufacturer specifications. Initial results show that emissions due to residential heating vary depending on heat pump technology and the energy mix of a region's electricity grid.

3 Human Decision Making in Smart and Connected Energy-aware Residential Communities

Huijeong Kim, Ilias Bilionis, Panagiota Karava, James E. Braun, Purdue University, West Lafayette, IN, Contact: kim2683@purdue.edu

Our goal is to realize a new paradigm for energy-aware communities that leverages smart devices and social games to engage residents in understanding and reducing their home energy use. Towards this goal, we introduce a household utility model for learning attributes that affect users' decision making during eco-feedback intervention. Our modeling approach derives a linear equation that quantifies household's preferences over indoor temperatures given the decision attributes related to their thermal environment and the feedback information. To learn the latent parameters determining user characteristics, we structured a non-centered hierarchical Bayesian model and calibrated it to the field data collected from a multi-unit residential community located in Fort Wayne, IN. From the calibration, we quantified the impact of eco-feedback on households' decisions.

4 Equitable Coordination of Energy Flexibility Across Building Communities

Javad Mohammadi, UT Austin, Austin, TX

The future electric infrastructure will differ from the current system by the increased integration of smart grid-interactive buildings, decentralized energy generation, widespread energy storage, communications, and sensing technologies. These advancements, combined with climate change concerns, resiliency needs, and equity considerations, require revisiting our decision-making paradigms. Coordination among system entities is the key to reliable and resilient electric grid operations.In this talk, I will consider the problem of coordinating energy flexibility across building communities and discuss pathways to accommodate equity considerations in algorithmic designs.

Tuesday, 8AM–9:15AM

TA52

M - Lincoln
Scheduling in Practice
General Session

Session Chair
Emrah Cimren, Amazon, Issaquah, WA

1 Human-computer Interactions in Retail Staffing Decisions

Caleb Kwon[1], Ananth Raman[2], [1]Harvard, Allston, MA, [2]Harvard University, Boston, MA, Contact: ckwon@hbs.edu

We study the interaction between humans and algorithms in the context of labor scheduling and staffing in retail stores. We study if, and to what extent, managers possess private information that can improve upon the decisions made by an algorithm that forecasts demand and schedules shifts for all employees. To do so, we test how overrides to a scheduling algorithm made by managers affect stores' labor productivity. We obtain novel retailer data that contains: (1) Employee schedules generated by an algorithm which attempts to service forecasted demand with available labor, and (2) Manager overrides to the algorithm. Combined, the data contains over 20 million shifts across 1,000 retail stores. We find that overrides have a negative effect on both store and employee level outcomes.

2 Optimisation-based Scheduling for The Diffusion Area of Wafer Fabs: An Industrial Application at a Renesas Electronics Wafer Fab

Ruaridh Williamson[1], Jay Maguire[2], Johannes Wiebe[1], [1]Flexciton, London, United Kingdom; [2]Renesas Electronics, Palm Bay, FL, Contact: ruaridh.williamson@flexciton.com

Semiconductor wafer fabs exhibit one of the most complex flexible job shop problems with high degrees of re-entrancy. We consider a parallel batch scheduling model applied to data from a Renesas Electronics facility in Palm Bay, FL, USA. The model is a hybrid two-stage solution strategy, combining Mixed Integer Linear Programming models and heuristics applied to the diffusion and clean area. It considers batching operating costs, machine downtime, incompatible job families, consecutive steps of a job, and parallel machines. The aim is to minimize the total weighted batching cost, queuing time, and the number of violations to timelink constraints. We demonstrate considerable improvements to factory KPIs when comparing schedules from the Flexciton optimiser evaluated under uncertainty against actual historical moves for large, realistic industrial instances.

3 Solving Job Shop Scheduling Problem Using GPU-based Vehicle Routing Solver

Rajesh Gandham[1], Akif Coerduek[2], Alex Fender[3], [1]NVIDIA, Brooklyn, NY, [2]NVIDIA, Munich, Germany; [3]NVIDIA, Winter Springs, FL, Contact: rgandham@nvidia.com

Vehicle routing problem (VRP) and Job shop scheduling problem (JSP) exhibit several similar characteristics. However, in general, the solution techniques vary because of the efficiency of algorithms and implementations. In this work, we explore the usage of a VRP solver for solving JSP. We perform this study in the context of a massively parallel GPU-based solver. JSP requires that a set of activities be performed in a specified order, we implement generalized precedence constraints in the VRP solver to model the order of execution. In addition, we implement suitable optimization criteria. Finally, we will show the comparison of the quality and efficiency of the solutions from the VRP solver with the solutions obtained by existing JSP solvers.

4 Design of a Job Recommender Using Content-Based Filtering in an Optimization Framework

Emrah Cimren, Amazon, Seattle, WA

This study describes the development of a job recommendation model (JRM) using content-based filtering in an optimization framework. We tested JRM recommendations by sending personalized SMS and email messages to candidates in the hiring funnel. We designed, implemented, and executed A/B testing experiments to measure the impact of JRM in sending targeted communications. As a result of A/B testing, we observed that JRM and targeted SMS and email messaging increased candidate conversion from job application to first day start at work significantly.

Tuesday, 8AM–9:15AM

TA53

M - Denver
Revenue Management
Contributed Session

Session Chair

Yifan Hu, University of Illinois at Urbana-Champaign, Urbana, IL

1 Risk-Sensitive Network Revenue Management

Martin Glanzer[1], Christiane Barz[2], [1]University of Zurich, Zurich, Switzerland; [2]University of Zurich, Ermatingen, Switzerland. Contact: martin.glanzer@business.uzh.ch

We extend the traditional expected revenue maximizing network revenue management model to the case of an expected utility maximizing decision maker with constant absolute risk aversion. We model the problem as a risk-sensitive Markov decision process. To overcome the curse of dimensionality, we propose a math programming based approximate dynamic programming approach with a new nonlinear value function approximation, which is a natural extension of the popular affine approximation in the risk-neutral setting. The proposed approximate model induces risk-averse policies with intuitive properties. Leveraging tools for signomial programming, we present an algorithmic solution. For given (absolute) risk-aversion, our algorithm determines a risk-averse policy, which can decrease revenue risk substantially in return for sacrificing only little expected revenue.

2 Release Policy for New Movies on Over-the-top Platforms: A Revenue Management Perspective

Raunak Joshi[1], Megha Sharma[1], Soumyakanti Chakraborty[1], Sumanta Basu[1], Indranil Bose[2], [1]Indian Institute of Management Calcutta, Kolkata, India; [2]Neoma Business School, Paris, France.

The release policy of a production house for the new movie on the OTT platform presents an important trade-off - an early release on the OTT platform may coerce viewers to join the platform but hurts the theatre revenue, whereas a delayed release of the movie on the platform generates higher theatre revenue but fewer viewers may join the platform. We study this trade-off from the lens of revenue management and provide several managerial insights under various market conditions.

3 Stochastic Nonconvex Optimization with Implicit Convex Reformulation and Its Application in Revenue Management

Yifan Hu[1], Xin Chen[2], Zikun Ye[3], Niao He[4], [1]EPFL, Lausanne, Switzerland; [2]Georgia Institute of Technology, Atlanta, GA, [3]University of Illinois Urbana Champaign, Urbana, IL, [4]ETH Zurich, Zurich, Switzerland. Contact: yifanhu3@illinois.edu

We study a class of nonconvex stochastic optimization, where the objective function is a composition of a convex function and a random function. Leveraging a convex reformulation via a (implicit) variable transformation, we develop Mirror Stochastic Gradient (MSG) that operates only in the original space and achieves $\tilde \cO(\eps^{-2})$ sample and gradient complexities for finding an $\eps$-global optimal solution for the nonconvex problem. An important application of such problems is the booking limits control for air-cargo network revenue management with random two-dimensional capacity, random consumption, and routing flexibility. Extensive numerical experiments illustrate the superior performance of MSG for booking limit control over the state-of-the-art bid-price-based control policies, especially when the variance of random capacity is large.

4 Optimal Signaling Mechanism in Parallel Queues

Niloofar Zamani Foroushani[1], Jiahua Wu[2], Zhe Liu[3], [1]Imperial college London, LONDON, United Kingdom; [2]Imperial College Business School, London, United Kingdom; [3]Imperial College Business School, New York, NY

We investigate the problem of information design for two parallel service providers with unobservable queue lengths which are competing against each other on a platform environment. Service providers are offering service at a fixed price. The delay-sensitive customers arrive with a Poisson rate and tend to maximize their utility. On the other hand, the platform charges the service providers a fee when a customer is served, and it aims to maximize its own total revenue.

Upon arrival, queue lengths are fully observable only to the platform, which can use this information to give signals to the customers and impact their behavior. Our goal is to investigate the optimal signaling mechanism for the platform and analyze its structure

Tuesday, 8AM–9:15AM

TA54

M - Marriott 1
Queueing and Scheduling: Multiserver Systems and Uncertainty
General Session

Session Chair
Ziv Scully, Carnegie Mellon University, Pittsburgh, PA

1 A Tight Analysis of Server Farms with Setup Times

Jalani Williams, Weina Wang, Mor Harchol-Balter, Carnegie Mellon University, Pittsburgh, PA

Setup times arise in queueing systems whenever a server must ``boot up'' before providing service. While the effect of setup times on queue lengths is well-understood in the single-server setting, much less is known in the multi-server setting. Moreover, most work has focused on the case where setup times are exponentially-distributed; the more practical case, where setup times are deterministic, is entirely open. We provide the first tight characterization of the queue length in a multiserver system with deterministic setup times.

2 Large-system Insensitivity of Zero-waiting Load Balancing Algorithms

Xin Liu[1], Lei Ying[2], [1]The ShanghaiTech University, Shanghai, China; [2]The University of Michigan, Ann Arbor, Ann Arbor, MI, Contact: leiying@umich.edu

This talk considers the sensitivity (or insensitivity) of a class of load balancing algorithms that achieve asymptotic zero-waiting named LB-zero. Most existing results on zero-waiting load balancing algorithms assume the service time distribution is exponential. Our recent result establishes the large-system insensitivity of LB-zero for jobs whose service time follows a Coxian distribution with a finite number of phases. To prove this result, we developed a new technique, called "Iterative State-Space Peeling" (or ISSP for short). ISSP first identifies an iterative relation between the upper and lower bounds on the queue states and then proves that the system lives near the fixed point of the iterative bounds with a high probability. Based on ISSP, the steady-state distribution of the system is further analyzed by applying Stein's method.

3 SEH: Size Estimate Hedging Scheduling of Queues

Douglas Down, Maryam Akbari Moghaddam, McMaster University, Hamilton, ON, Canada. Contact: downd@mcmaster.ca

For a single server system, Shortest Remaining Processing Time (SRPT) is known to be optimal. We consider the case when exact information about processing times is unavailable. When SRPT uses estimated processing times, underestimation of large jobs can significantly degrade performance. We propose an index-based policy with a single parameter, Size Estimate Hedging (SEH), that only requires estimated processing times. A job's priority is increased dynamically according to an SRPT rule until it is determined that it is underestimated, at which time the priority is frozen. Numerical results suggest that SEH has desirable performance for settings that are consistent with what is seen in practice.

4 Heavy-traffic Optimality in Load Balancing: From The First Moment to Distribution

Xingyu Zhou, Wayne State University, Rochester Hills, MI

In this talk, we first present an overview of recent advances in load balancing in heavy traffic. The key insight here is that the standard first-moment delay optimality in heavy traffic can be obtained in a flexible way. More specifically, beyond the popular join-shortest-queue (JSQ) and power-of-d algorithms, there exist many other load balancing algorithms that are able to achieve first-moment delay optimality, even under multiple dispatchers and delayed feedback. Then, via Stein's method as a bridge, we can not only directly translate the above first-moment optimality into asymptotic optimality of the total number of jobs in the system, but also obtain a characterization of the convergence rate in heavy traffic.

Tuesday, 8AM–9:15AM

TA55

M - Marriott 2
Cutting-edge Algorithms for Data-driven Decision-making
General Session

Session Chair
Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA

Session Chair
Kan Xu, University of Pennsylvania, Philadelphia, PA

1 Learning Across Bandits in High Dimension Via Robust Statistics

Kan Xu[1], Hamsa Sridhar Bastani[2], [1]University of Pennsylvania, Philadelphia, PA, [2]Wharton School, Philadelphia, PA, Contact: kanxu@sas.upenn.edu

Decision-makers often face the "many bandits" problem, where one must simultaneously learn across related but heterogeneous contextual bandit instances. We study the setting where the unknown parameter in each bandit instance can be decomposed into a global parameter plus a sparse instance-specific term. Then, we propose a novel two-stage estimator that exploits this structure efficiently by using a combination of robust statistics (to learn across similar instances) and LASSO (to debias the results). We embed this estimator within a bandit algorithm, and prove that it improves asymptotic regret bounds in the context dimension d; this improvement is exponential for data-poor instances. We further demonstrate how our results depend on the underlying network structure of bandit instances. Finally, we illustrate the value of our approach on synthetic and real datasets.

2 Design and Analysis of Multivariate Switchback Experiments

Iavor Bojinov[1], Jinglong Zhao[2], NI TU[3], [1]Harvard Business School, Somerville, MA, [2]Boston University, Boston, MA, [3]National University of Singapore, Singapore, Singapore. Contact: ibojinov@hbs.edu

Recently, firms have begun transitioning away from the static single intervention A/B testing into dynamic experiments, where customers' treatments can change over time. This talk presents the design-based foundations for analyzing and designing such dynamic experiments. Starting with the extreme case of running an experiment on a single unit, we present the optimal design of switchback experiments under various assumptions on the order of the carryover effect. Next, we explain how to extend this framework to multiple units and what happens when these units are subject to specific types of population interference (the setting where one unit's treatment can impact another's outcomes). Finally, we present an optimal design of experiments for panel switchback experiments that balance the population interference and the temporal interference.

3 Bayesian Dynamic Pricing and Subscription Period Selection with Unknown Customer Utility

Yuan-Mao Kao[1], N. Bora Keskin[2], Kevin Shang[3], [1]Baruch College, City University of New York, Jersey City, NJ, [2]Duke University, Durham, NC, [3]Duke University, Durham, NC, Contact: yuan-mao.kao@baruch.cuny.edu

We consider a provider offering subscription services to customers over a multiperiod planning horizon. The provider has a prior belief about the customers' utility model and updates its belief based on the transaction data of new customers and the usage data of existing subscribers. The provider aims to minimize its regret, i.e., the profit loss relative to a clairvoyant who knows the utility model. We first develop a method to resolve the curse of dimensionality in obtaining the clairvoyant's optimal policy. In the absence of full information, we show that a certainty-equivalence policy may perform poorly due to incomplete learning, slow learning, or offering a suboptimal and long contract at the beginning. We design a two-phase policy that first focuses on information collection and then profit maximization, and show that it achieves asymptotically optimal performance.

4 Decision-Aware Data Aggregation

Vishal Gupta, University of Southern California, Los Angeles, CA

When data are scarce, aggregating data across "similar" problems before applying an optimization method is common. (For example, consider aggregating data across similar products to formulate a revenue maximization problem.) While many methods exist for identifying "similar" problems (e.g K-means clustering), these methods are often blind to the downstream optimization problem. We propose a decision-aware data aggregation procedure that provably finds the best grouping for the particular downstream task. We present theoretical and empirical evidence for its superiority over common proposals for data aggregation.

Tuesday, 8AM–9:15AM

TA56

M - Marriott 3
Applied Probability Flash Session
Flash Session

Session Chair
Belleh Fontem, University of Massachusetts Lowell, Lowell, MA

1 How to Analyze and Optimize Scheduling Policies: New Tools in Queueing Theory

Ziv Scully, Carnegie Mellon University, Pittsburgh, PA

A classic result in queueing theory is that to minimize average waiting time of a single-server queue, SRPT (Shortest Remaining Processing Time) is optimal. But there are many obstacles to translating this result to practical settings. What if there are multiple servers? What if processing time estimates are subject to noise? What if preempting jobs incurs overhead or is otherwise constrained? This brief talk will showcase two new techniques, called "SOAP" and "WINE", which enable researchers to attack these questions and more from a queueing theoretic perspective.

2 Overcoming The Long Horizon Barrier for Sample-efficient Reinforcement Learning with Latent Low-rank Structure

Tyler Sam, Yudong Chen, Christina Lee Yu, Cornell University, Ithaca, NY, Contact: tjs355@cornell.edu

The practicality of RL algorithms has been limited due to poor scaling with respect to the problem size; the sample complexity of learning an □-optimal policy is Ω(|S||A|H^3 / $□^2$). We consider a class of MDPs with low rank structure, and unknown latent features, and prove that a natural combination of value iteration and low-rank matrix estimation results in an estimation error that grows doubly exponentially in the horizon. We provide a new algorithm that efficiently exploits various low rank structural assumptions given access to a generative model to achieve a sample complexity of\Tilde{□}(d^5(|S|+|A|)poly(H)/$□^2$) for a rank d setting, which is minimax optimal with respect to |S|, |A|, and □.

3 Modeling Interference with Experiment Rollout

Ariel Boyarsky[1], Hongseok Namkoong[1], Jean Pouget-Abadie[2], [1]Columbia Business School, New York, NY, [2]Google Research, New York, NY

Experimentation is the foundation of scientific decision-making on online marketplaces and social networks. However, experiments often suffer from interference where intervention on a participant impacts other outcomes. Motivated by the ubiquity of staggered rollout designs, we present a framework for modeling interference based on temporal variations in treatment assignments. We employ machine learning models to estimate interference effects and perform model selection using a cross-validation-like scheme. We prove that staggered rollouts allow identifying complex interference patterns and provide an inferential framework for standard estimands such as the total treatment effect.

4 The Structure of Conservative Gradient Fields

Adrian Lewis, Tonghua Tian, Cornell University, Ithaca, NY, Contact: tt543@cornell.edu

The classical Clarke subdifferential alone is inadequate for understanding automatic differentiation in nonsmooth contexts. Instead, we can sometimes rely on enlarged generalized gradients called "conservative fields", defined through the natural pathwise chain rule: one application is the convergence analysis of gradient-based deep learning algorithms. In the semialgebraic case, we show that all conservative fields are in fact just Clarke subdifferentials plus normals of manifolds in underlying Whitney stratifications.

5 Rate of Convergence of The Smoothed Empirical Wasserstein Distance

Zeyu Jia, Massachusetts Institute of Technology, Cambridge, MA, Contact: zyjia@mit.edu

Consider an empirical measure P_n induced by n iid samples from a d-dimensional K-subgaussian distribution P and let □=N(0,$□^2I_d$) be the isotropic Gaussian measure. We study the convergence speed of the smoothed Wasserstein distance W_2(P_n □,P □)=n^(−□+o(1)). For K<□ and we show that □=1/2. For K>□ in dimension d=1 we give the exact value of □, which is less than 1/2. In addition, we also show that KL(P_n □ P □) has convergence rate O(1/n) for K<□ and O((log n)$^{d+1}$/n) for K>□. The surprising difference of the behavior of W2 and KL implies the failure of T2-transportation inequality when □<K. This also indicates that K<□ is necessary for log-Sobolev inequality of P N(0,$□^2$).

6 Analysis of The Finite State Ergodic Master Equation

Ethan Zell, University of Michigan, Ann Arbor, MI, Contact: ezell@umich.edu

Mean field games (MFG) model equilibria in games with a continuum of players as limiting systems of symmetric n-player games. We consider a finite-state, infinite-horizon problem with two cost criteria: discounted and ergodic. Under the Lasry-Lions monotonicity condition we characterize the stationary ergodic mean field game equilibrium by a mean field game system of two coupled equations: one for the value and the other for the measure. Then several discounted MFG systems are used to set up the relevant discounted master equations. We show that the discounted master equations are smooth, uniformly in the discount factor and use this to obtain the smoothness of the ergodic master equation.

8 On Warranty Design and Risk Aware Timing of Product Recalls

Belleh Fontem, University of Massachusetts Lowell, Lowell, MA

Motivated by the financial risk concerns of a certain warrantor, we analyze from a risk averse viewpoint, the connection between the design of a non-repairable product's warranty and the optimal time to voluntarily recall the product. The warranty depends on two endogenous parameters that independently control when, and how rapidly the product's warrantor sheds the obligation of full reimbursement over a horizon. Owing to certain nonlinearities, the problem is not amenable to a dynamic-programming-based approach. We reveal an impossible trilemma between the expected time to recall, risk-sensitivity, and the warranty's compensation generosity. Then, under an alternative approach to risk quantification, we prove optimality of a "bang-bang" stopping time and determine when there is guaranteed to exist a warranty configuration under which it is best to never recall.

9 Bayesian Modeling of Power System Device Failures

Luis J. Novoa, James Madison University, Harrisonburg, VA

A power system is a network of electrical components to transfer electric power. It includes various devices connected to the system, some of which are overhead, on ground, or underground, like the circuit switcher, conductor, line fuse, etc. Understanding the reliability of each device allows for developing device specific maintenance policies and repair schedules. We develop hierarchical parametric and semi-parametric Bayesian models to assess the reliability of different devices in a power system under different weather scenarios.

Tuesday, 8AM–9:15AM

TA57

M - Marriott 4

Time Series Methods for Reliability and Quality Control

General Session

Session Chair

Refik Soyer, George Washington University, Washington

Session Chair

Tevfik Aktekin, Paul College of Business and Economics, Durham, NH

1 A Dynamic Integer Autoregressive Model for Multivariate Time Series of Counts and its Bayesian Analysis

Di Zhang, The George Washington University, Bethesda, MD, Contact: zhangdi1990@gwu.edu

The integer autoregressive processes play a vital role in modeling count series. In this paper, we integrate a random environment that follows a state-space evolution into the univariate INAR(1) model from McKenzie (1985), and we term our model dynamic multivariate INAR(1). The random environment provides an efficient and scalable multivariate generalization with dynamic multivariate negative binomial predictive distributions. Furthermore, it also allows the dynamic multivariate INAR(1) model to account for time-varying contemporary dependency structures. We propose a Monte Carlo Markov Chain method and a Particle Learning algorithm for parameter learning and state filtering. Using a real dataset, we show that the dynamic multivariate INAR(1) model substantially outperforms competing models in terms of one-step-ahead out-of-sample forecasts.

2 A State Space Analysis of Non-Gaussian Time Series Models

Tevfik Aktekin, University of New Hampshire, Durham, NH

In this talk, we propose a class of non-Gaussian state space time series models and consider their Bayesian analysis. Special emphasis is given to count data with inflated number of zeros. A key feature of our proposed model is its ability to account for correlations across time as well as across series (contemporary) via a common random environment. The proposed modeling approach yields conditionally tractable dynamic marginal likelihoods, a property not typically found outside of linear Gaussian time series models. The availability of the marginal likelihoods allows us to develop efficient estimation methods for various settings using Markov chain Monte Carlo as well as sequential Monte Carlo methods. To illustrate our methodology, we use simulated data examples and a real application.

3 Tracking Travel Time Reliability in Real-time Using Bayesian Analysis

Vadim Sokolov, George Mason University, Fairfax, VA

We develop a statistical model that allows an explicit treatment of second moment of travel time, namely travel time reliability. The advantage of the model is that it allows a real-time tracking of the reliability via fusing historical data with the real time data from traffic flow sensors and information about non-recurrent events, such as severe weather or a special event. Further, the model can be used to forecast the reliability of travel time by incorporating forecasts about non-recurrent events into prior distributions based on the historical data. We use Bayesian update to assimilate the real-time and forecasted data into the model.

Tuesday, 8AM–9:15AM

TA58

M - Marriott 5

Operations & Maintenance Analytics for Renewable Energy Systems

General Session

Session Chair

Petros Papadopoulos, Rutgers University, Piscattaway, NJ

Session Chair

Ahmed Aziz, Rutgers University, Piscataway, NJ

1 Structured Replacement Policies for Offshore Wind Turbines

Morteza Soltani, Jeffrey P. Kharoufeh, Amin Khademi, Clemson University, Clemson, SC

We present structured optimal replacement policies for a collection of offshore wind turbines in a common environment. Specifically, we establish the optimality of a threshold-type policy that depends on the degradation status of the turbines in the wind farm. Moreover, we establish conditions for which the replacement thresholds are monotone.

2 A Chance-constrained Optimization Framework for Wind Farms to Manage Fleet-level Availability in Condition Based Maintenance and Operations

Murat Yildirim[1], Farnaz Fallahi[1], Ilke Bakir[2], [1]Wayne State University, Detroit, MI, [2]University of Groningen, Groningen, Netherlands. Contact: murat@wayne.edu

This talk proposes a unified condition-based maintenance and operations scheduling approach for wind farms that models uncertainties related to turbine availability, wind power output and market price. The proposed formulation explicitly considers the turbine-to-turbine dependencies in operations and maintenance, such as opportunistic maintenance, to identify the O&M decisions that are optimal for multiple wind farms. The problem is formulated as a chance-constrained stochastic programming model to maximize operational revenue while ensuring high levels of turbine availability and generation. Our results demonstrate significant improvements in asset availability, market revenue and maintenance costs in large scale wind farms.

3 Operations and Analytics of a Renewable Energy System with Battery

Ben Wang[1], Jeffery Choy[2], Eunshin Byon[1], Romesh Saigal[1], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: papaver@umich.edu

Due to the intermittent and variable nature of renewable energy generation, the renewable energy increasingly relies on storage devices like batteries to stabilize the farm output, making the management of the energy system more complicated. In this talk, we model the energy storage management problem in a continuous dynamic contract setting where the system operator faces the challenge of incentivizing farm owners to provide a stable energy supply while simultaneously maximizing all participants' profits in the described systems. We propose two models, in the first where all the investment in the battery is by the farm and thus it carries all the risks, and the other where an independent entity is incentivized to invest in the battery, thus sharing the risks with the farm.

4 Wind Plant Operations & Maintenance Research Opportunities and Challenges

Shawn Sheng, Jason Fields, Matt Shields, National Renewable Energy Laboratory, Denver, CO, Contact: shawn.sheng@nrel.gov

Global wind industry has experienced tremendous growth during the past two decades and the trend does not appear changing in near future. However, the industry is still challenged by premature component failures and high operations & maintenance (O&M) costs, which can account for up to 35% of levelized cost of energy. It is imperative for the industry to improve performance, reliability and reduce O&M costs through advanced research in order to be competitive. This talk will first briefly discuss the challenges with wind plant O&M research, then give an overview of related NREL work in the areas of performance, reliability, and O&M cost modeling, and finally touch on future research opportunities in related areas. The authors hope some of these challenges are of interest to and can be addressed by the INFORMS community in future to benefit the wind industry.

Tuesday, 8AM–9:15AM

TA59

M - Marriott 6

Artificial Intelligence & Machine Learning for Enhanced Safety & Quality of Smart & Connected Vehicles

General Session

Session Chair

Abdallah A. Chehade, University of Michigan-Dearborn, Canton, MI

Session Chair

Mayuresh Savargaonkar, UMICH

1 Warranty Claims Forecasting Analytics

Yichao Zeng, University of Michigan - Dearborn, Dearborn, MI, Contact: zyichao@umich.edu

Forecasting warranty claims for sophisticated products is a reliability challenge for most manufacturers, particularly important for large automotive companies. The main obstacle for warranty forecasting is reporting delays, warranty expiration, production heterogeneity, and lot-rot. These factors can be summarized as impacts due to warranty data maturation. Unfortunately, most of the existing models for warranty claims forecasting fail to explicitly consider warranty data maturation. This work addresses the warranty data maturation by using the proper model. This deep learning model uses historical warranty data as the input and could predict warranty trends at both current and future maturation levels. This model is validated on an extensively collected automotive warranty claims dataset with more than 15,000 different components and several model years.

2 A Polynomial Regression Model with Bayesian Inference for State-of-health Prediction of Li-ion Batteries

Isaiah Oyewole[1], Meriam Chelbi[2], Abdallah A. Chehade[3], Alaa A. Hussein[4], [1]University of Michigan-Dearborn, Detroit, MI, [2]University of Michigan-Dearborn, Dearborn, MI, [3]University of Michigan-Dearborn, Dearborn, MI, [4]Prince Mohammad Bin Fahd University, Al Khobar, Saudi Arabia. Contact: ioyewole@umich.edu

This paper proposes a polynomial regression model with Bayesian inference (PRMBI) for robust state-of-health (SOH) prediction of lithium-ion batteries. The proposed PRMBI architecture leverages the strength of the semi-empirical modeling and data-driven methods for robust SOH prediction. First, the proposed architecture fits a robust polynomial model using aged battery cells data and consequently constructs a prior distribution of the model's parameters. Then, it samples the parameter sets that best describe the limited available SOH data for a new target battery cell of interest. The experimental results demonstrate that the proposed model achieves around 80% and 30% prediction improvement in RMSE relative to a deep neural network and LSTM benchmark models, respectively, for the target cell when trained on the data of the first 60 cycles only.

3 Importance of Infrastructure Information in The Development of Autonomous Vehicles

Mayuresh Savargaonkar, University of Michigan - Dearborn, Dearborn, MI, Contact: mayuresh@umich.edu

State-of-art computer vision and perception models have been developed using publicly available datasets such as Argoverse and ApolloScape. One major limitation of these datasets is the absence of infrastructure information, including lane line details, traffic signs, and intersection information. Such information is necessary and not complementary to eliminate common edge cases. Taking a leap in the future, we introduce a state-of-art synthetically generated dataset with detailed lane and vehicle information for the next generation of self-driving perception and computer vision solutions, named 'VTrackIt.' The main objective of the 'VTrackIt' dataset is thus to enabling the development of a new generation of AI/ML solutions that leverages infrastructure information.

4 Leveraging Machine Learning to Estimate Rial Corrugation from Multi-sensor Rail Vehicle

Wael Hassanieh, Dearborn, MI

Rail corrugation is a prominent degradative problem in the health monitoring of railway systems. Monitoring process is dependent on use of a diagnostic trolley, which is expensive and needs the track to be out-of-service. Alternatively, in-service rail vehicles with axle-box acceleration measurement systems installed, have shown success in detecting rail corrugations based on physical models, albeit with great limitations. Extending this approach, we build a Machine Learning model trained on collected accelerometer signals along with other offline and/or static features. We also propose a method to engineer acceleration-based features which reduces dynamically coupled vibration effects between left and right rails. The resulting model is able to recreate the target measurements of the rail irregularity profile, especially in highly corrugated sections.

Tuesday, 8AM–9:15AM

TA60

M - Marriott 7

ENRE/Energy-Climate Flash Session

Flash Session

Session Chair
Ana Dyreson, Michigan Technological University, Houghton, MI

1 Optimal Planning and Operations for Battery Electric and Hydrogen Vehicle Fleets

Thomas Lee, Sijia Geng, Audun Botterud, Massachusetts Institute of Technology, Cambridge, MA, Contact: t_lee@mit.edu

Transportation is a key part of the decarbonization challenge. For heavy-duty fleets, the energy infrastructure and operational tradeoffs between battery versus hydrogen vehicles differ from those of personal vehicles. We build a multi-energy model to study the optimal planning and charging operations of a depot-based fleet's technology composition (across multiple vehicle types and charger levels) in order satisfy known service schedules. We develop an integer clustering method that significantly improves the tractability of state of charge constraints for all vehicles. We apply the model to a case study on the geospatial timetable dataset of an urban transit bus network (Boston's MBTA).

2 Power Market Structure Impacts to EV Fleet Optimization and Scheduling

Chase P. Dowling[1], Nawaf Nazir[2], Malini Ghosal[1], Soumya Kundu[3], [1]Pacific Northwest National Laboratory, Seattle, WA, [2]Pacific Northwest National Lab, Richland, WA, [3]Pacific Northwest National Laboratory, Seattle, WA

Fleet electrification presents a unique opportunity to further develop the federation of distributed energy resources by expediting go-to-market for aggregators like virtual power plants, but also poses a unique set of operational objectives and constraints for consideration. We'll briefly outline the problem facing EV fleet operators and define prospective optimization problems over the different types of power markets across the United States. With identical hardware and business objectives, we'll see how deployment of fleets of EV's as a distributed energy resource may vary as of a function of their location in the US, impacting end uses cases like routing and scheduling from state to state.

3 Cyber-physical System (CPS) Resilience Through Data-driven, Intelligently Designed Control

Veronica Adetola, Pacific Northwest National Laboratory, Richland, WA

As our critical infrastructures (e.g., energy systems) are becoming more complex and connected, advancements in sensing, analytical methods, and controls are needed to provide situation awareness and assure the resiliency of the systems under cyber and physically induced disruptions. We will provide an overview of an ongoing research program at the Pacific Northwest National Laboratory to develop and demonstrate adaptive and autonomous control solutions for assured CPS resiliency. Key elements of the program include experimental characterization and data-driven understanding of CPS phenomenology under adverse conditions, distributed control, and sensing and control co-design.

4 Multi-Period Integrated Energy System Conceptual Design Problem with Market Surrogates

Xinhe Chen, University of Notre Dame, South Bend, IN

Integrated Energy System(IES) design problems using 'price taker' assumption do not capture the inherent exogenous uncertainty. In our work, we introduce a conceptual design problem that combines market-based surrogate models with detailed plant physics in a stochastic programming framework. Our modeling framework uses surrogate models to capture interactions between market and energy systems while the operation co-optimization is considered at the same time. Time series clustering methods are employed in this work to obtain the frequency for different scenarios.

5 The Influence of Carbon Pricing and System Flexibility on The Production and Supply of Grid-tied Electrolytic Hydrogen

Edgar Virguez[1], Paolo Gabrielli[2], Tyler Ruggles[3], [1]Carnegie Institution for Science, Palo Alto, CA, [2]ETHZ, Zurich, Switzerland; [3]Carnegie Institution for Science, Stanford, CA, Contact: evirguez@carnegiescience.edu

The myriad models that explore decarbonized energy systems frequently identify grid-tied electrolytic hydrogen as an essential energy carrier of least-cost energy systems. In this study, we analyze the influence of carbon pricing and system flexibility on the production and supply of least-cost grid-tied electrolytic hydrogen systems.

Using wholesale electricity market information (e.g., locational marginal prices) from representative regions in the US and a stylized production-cost model, we calculate the least-cost configurations for the production and supply of hydrogen, exploring the effects of introducing carbon pricing and emission constraints.

6 Integrating Physical Model with Machine Learning for Energy Storage Control

Bolun Xu, Ningkun Zheng, Steven Liu, Columbia University, New York, NY, Contact: bx2177@columbia.edu

This talk will present a new approach to ccontrol energy storage to provide grid services by combining a physical model with machine learning based on the opportunity value. We will use a physical model to calculate optimal historical opportunity values for time-coupling constraints and use machine learning to fit the opportunity value with historical data. The outcome is to use machine learning to directly predict storage future opportunity values using past signals, which achieves extreme computation efficiency and accuracy.

7 Strategic Energy Storage Investments: A Case Study of The CAISO Electricity Market

Dongwei Zhao[1], Mehdi Jafari[2], Audun Botterud[1], Apurba Sakti[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology-MIT, Cambridge, MA, Contact: zhaodw@mit.edu

Energy storage can provide a range of revenue streams for investors in electricity markets. However, the increasing deployment of storage will impact prices and reduce revenues. Based on the data from CAISO, we investigate strategic behavior among competing investors using a non-cooperative game, where they decide on the investment and operation of storage. This work provides insights into the market potential of arbitrage values and competition equilibrium among storage investors. We present the analytical and numerical results in the case of CAISO considering the increasing number of investors, increasing renewable energy penetration, and technology heterogeneity of competing investors.

8 Optimization Under Uncertainty with Bayesian Hybrid Models

Elvis Eugene[1], Kyla Jones[1], Alexander Dowling[2], [1]University of Notre Dame, Notre Dame, IN, [2]University of Notre Dame, Notre Dame, IN, Contact: kjones29@nd.edu

In science and engineering, multiscale models guide discovery and facilitate optimization-based decision making. Hybrid models use ML to quantify epistemic uncertainty associated with simplified mechanistic models. In this talk, we explore optimization (decision-making) under both parametric and epistemic uncertainty using Kennedy-O'Hagan (e.g., Gaussian process regression) hybrid models. Using a reaction engineering motivating example, we show how decision-making with hybrid models are more robust to perturbations in training data. We also discuss stochastic programming formulations for decision-making with these hybrid models.

9 Bayesian Optimization in Material Science and Applications to Thermoelectric Materials

Ke Wang, University of Notre Dame

Solid-state thermoelectric materials can convert low temperature waste heat into electrical energy, and thus have great potential to improve energy efficiency or power wearable electronics. In this work, we present several applications of Bayesian optimization to improve the additive manufacturing of thermoelectric materials, including the selection of dopant composition and flash sintering operating conditions. We focus on transferable strategies to harmonize machine learning predictions, Bayesian optimization, and human intuition. We demonstrate how, through BO, state-of-the-art material performance can be achieved with fewer than 50 experiments.

10 Exploring Power System Operation Under Extremes Using Simulated Heat Wave and Historical Drought

Ana Dyreson[1], Naresh Devineni[2], Sean Turner[3], Thushara De Silva[4], Ariel Miara[5], Nathalie Voisin[6], Stuart Cohen[7], Jordan Macknick[7], [1]Michigan Technological University, Houghton, MI, [2]CUNY, New York, NY, [3]Pacific Northwest National Laboratory, Seattle, WA, [4]National Renewable Energy Laboratory, Nashville, TN, [5]National Renewable Energy Laboratory, Denver, CO, [6]Pacific Northwest National Lab., Seattle, WA, [7]National Renewable Energy Laboratory, Golden, CO, Contact: adyreson@mtu.edu

The combined impacts of increasing variable renewable energy and extreme conditions due to climate change challenge models to capture uncertainties in infrastructure changes and climate and create a trade-off with power system model resolution. Further, the ability of climate models to capture extremes is limited, and historically-based events may be familiar and more relevant to stakeholders. We explore changes in demand, hydropower, and conventional power due to heat (from stochastic simulations forced by observational data) and drought (from hydrological and water resource models of a historic drought) in the Western U.S. for two infrastructures using a high resolution power system model.

Tuesday, 8AM–9:15AM

TA61

M - Marriott 8

EV Integration with the Power Grid

General Session

Session Chair

Diwas Paudel, Tampa, FL

1 **Efficient Representation for Electric Vehicle Charging Station Operations Using Reinforcement Learning**

Kyung-bin Kwon[1], Hao Zhu[2], [1]The University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, Austin, TX, Contact: haozhu@utexas.edu

This talk aims to minimize the total electricity cost of electric vehicle charging station (EVCS) for meeting the EV demand using reinforcement learning. To deal with the high dimension of state/action spaces that grows with the number of EVs, we advocate developing aggregation schemes according to the emergency of EV charging, or its laxity. A least-laxity first rule is used to consider only the total charging power of the EVCS while ensuring the feasibility of individual EV schedules. In addition, we propose an equivalent aggregation that can guarantee to attain the same optimal policy, and the policy gradient method is applied with a linear Gaussian policy. Numerical tests have demonstrated the performance improvement of the proposed representation approaches in increasing the total reward over the existing approximation-based method.

2 **A Distributionally Robust Model for Power Purchase Commitment by Electric Vehicle Charging Hubs**

Nicolas Bustos, University of South Florida, Tampa, FL, Contact: bustos@usf.edu

With the growth in electric vehicles (EVs), availability of electric vehicle charging hubs (EVCH) is expected to increase. Large scale EVCH operators are likely to participate in the electricity market by bidding for the day-ahead commitment of power. For efficient bidding, they will have to consider uncertainties in the electricity prices (both day-ahead and real time) as well as in the charging demand. We propose a two stage distributionally robust day ahead commitment model and use a linear decision rule-based methodology for model solution. Effectiveness of the method is demonstrated using a numerical case study.

3 **Optimal Routing and Vehicle-to-Grid Integration Improves Operational Viability of Electric Delivery Fleets**

Rami Ariss, Carnegie Mellon University, Pittburgh, PA

Transportation is the largest source of greenhouse gas (GHG) emissions in the United States today, and electrification is one of the few ways to provide transportation services with near-zero GHG emissions. We investigate the coordination of transportation and grid services to improve economic and operational competitiveness of electric delivery trucks. We develop a novel mixed integer linear program formulation that extends the electric vehicle routing problem to optimally size the fleet and simultaneously determine routing and vehicle-to-grid service operations. Preliminary results suggest grid services are sufficient to make electric delivery fleets more profitable than diesel fleets with today's technology in California and China.

4 **Real Time Operation of An Electric Vehicle Charging Hub: A Deep Reinforcement Learning Approach**

Diwas Paudel, University of South Florida, Tampa, FL

Publicly available electric vehicle charging hubs (EVCHs) will grow to meet the anticipated increase in EV charging demand. Effective operation of EVCHs will be influenced by the uncertainties in the prices of electricity and EV charging demand. In this paper, we consider these uncertainties and formulate the operation of an EVCH as a Markov decision problem, where the decisions involve procurement of power from the grid and the operation of the available battery storage system in the EVCH. We solve this problem using a deep reinforcement learning algorithm and demonstrate its effectiveness using a sample problem.

Tuesday, 8AM–9:15AM

TA62

M - Marriott 9

Optimization and Machine Learning for Renewable Energy Integration

General Session

Session Chair

Neng Fan, University of Arizona, Tucson, AZ

1 **Quantile Regression-based Probabilistic Water Inflow Forecast and Stochastic Optimization for Hydropower Systems**

Jiarong Xia, Stevens Institute of Technology, Hoboken, NJ

Accurate probabilistic hourly water inflow forecast and rigorous operation models are vitally important for the optimal day-ahead scheduling of cascaded hydropower systems (CHS). We proposes a quantile regression -based probabilistic water inflow forecast model by incorporating relevant correlation features to improve forecast accuracy. A scenario generation approach is then presented which leverages the quantile regression forecasting results to generate multiple scenarios for capturing chronological dependency of future water inflow uncertainties. With this, a stochastic optimization-based day-ahead hydropower scheduling model is developed to optimize scenario-independent hourly forebay levels, which will assist operators to maximize the profit of hydropower and effectively utilize available water against water inflow uncertainties.

2 Facilitating Electrification in Green and Resilient Microgrids by Optimally Sizing and Locating Battery Storage

Linda Punt, Gar Goei Loke, Yashar Ghiassi-Farrokhfal, Erasmus University, Rotterdam School of Management, Rotterdam, Netherlands. Contact: punt@rsm.nl

The rise of distributed energy resources increases uncertainty in electricity supply. Additionally, the emergence of electrification increases the demand uncertainty. This combination challenges supply-demand matching, highlighting the importance of optimally locating and sizing storage in designing a green and resilient microgrid. Current literature is limited and non-conclusive. To close this research gap, we propose a multi-objective robust optimization model to guarantee system reliability and incorporate uncertainty. We apply the model to a multi-energy microgrid including renewable generation, electric vehicles, and battery storage. The outcomes can provide critical insights for shaping policy and making investments.

Tuesday, 8AM–9:15AM

TA63

M - Marriott 10

Energy Systems Integration

General Session

Session Chair

Dharik Sanchan Mallapragada, MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA

1 Generalized Nash Equilibrium Model for Joint Planning of Gas-electricity Systems Under Carbon Constraints

Rahman Khorramfar[1], Dharik Sanchan Mallapragada[2], Saurabh Amin[3], [1]MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, United States, Cambridge, MA, [2]MIT Energy Initiative, Massachusetts Institute of Technology, Cambridge, MA, [3]MIT, Cambridge, MA, Contact: khorram@mit.edu

This presentation considers generation and transmission expansion problems (GTEP) of NG and electricity systems and proposes a generalized Nash equilibrium model to capture the decentralized nature of joint planning. Our modeling framework considers these systems as competing players coupled in two sets of constraints. The first constraint models the flow of natural gas between the systems, and the second one limits the CO2 emission induced by natural gas. We establish the existence of Nash equilibrium and identify some structural properties which enable us to develop a solution approaches that provide a range of Nash equilibria. We apply the proposed modeling framework to realistic data of the New England region. Our analysis reveals new policy insights based on extensive sensitivity analysis on the key parameters of the model.

2 Inspecting Decarbonization Pathways in An Open Energy Outlook for The United States

Aditya Sinha, North Carolina State University, Raleigh, NC, Contact: asinha2@ncsu.edu

In 2019, the United States (US) accounted for 17% of global primary energy supply and 14% of global greenhouse gas emissions. US mitigation efforts will be critical to the global effort to reach carbon neutrality. Energy system optimization models can examine future system evolution, test proposed policy effects, and explore the role of uncertainty. Open Energy Outlook represents a novel approach in macro-energy systems analysis by (1) using documented open-source tools and data, (2) conducting extensive sensitivity and uncertainty analysis, and (3) leveraging the domain knowledge of sector-specific experts. Here, we examine low emissions scenarios that extend through mid-century. In addition, we apply modeling-to-generate alternatives to quantify the flexibility in technology deployment across the modeled energy system under different budget constraints.

3 Integrated Strategic System Planning Modeling: Linking Regional Technology Portfolio Models and Nodal Capacity Expansion Planning and Operations Simulation Models

Naga Srujana Goteti[1], Napoleon Costilla-Enriquez[2], Phillip de Mello[1], Anish Gaikwad[3], Miguel Ortega-Vazquez[4], Nidhi Santen[4], Devin Van Zandt[1], Qianru Zhu[4], [1]Electric Power Research Institute, Washington, DC, [2]Electric Power Research Institute, Phoenix, AZ, [3]Electric Power Research Institute, Knoxville, TN, [4]Electric Power Research Institute, Palo Alto, CA, Contact: ngoteti@epri.com

Increasing deployment of variable energy resources for decarbonization has created reliability challenges in power systems planning. Future resource planning requires considering resource adequacy and reliability with generation and transmission expansion. This work provides an integrated framework for a cost-effective resource portfolio linking regional-scale technology pathways to inform detailed unit-level expansion of generation and transmission resources. Unit-level decisions are used to assess reliability under multiple realizations of adverse conditions using an hourly and sub-hourly operations model, reliability, and reserve analysis models. We demonstrate the results for New York as a case study. This work explores the interactions between granular tools and macro-level planning problems, with an explicit focus on system reliability.

4 Bottom-up Representation of Industrial Decarbonization

Maxwell Brown, National Renewable Energy Lab (NREL)

This presentation focusses on recent work in the space of industrial decarbonization. Specifically, we present on the Fuels and Industry Integrated Optimization (FINITO) model - a bottom-up representation of the industrial sectors with a particular focus on cement, ammonia, iron/steel, and hydrogen production. FINITO represents industrial operations and sectoral evolution through a cost minimization framework with the potential for integer investment decisions at the freight analysis framework regionality Results are presented for a variety of policy and market conditions (fuel price, demand growth,) with a focus on decarbonization pathways.

Tuesday, 8AM–9:15AM

TA64

M - Indiana A

Complex and Dynamic Systems

Contributed Session

Session Chair

Mohamad Kazma, Vanderbilt University, Nashville, TN

1 Human and Technology Collaboration: A System Readiness Level Approach in Logistics Systems

Janeth Gabaldon, Brian Sauser, Abhijeet Kumar, University of North Texas, Denton, TX, Contact: janeth.gabaldon@unt.edu

To increase efficiency, effectiveness, and agility, firms invest heavily in collaborative workspaces where humans and robots interact to execute goals that neither can achieve independently. New technologies enable safe human-robot collaboration, but its coexistence depends on the technologies available and the human interaction. Thus, there is a need to study the non-static and complex human and technology collaboration process. This paper offers a framework for the implementation and complexity of people's interaction with technology assessed by the system readiness level metric to indicate the current system's state. We contribute to the literature with a holistic and empirical approach. As a result, practitioners may proactively decide how technologies and users influence the system's investments and risks.

2 Modelling The Dynamics of Mental Workload and Fatigue in Safety-critical Monitoring Roles

Georgia Ning-Yuan Liu[1], Hesam Mahmoudi[2], Konstantinos P. Triantis[3], Bart Roets[4], [1]VirginiaTech, Falls Church, VA, [2]Virginia Tech, Blacksburg, VA, [3]Virginia Tech, Falls Church, VA, [4]Infrabel, Brussels, Belgium. Contact: ningyuan@vt.edu

In complex systems, mental fatigue resulting from high levels of stress or boredom during monitoring tasks may lead to a higher risk of human errors and accidents.

We present a dynamic model of the suboptimality of workload and its interaction with fatigue through time in safety-critical monitoring roles. Using real-world data of Traffic Controllers (TC), we have set to examine the dynamic hypotheses of mental fatigue affecting the workers' overload and underload thresholds of TCs and consequently their comfort range of workload through time. The simulated model results show that night shift workers experience higher mental fatigue than morning and afternoon shifts, due to accumulated boredom. Finally, we take the first leap to utilize simulation models and quantify the suboptimality of workload by considering the changes in the operator's mental fatigue through time.

3 Revisiting The Optimal Sensor Placement Problem in Power Networks

Mohamad Kazma, Ahmad Taha, Vanderbilt University, Nashville, TN, Contact: mohamad.h.kazma@vanderbilt.edu

Future power networks that are dominated by renewables face challenges related to maintaining network-wide stability. To address these challenges, wide-area monitoring systems and phasor measurement units (PMUs) provide real-time sensor data of physics-based states. Various studies have investigated mixed-integer programming formulations to optimally determine the geographic PMU placements.

While such studies addressed a plethora of challenges, they mostly adopt a simple representation of system dynamics, ignore basic algebraic equations modeling power flows, forgo including renewables such as solar and wind, and do not model their uncertainty. To that end, the objective of this work is to revisit the PMU placement problem and address these challenges via a novel optimization formulation. The proposed approach is validated on standard IEEE power networks.

Tuesday, 8AM–9:15AM

TA65

M - Indiana B
Economics and Computation I
Award Session

1 **[ec2022] Optimal and Differentially Private Data Acquisition: Central and Local Mechanisms**
Alireza Fallah[1], Ali Makhdoumi[2], Azarakhsh Malekian[3], Asuman Ozdaglar[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Duke University, Durham, NC, [3]University of Toronto Joseph L Rotman School of Management, Toronto, ON, Canada. Contact: afallah@mit.edu
We consider a platform's problem of collecting data from privacy sensitive users to estimate a parameter of interest. We formulate this question as a Bayesian-optimal mechanism design problem, in which an individual can share her data in exchange for a monetary reward, but at the same time has a private heterogeneous privacy cost which we quantify using differential privacy. We consider two popular differential privacy settings: central and local. In both settings, we establish minimax lower bounds for the estimation error and derive (near) optimal estimators for given heterogeneous privacy loss levels for users. Next, we pose the mechanism design problem as the optimal selection of an estimator and payments that elicit truthful reporting of users' privacy sensitivities. We further develop efficient algorithmic mechanisms to solve this problem in both privacy settings.

2 **[ec2022] Long-term Data Sharing Under Exclusivity Attacks**
Yotam Gafni, Moshe Tennenholtz, Technion - Israel Institute of Technology, Haifa, Israel. Contact: yotam.gafni@campus.technion.ac.il
The quality of learning generally improves with the scale and diversity of data. Companies and institutions can therefore benefit from building models over shared data. Many cloud and blockchain platforms, as well as government initiatives, are interested in providing this type of service.
These cooperative efforts face a challenge, which we call ``exclusivity attacks''. A firm can share distorted data, so that it learns the best model fit, but is also able to mislead others. We study protocols for long-term interactions and their vulnerability to these attacks, in particular for regression and clustering tasks. We conclude that the choice of protocol, as well as the number of Sybil identities an attacker may control, is material to vulnerability.

3 **[ec2022] Strategic Mining Against Cryptographic Self-selection in Proof-of-stake**
Matheus Venturyne Xavier Ferreira[1], Ye Lin Sally Hahn[2], S. Matthew Weinberg[3], Catherine Yu[2], [1]Harvard University, Cambridge, MA, [2]Princeton University, Princeton, NJ, [3]Princeton University, Princeton, NJ, Contact: matheusventuryne@gmail.com
Cryptographic Self-Selection is a subroutine used to select a leader for state-of-the-art energy-efficient blockchains. Miners lock capital, and as an incentive to propose blocks, they receive a reward per block. For a fair protocol, miners get a yield proportional to their fraction of locked capital. We show such protocols leave open the possibility of a selfish-mining-style attack: a user always benefits from dividing their wealth among multiple accounts to maximize their chances of creating blocks in the future. We characterize the optimal strategy; first by proving the existence of optimal positive recurrent strategies whenever the adversary owns last than 38% of the stake. Then, we provide a Markov decision process formulation to compute the optimal strategy.

Session Chair
Alireza Fallah, Massachusetts Institute of Technology, Cambridge, MA

Tuesday, 8AM–9:15AM

TA66

M - Indiana C
Pricing Energy and Markets
General Session

Session Chair
Luce Brotcorne, INRIA, Villeneuve-D'ascq, France.

1 **Sustainability in a Market Design for Electricity**
Lamia Varawala[1], Mohammad Reza Hesamzadeh[1], György Dán[1], Derek W. Bunn[2], Juan Rosellon[3], [1]KTH Royal Institute of Technology, Stockholm, Sweden; [2]London Business School, London, United Kingdom; [3]CIDE, Mexico City, Mexico. Contact: varawala@kth.se
The electricity industry has been one of the first to face technological changes motivated by sustainability concerns. Whilst efficiency aspects of market design have tended

to focus upon market power concerns, the new policy challenges emphasise sustainability. We argue that market designs need to develop remedies for market conduct integrated with regard to environmental externalities. Accordingly, we develop an incentive-based market clearing mechanism using a power network representation with a distinctive feature of incomplete information regarding generation costs. The shortcomings of price caps to mitigate market power, in this context, are overcome in under the proposed mechanism.

2 Robust Pricing for Residential Demand Response with Human-in-the-loop

Constance Crozier, Kyri Baker, University of Colorado Boulder, Boulder, CO, Contact: constance.crozier@colorado.edu

Residential demand response has the potential to support decarbonization of electricity networks. Time of use tariffs are currently used to encourage shifting of demand to times of lower constraint. However, as deployment of smart devices increases, rebound effects (where too many consumers respond instantaneously) are becoming of concern. Here we explore a method of designing residential pricing which is robust to human behavior, while still optimizing for grid-level goals.

3 Artelys Libra Optimization Module use Case: The European Market Clearing Platform TERRE

Julien Cote-Massicotte, Artelys Corporation, Chicago, IL, Contact: julien.cote@artelys.com

Artelys supports the design, development and implementation of energy market software by leveraging its skills in mathematical optimization and its solvers. TERRE (Trans European Replacement Reserve Exchange) project delivers a European platform for the exchange of balancing energy from replacement reserves based on LIBRA solution, a common IT system which supports the exchange of the balancing energy.

The challenge was to develop a market clearing algorithm to select the optimal set of bids to cover the replacement reserve needs and ensure that the solutions respect complex business rules. The problem has been modelled and solved with FICO® Xpress Optimization Suite.

Tuesday, 8AM–9:15AM

TA67

M - Indiana D

Revenue Management and Online Platform Analytics

General Session

Session Chair

Can Kucukgul, The University of Texas at Dallas, Richardson, TX

1 Online Selection Subject to Ordinal Fairness

Jad Salem[1], Deven Desai[1], Swati Gupta[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: jsalem7@gatech.edu

Applicant-screening often involves scoring applicants and making decisions based on the induced ranking. Actions to address discrimination in practice typically involve ensuring similar selection rates across protected groups, but these are arguably non-individualistic approaches. In this work, we model bias as a partial order on applicants, where applicants that are difficult to rank due to biases or uncertainties are deemed incomparable. Modeling this biased screening process as the (online) k-secretary problem under partial ordinal information, we design an asymptotically tight algorithm (i.e., one which achieves the optimal competitive ratio as the number of applicants and selections go to infinity). We discuss the feasibility of this approach given the legal backdrop of bias mitigation in the U.S. and highlight unresolved legal questions.

2 Novelty in Restaurant Reviews: The Impact on Businesses and Consumers

Dicle Yagmur Ozdemir[1], Harpreet Singh[2], Sumit Sarkar[2], [1]The University of Texas at Dallas, Dallas, TX, [2]University of Texas-Dallas, Richardson, TX, Contact: dxo170430@utdallas.edu

The popularity of electronic word-of-mouth has increased dramatically over the years. Consequently, it has become important to understand the various ways in which online reviews impact relevant stakeholders such as platforms, businesses, and consumers. While prior works have examined the impact of different review characteristics, the impact of new information provided in reviews (review novelty) has not received attention. We study how review novelty impacts different stakeholders. We examine how novel content in reviews influences consumers' restaurant check-ins and their perceptions of review helpfulness.

We examine if review helpfulness mediates the effect of review novelty on restaurant check-ins. We also investigate heterogeneity in the impact of novel reviews on low-priced and high-priced restaurants.

3 Competitive Agricultural Supply Chain Network Design with Environmental and Social Sustainability Considerations

Deniz Besik[1], Sara Saberi[2], Pritha Dutta[3], Rodrigo Mercado Fernandez[4], [1]University of Richmond, Richmond, VA, [2]Worcester Polytechnic Institute (WPI), Worcester, [3]Pace University, New York, NY, [4]Appalachian State University, Boone, NC, Contact: dbesik@richmond.edu

According to the United Nations, increasing world population and overconsumption have caused an exponential rise in the demand for food, which is one of the three pillars of sustainable development. We develop a multicriteria competitive agricultural supply chain network design model that captures all three aspects of sustainability which are financial, environmental, and social. The competition among firms is studied through game theory, where the governing Cournot-Nash equilibrium conditions correspond to a variational inequality problem. Further, we utilize our modeling framework to analyze a case study and discuss the insights obtained from the analysis.

4 Winners, Losers, or Both: Should Ad-exchanges Subsidize The Acquisition of Targeting Data in Ad Auctions?

Wangsheng Zhu[1], Shaojie Tang[2], Vijay S. Mookerjee[3], [1]The University of Texas at Dallas, Plano, TX, [2]University of Texas-Dallas, Mckinney, TX, [3]University of Texas- Dallas, Richardson, TX

Today, large volumes of online impressions are used to deliver targeted ads to consumers. In targeted advertising, advertisers utilize data to learn about each user's preferences and select the most appropriate ad. An important data source for targeting is a data management platform (DMP) that integrates user data from various websites and apps. However, ad exchanges have mainly been passive about the acquisition of user data from DMPs by advertisers. While prior studies have examined whether ad exchanges should reveal the information owned by them to advertisers, little attention has been paid to the active role an ad exchange can play when a third-party DMP sells targeting data to advertisers. To bridge this gap, we explore the potential of increasing the profit of the ad exchange by subsidizing the data acquisition and inducing more advertisers to buy data from DMPs.

Tuesday, 8AM–9:15AM

TA68

M - Indiana E

Strategic Delay, Customer Reviews, and Resource Sharing in Marketplace Platforms

General Session

Session Chair

N. Bora Keskin, Duke University, Durham, NC

Session Chair

Chenghuai Li, [1]</sup

1 Dynamic Payment and Lead-time Control in Queueing Systems with Heterogeneous Customers and Strategic Delay

Chen-An Lin, Kevin Shang, Peng Sun, Duke University, Durham, NC, Contact: cl419@duke.edu

We consider a first-come-first-serve, single-server queue in which customers arrive according to a Poisson process. Customers are heterogeneous in their instant service valuation and level of patience, and the firm only knows the portion of each type. The model is motivated from make-to-order systems that customize products for customers. The firm announces a menu of options that depend on the system wait time. Each option consists of a payment and a quoted completion time. An arriving customer chooses an option to maximize his utility. The objective is to maximize the average revenue. Our study suggests that it may be optimal for the firm to strategically quote a longer completion time to a patient customer when the proportion of impatient customers is high and the system wait time is short.

2 Do Noisy Customer Reviews Discourage Platform Sellers? Empirical Analysis of An Online Solar Marketplace

Herbie Huang[1], Nur Sunar[2], Jayashankar M. Swaminathan[3], Rahul Roy[1], [1]University of North Carolina at Chapel Hill, Chapel Hill, NC, [2]UNC, Chapel Hill, NC, [3]University of North Carolina Chapel Hill, Chapel Hill, NC, Contact: Rahul_Roy@kenan-flagler.unc.edu

In collaboration with one of the largest online solar marketplaces in the U.S., we empirically analyze how dispersions in customer reviews of a focal seller and that of her competitors impact the number of proposals offered by the focal seller. We observe that the number of proposals offered by the focal seller exhibits an inverted U-shaped relationship with dispersions in customer reviews of both the seller and that of her competitors. We also find a significant and inverted U-shaped relationship between the market-level review dispersion and transactions. Our paper uses traditional econometrics methods, a clustering method, and a deep-learning-based natural language processing model.

3 Friend or Foe? The Impact of Home-sharing Professional Investors on The Housing Market

Saif Benjaafar, Jiali Huang, Ankur Mani, Shihong Xiao, University of Minnesota, Minneapolis, MN, Contact: amani@umn.edu

Home-sharing professional investors have been actively purchasing properties to rent on home-sharing platforms for profit. Policy makers in different cities have various attitudes towards these investors: some pass regulations to restrict their investments yet others legitimize them. It is unclear whether professional investors always help or always hurt the local population and how to regulate professional investment. In this study, we investigate the impact of home-sharing professional investors on the local market outcomes, including home selling price, rents, and local welfare. We find that The home selling price and the rent both decrease in the investor pool size when the investor pool size is small, but then increase in the investor pool size when the size becomes large.

4 Courier Sharing in Food Delivery

Arseniy Gorbushin[1], Ming Hu[2], Yun Zhou[3], [1]Rotman School of Management, Toronto, ON, Canada; [2]University of Toronto, Minneapolis, MN, [3]McMaster University, Hamilton, ON, Canada. Contact: arseniy.gorbushin@rotman.utoronto.ca

The food delivery market largely migrated to online platforms. In contrast with the traditional restaurant-operated food delivery, an online platform uses a centralized pool of couriers to deliver for multiple restaurants. We consider a spatial queuing model to compare the two systems: the dedicated system where each courier is anchored to a specific restaurant, and the shared system where couriers deliver for multiple restaurants. We show that the dedicated system could achieve a higher profit than the shared system due to the more unbalanced spatial distribution of the couriers in that latter system. Nevertheless, the shared system performs better in markets where customers have more distinct taste and order frequently from far-away restaurants that better fit their tastes.

Tuesday, 8AM–9:15AM

TA69

M - Indiana F

Revenue Management and Choice Modeling

General Session

Session Chair

Ashwin Venkataraman, University of Texas at Dallas, Richardson, TX

Session Chair

Srikanth Jagabathula, NYU Stern School of Business, New York, NY

1 Pricing Optimization Under The Featurized Rank-based Model

Mohammad Amin Farzaneh[1], Ashwin Venkataraman[1], Sajad Modaresi[2], [1]University of Texas at Dallas, Richardson, TX, [2]UNC Chapel Hill, Kenan-Flagler Business School, Chapel Hill, NC, Contact: mxf180000@utdallas.edu

The availability of sales data coupled with algorithmic advances in estimation and optimization have made the nonparametric rank-based model a popular choice for modeling customer demand. Despite its flexibility, the rank-based model suffers from two limitations. First, it assumes strict rankings over the products and hence, cannot capture indifferent preferences among a subset of products. Second, the rankings do not account for product features. We introduce the featurized rank-based model that addresses these limitations. Given an offer set, each customer forms a partial order over the products. Then, the customer chooses among the most preferred products in the partial order according to the MNL model. We study pricing optimization problem under the featurized rank-based model. Our results show that the optimal prices can be computed for several special cases.

2 Randomized Assortment Optimization

Zhengchao Wang, Heikki Peura, Wolfram Wiesemann, Imperial College Business School, London, United Kingdom. Contact: z.wang19@imperial.ac.uk

In assortment optimization, estimation error in the underlying choice model parameters may lead to significantly suboptimal decisions. Recent work has sought to mitigate this issue using robust optimization. We show that a firm may further benefit from randomizing its assortment choice. That is, the firm can improve its worst-case expected revenues by selecting an assortment randomly according to a prudently designed probability distribution. These benefits extend across popular choice models: the multinomial logit model, the Markov chain model, and the preference ranking model. Besides superior in-sample performance, we demonstrate improved out-of-sample performance in a data-driven setting that combines estimation with optimization.

3 Revenue Management with Flexible Products

Wenchang Zhu[1], Huseyin Topaloglu[2], [1]Cornell University, Ithaca, NY, [2]Cornell Tech, New York, NY, Contact: wz368@cornell.edu

We provide an approximation algorithm for network revenue management problems with flexible products. Flexible products allow delaying the assignment decision of which resources to use to serve each request, but also make it difficult to track the inventory state when designing algorithms. Our algorithm uses value function approximations constructed by solving an integer program with linear objective to reshuffle inventories at each time period. We show that if each route uses at most L resources, then the total expected revenue obtained by our approximate policy is at least 1/(1+L) of the optimal total expected revenue. Our computational experiments demonstrate that our policy performs quite well and flexible products do increase the total expected revenue by delaying the assignment decisions to the end of the time horizon.

4 The Generalized Stochastic Preference Choice Model

Ashwin Venkataraman[1], Gerardo Berbeglia[2], [1]University of Texas at Dallas, Richardson, TX, [2]Melbourne Business School, newport, Australia. Contact: ashwin.venkataraman@utdallas.edu

We propose a new discrete choice model, called Generalized Stochastic Preference (GSP) model, that incorporates non-rationality into the random utility maximization (RUM) model class. Our model can explain several choice phenomena that cannot be represented by a RUM such as the attraction effect and the compromise effect, but still subsumes the RUM model class. The GSP model is defined as a distribution over customer types, and we propose an iterative estimation method that requires solving a ILP in each iteration. Moreover, we show that our notion of non-rationality can be incorporated into other choice models, like the classical MNL model, for which we present an efficient EM-based estimation algorithm. Numerical evaluation on real choice data shows that our proposed models outperform the rank-based and MNL choice models, both in-sample and out-of-sample.

Tuesday, 8AM–9:15AM

TA70

M - Indiana G

Applications of MIP in Machine Learning

General Session

Session Chair

Calvin Tsay, 1</sup

1 Optimization of Trained Neural Network Ensemble

Keliang Wang[1], Leonardo Lozano[2], Carlos Henrique Cardonha[3], David Bergman[3], [1]University of Connecticut, Storrs, CT, [2]University of Cincinnati, Cincinnati, OH, [3]University of Connecticut, Storrs, CT, Contact: keliang.wang@uconn.edu

We study optimization problems where the objective function is modeled through an ensemble of neural networks with rectified linear unit (ReLU) activation. We present a mixed-integer linear program based on existing popular big-M formulations for optimizing over a single neural network. We develop a two-phase approach for our model that combines preprocessing procedures to tighten bounds for critical neurons in the neural networks with a Lagrangian relaxation-based branch-and-bound approach. Experimental evaluations suggest that using neural network ensemble yields more stable and higher quality solutions, compared to a single neural network, and that our optimization algorithm outperforms (the adaption of) a state-of-the-art approach in terms of computational time and optimality gaps.

2 P-split Formulations: A Class of Intermediate Formulations Between Big-m and Convex Hull for Disjunctive Constraints

Jan Kronqvist[1], Ruth Misener[2], Calvin Tsay[2], [1]KTH Royal Institute of Technology, Stockholm, Sweden; [2]Imperial College London, London, United Kingdom. Contact: jankr@kth.se

Disjunctive constraints appear naturally in a large variety of different mixed-integer optimization problems. Such problems include classical OR applications but also applications in AI and ML, e.g., clustering and optimization over ReLU DNNs. The classical modelling approaches for disjunctive constraints can result in very weak continuous relaxations or strong but computationally challenging relaxations. In this talk we discuss a new class of formulation called p-split formulations, that combines the advantages of big-M and convex hull formulations. Technical details and theoretical properties of the formulations are presented along with computational results.

3 Verifying Correctness of Neural-network-based Control Systems Using Mixed-integer Programming

Calvin Tsay[1], Jan Kronqvist[2], Alexander Thebelt[1], Ruth Misener[3], [1]Imperial College London, London, United Kingdom; [2]KTH Royal Institute of Technology, Stockholm, Sweden; [3]Imperial College London, London, United Kingdom.

Recent decades have seen the adoption of optimization-based control systems, notably model predictive control (MPC), but online deployment can be intractable, owing to, e.g., model size. Therefore, several so-called *explicit MPC* strategies deploy neural networks (NNs) by training them on MPC controllers offline, then using the trained NN as a controller online. Although NNs can approximate complex functions and be evaluated quickly, they are prone to overfitting, limiting their adoption in risk-critical applications. This work shows how embedding ReLU-NN controllers in mixed-integer optimization enables analyzing extreme behavior of closed-loop system dynamics. We propose two formulations to verify "correctness": (i) identifying the maximum deviation from the original control system and (ii) computing extreme values of system states.

4 Robust Counterfactual Explanations for Random Forests

Alexandre Forel[1], Thibaut Vidal[2], Axel Parmentier[3], [1]MAGI, Polytechnique Montreal, Montreal, QC, Canada; [2]MAGI, Polytechnique Montreal, Montréal, QC, Canada; [3]CERMICS, Ecole des Ponts, Champs sur Marne, France. Contact: alexandre.forel@polymtl.ca

Counterfactual explanations describe how to modify a feature vector to flip the outcome of a trained classifier. Several methods have been proposed to generate counterfactual explanations, but their robustness when the classifier is re-trained has not been studied so far. Our goal is to obtain counterfactual explanations for random forests that are robust to algorithmic uncertainty. We study the link between the robustness of ensemble models and base learners and formulate a chance-constrained optimization model. We provide statistical guarantees for random forests of stumps and develop a practical method with good performance. We show that existing naive and plausibility-based methods provide surprisingly low robustness. Our method achieves the best trade-off between robustness and the distance of counterfactual explanations to the initial observation.

Tuesday, 8AM–9:15AM

TA71

M - Arizona

Quantum Computing and Optimization

General Session

Session Chair

Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY

1 Quantum Computing Trends

Yuri Alexeev, Argonne National Lab, Lemont, IL, Contact: yuri@anl.gov

In this presentation, I will discuss the state of quantum computing. In particular, I will describe recent developments, identify scientific and community needs, opportunities, and significant challenges for the development of quantum computers for science. Special emphasis will be given to demonstrations of quantum supremacy and advantage using supercomputers.

2 Benchmarking Combinatorial Optimization on Quantum Annealing Computers

Carleton Coffrin, Los Alamos National Laboratory, los Alamos, NM

Quantum Annealing was proposed in 1998 as a heuristic for solving combinatorial optimization problems that would leverage quantum mechanics to find high-quality solutions. Due to the computational difficulty in simulating quantum systems, Quantum Annealing remained a theoretical curiosity until 2011, when D-Wave Systems started selling quantum computers that could execute the Quantum Annealing algorithm in hardware. In this work report our experience in benchmarking D-Wave Systems' quantum annealing computers for conducting combinatorial optimization and present new results on the recently released *Advantage* platform, which supports combinatorial optimization problems with more than 5,000 binary decision variables.

3 The Quantum Gradient Algorithm is (almost) Optimal for Quantum State Tomography

Giacomo Nannicini, IBM T.J. Watson, Yorktown Heights, NY

Quantum state tomography is the process of obtaining a description of an unknown quantum state. We show that when we have access to a state-preparation unitary, modifications of the quantum gradient algorithm yield (almost) optimal algorithm, improving the dependence on precision of previously known tomography algorithm. This has important applications in some quantum optimization algorithms, where obtaining a description of the quantum state allows us to recover a description of the solution.

Tuesday, 8AM–9:15AM

TA72

M - California

Data Analysis and Optimization in Communication and Social Networks

General Session

Session Chair
Alexander Semenov, University of Florida and St. Petersburg State University, Shalimar

1 Cascade Prediction in Social Networks via Euclidean Embedding

Wondi Geremew, Stockton University, NJ

In this presentation we will discuss how a Euclidean embedding approach can be used for explaining and predicting the propagation of information cascades in social networks. The designed model casts social media content-sharing individuals into the space of latent features reflecting the individuals' interests, and thus, traits of the content they will tend to post and repost. The likelihood optimization problem, formulated to fit the model to observed cascade diffusion data, employs a penalty method. Experimental results, reported with both synthetic and large-scale real world data, showcase the strong predictive power of the model.

2 A Fast Algorithm for The Q-composite Key Management Problem

Maciej Rysz[1], Alexander Semenov[2], [1]Miami University, Oxford, OH, [2]University of Florida and St. Petersburg State University, Shalimar, Contact: ryszmw@miamioh.edu

We investigate graph properties that induce optimal communications encryption for the q-Composite key management scheme. The results are used to construct a fast key distribution algorithm that guarantees network-wide communication. Numerical experiments demonstrate the effectiveness of our approach on large-scale networks.

Tuesday, 8AM–9:15AM

TA73

M - Colorado
Stochastic Models of Service: Behavior, Design, and Dynamics
General Session

Session Chair
Andrew Daw, 1</sup

1 Optimal Fair Incentives for Retention

Chamsi Hssaine[1], Daniel Freund[2], [1]Cornell University, Ithaca, NY, [2]MIT Sloan School of Management, Cambridge, MA, Contact: ch822@cornell.edu

We study an organization's problem of finding optimal fair monetary incentives when faced with agents who myopically base their participation decisions on limited information with respect to these incentives. Our model induces a complex stochastic optimization problem whose natural fluid relaxation is also a priori intractable. Nevertheless, we uncover a surprising structural property of the relaxation that allows us to design a tractable, fast-converging heuristic policy that is asymptotically optimal amongst the space of all policies that fulfill a natural fairness property, and derive ``price-of-fairness’’-type bounds when this property is relaxed.

2 Statistical Analysis of Ridesharing to Inform Customer-driver Matching

Weiqing Xu[1,2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: xwqxu@uchicago.edu

In ride-sharing applications, customer and driver arrivals tend to change very quickly over the course of a day. As a result, a non-homogeneous Poisson process with piecewise constant rates may not be a good candidate to model arrivals. We analyze a dataset provided by a major ride-sharing company in China, and show (1) that arrivals can be modeled by a Poisson process, but (2) that the rates shift between being time-stationary and time-varying throughout the day. We use this knowledge to develop algorithms to match customers and drivers, that take into account the aforementioned shifts.

3 Price/waiting Trade-offs in Ride-hailing Platforms: Drivers, Riders, and Platform Controls

Aikaterini Giannoutsou, University of Southern California, LOS ANGELES, CA

We study a ride-hailing platform that is faced with price and delay sensitive riders and drivers. The platform is considering offering two different service classes which are differentiated in prices and delays (ETAS). We study the price/waiting trade-offs that arise on both the rider and on the driver side and how the characteristics and decisions of each side lead to different equilibria in the system. We show what the equilibria would be under different market conditions, and propose what the platform actions and controls should be depending on the characteristics of riders and drivers and their interaction.

4 When Machine Learning Classifications Impact Resource Allocation Decisions: Routing for Fairness and Efficiency in a Queueing Model

Zhiqiang Zhang[1], Pengyi Shi[2], Amy R. Ward[1], [1]The University of Chicago Booth School of Business, Chicago, IL, [2]Purdue University, West Lafayette, Contact:

zqzhang0@chicagobooth.edu

We study how to route customers to balance fairness and efficiency in a queueing model, motivated by incarceration diversion in criminal justice. Clients can be routed to “treatment programs”, and the routing decisions can depend on client’s risk level estimated by machine learning (ML) algorithms. Different from the ML literature on predictive fairness, we eliminate the two-step “predict-then-decide” procedure. We directly study how to balance fairness and efficiency in routing and characterize the cost of fairness in terms of efficiency loss.

5 Competitive Bundling and Offer Design in a Symmetric Bertrand Duopoly

Guillaume Roels[1], Uday S. Karmarkar[2], Araz Khodabakhshian[3], [1]INSEAD, Fontainebleau, France; [2]UCLA Anderson School of Management, Los Angeles, CA, [3]UCLA, Glendale, CA, Contact: guillaume.roels@insead.edu

How should competing service platforms bundle their offerings to capture a large market while seeking differentiation? To answer this question, we consider the most generic model of competition, namely: Two symmetric firms competing on price with regard to two homogeneous zero-cost components, without restrictions on their product offering. We show that three outcomes emerge in equilibrium, namely, a full-mixed bundling monopoly preempting entry, a full-mixed bundling competitive duopoly leading to a price war, and a pure or partial-mixed bundling differentiated duopoly yielding positive profits for both firms.

Tuesday, 8AM–9:15AM

TA74

M - Florida

Technologies in Finance and Risk Management

General Session

Session Chair

Ruodu Wang, University of Waterloo, Waterloo, ON, Canada.

Session Chair

Qiuqi Wang, 1</sup

1 An Axiomatic Theory for Anonymized Risk Sharing

Ruodu Wang, University of Waterloo, Waterloo, ON, Canada.

We study the mechanism design and axiomatization of risk and block reward sharing with undisclosed preferences of the agents. A few axioms risk anonymity, risk fairness, actuarial fairness, and operational anonymity pins down the unique form of the conditional mean risk sharing rule. An application to axiomatize block reward sharing in cryptocurrency mining pools is presented.

2 W-shaped Smiles and The Gaussian Mixture Model

Paul Glasserman[1], Dan Pirjol[2], [1]Columbia University, New York, NY, [2]Stevens Institute of Technology, Hoboken, NJ

What does the shape of an implied volatility curve say about the shape of the risk-neutral density (RND)? We use level crossings of the implied volatility curve to infer the shape of the RND by bounding the number of times the RND crosses a lognormal density. We use this approach to examine the emergence of W-shaped smiles in equity markets and their connection with bimodal RNDs. We also study related properties of Gaussian mixture models and prove a novel convexity property of Black-Scholes prices. We show that neither a bimodal RND nor a W-shaped smile implies the other. In fact, a unimodal density can produce an infinitely oscillating implied volatility curve.

3 Learning High-dimensional Mckean-vlasov Forward-backward Stochastic Differential Equations with General Distribution Dependence

Ruimeng Hu, University of California, Santa Barbara, Santa Barbara, CA

One of the core problems in mean-field control and mean-field games is to solve the corresponding McKean-Vlasov forward-backward stochastic differential equations (MV-FBSDEs). Most existing methods are tailored to special cases in which the mean-field interaction only depends on expectation or other moments and thus inadequate to solve problems when the mean-field interaction has full distribution dependence. In this talk, we present a novel deep learning method for computing MV-FBSDEs with a general form of mean-field interactions, building on fictitious play and supervised learning. The recently proposed generalized maximum mean discrepancy [Han, Hu and Long, arXiv:2104.12036] is used to analyze the convergence of this algorithm. We then study the mean-field game of the Cucker-Smale model whose cost depends on the full distribution of the forward process.

4 Q-learning in Continuous Time

Yanwei Jia, Xunyu Zhou, Columbia University, New York, NY, Contact: xz2574@columbia.edu

We study the continuous-time counterpart of Q-learning for reinforcement learning (RL) under the entropy-regularized, exploratory diffusion process formulation introduced by Wang et al. (2020). As the conventional (big) Q-function collapses in continuous time, we consider its first-order approximation and coin the term "(little) q-function". This function is related to the instantaneous advantage rate function as well as the Hamiltonian. We develop a "q-learning" theory around the q-function that is independent of time discretization. Given a stochastic policy, we jointly characterize the associated q-function and value function by martingale conditions of certain stochastic processes. We then apply the theory to devise different actor-critic algorithms for solving underlying RL problems.

Tuesday, 8AM–9:15AM

TA75

M - Illinois

Marketing and Business Management

Contributed Session

Session Chair

Lukas Benjamin Heidbrink, Bielefeld University, Bielefeld, Germany.

1 Comparison of Probability Selling and Product Bundling

Chia-Wei Kuo, Kwei-Long Huang, Yung-Hsin Chung, National Taiwan University, Taipei, Taiwan.

We consider an optimal pricing problem where a seller offers two products under three selling strategies: traditional, probabilistic, and bundling selling. Customer valuations towards these two products are represented by a Hotelling model. We discuss two special cases in which all consumers prefer purchasing both or only one product. In both cases, we show probabilistic or bundle selling makes the seller better off when both production costs are relatively low. If there exist both types of consumers in the market, our results show that the seller's optimal strategies are affected not only the production costs but also product differentiation.

2 Does Business Leaders' Operational Experience Generate Firm Operational Performance?

Hyungchan Cho[1], Damian Beil[2], Andrew Wu[3], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, [3]University of Michigan, Ann Arbor, MI, Contact: chohc@umich.edu

Firms hire business leaders (executives, board members, etc.) for their experience and expertise. In this paper, we examine whether business leaders' operational excellence translates into firm operational performance. Using historical panel data on public firms' operational performance and senior leadership, we first formulate a measure of business leaders' operational excellence based on their employment history. Then, using this measure, we find that good operational excellence scores of business leaders are associated with better operational outcomes for firms. We find evidence of causality in this relationship by leveraging exogenous changes in firms' senior leadership, and perform a variety of checks to establish the robustness of our findings.

3 Should Online-First Brands Open a Retail Store?

Yongcong Liu[1], Yi Zhu[2], Yue Dai[3], [1]Fudan University, Shanghai, China; [2]University of Minnesota, Minneapolis, MN, [3]Fudan University, Shanghai, China. Contact: yongcongliu20@fudan.edu.cn

Many online-first brands increasingly open offline stores, which motivates us to examine whether adding offline stores benefits them. We construct a search model in a competitive setting where consumers could further search offline stores to confirm match information after obtaining price and partial match information from online channels. Our analysis shows that the consumers who search offline may reduce their perception of match difference between products and reverse their initial online purchasing choices due to updated match information. Such changes may thus intensify price competition between brands and decrease demand for the online-first brand that adds the offline stores. Furthermore, it does not always benefit the omnichannel brand by increasing consumers' additional match value in-store or lowering consumers' search costs.

4 Cash Flow Forecasting Methods for DCF-based Valuations

Lukas Benjamin Heidbrink, Bielefeld University, Bielefeld, Germany.

This talk discusses different forecasting methods for use with discounted cash flow based valuations such as multivariate autoregressive models, random forests and artificial neural networks. The empirical analysis uses financial accounting data from US-corporations between 1990 and 2019. I evaluate the different methods in terms of out-of-sample accuracy using one-step, many-step and iterative forecasts and their comprehensibility. Finally, I will discuss applicability to accounting regulation and potential improvements of the quality of financial statements.

Tuesday, 8AM–9:15AM

TA76

M - Michigan

Practices Reducing Environmental or Increasing Social Impact

General Session

Session Chair

Gokce Esenduran, Purdue University, West Lafayette, IN

1 Should I Curate by Quality or Not? a Game-theoretic Analysis of P2P Resale Marketplaces

Aditya Vedantam[1], Emre M. Demirezen[2], Subodha Kumar[3], [1]State University of New York at Buffalo, Williamsville, NY, [2]University of Florida, Gainesville, FL, [3]Fox School of Business, Temple University, Philadelphia, PA, Contact: adityave@buffalo.edu

Several peer-to-peer (P2P) resale marketplaces curate used products by quality (e.g., thredUP) while several others do not (e.g., Poshmark). In this study, we investigate the business value of quality curation for P2P resale marketplaces, the impact of quality curation on an independent retailer, and societal welfare. Our results shed light on why retailers are choosing to collaborate with quality curated marketplaces and provide prescriptions for policymakers debating about regulating low-quality and defective items on third-party marketplaces.

2 Competitive Industry's Response to Environmental Tax Incentives for Green Technology Adoption

Anton Ovchinnikov[1], Dmitry Krass[2], [1]Queen's University, Smith School of Business, Kingston, ON, Canada; [2]Rotman School of Management, University of Toronto, Toronto, ON, Canada. Contact: ao37@queensu.ca

We consider market response to environmental taxes by firms producing a commodity good with a polluting by-product. Firms are heterogeneous with respect to production efficiency and pollution control technology. Cournot quantity competition is assumed, two demand functions are considered: iso-elastic and linear, as well as two kinds of responses: market response, where firms choose production quantities given their technology choices, and technology response, where firms also choose among a discrete set of available pollution abatement technologies. We characterize the market and technological equilibria in these settings and examine the possibilities and limitations of using environmental taxes as a mechanism to incentivize "green" technology choice. We also show that results may qualitatively differ depending on the demand function assumed.

3 Manufacturing as a Service

Gokce Esenduran[1], Alok R. Chaturvedi[1], Gaurav Nanda[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN, Contact: gesendur@purdue.edu

We study a Manufacturing as a Service (MaaS) environment in a sharing economy context. Motivated by Saksham, a project implemented in Jharkhand in India, that aims to bring mobile manufacturing environment -- called Factories on Wheels (FOWs)-- to low income communities -called labor firms-- so that these communities have an opportunity to make/sell product and achieve economic growth and stability. We model the interaction between a social planner, labor firms, and FOWs. Analyzing this problem, we identify how the total welfare progresses, under what conditions the business model would succeed, and what the breakeven point would be from social planner's, labor firms', and FOWs' perspective.

4 Throwing Out Food Before Expiration and Still Reducing Food Waste: Online Vs. Offline Retail

Jorrit Barto[1], (Ayse) Sena Eruguz[2], Remy Spliet[3], Sanne Wøhlk[4], [1]Albert Heijn, Amsterdam, Netherlands; [2]VU Amsterdam, Amsterdam, Netherlands; [3]Erasmus Universiteit-Rotterdam, Rotterdam, Netherlands; [4]Aarhus University, Aarhus, Denmark.

Online retailers throw out food that has not yet expired. This gives rise to the question whether online retailers generate more food waste than online retailers. We focus on the food waste at the retailer which inherently ensues from the logistical set-up. We first provide a theoretical analysis to establish whether throwing out food before expiration indeed results in an increase in food waste, putting online retailers at a disadvantage compared to offline retailers. Next, we numerically compare the food waste of the online retailer with that of an offline retailer. Note that the online retailer has some advantages over offline retailers as well. Online retailers benefit from full control of order picking and the pooling effect. Our numerical experiments suggest that online retail yields less food waste for many products, despite throwing out food before expiration.

Tuesday, 8AM–9:15AM

TA77

M - Texas

Data-driven Behavioral Operations in Services
General Session

Session Chair
Qiuping Yu, Scheller College of Business, Georgia Tech, Atlanta, GA

1 Evidence of The Unintended Labor Scheduling Implications of The Minimum Wage
Qiuping Yu[1], Shawn Mankad[2], Masha Shunko[3], [1]Scheller College of Business, Georgia Tech, Atlanta, GA, [2]Cornell University, Ithaca, NY, [3]University of Washington, Seattle, WA, Contact: qiuping.yu@scheller.gatech.edu
We empirically study the impact of the minimum wage on firms' scheduling practices using a highly granular dataset of wage and work schedule data from 2015 to 2018 for more than 5,000 employees of a national fashion retailer. We estimated that increasing the minimum wage would lead to more workers scheduled per week, but fewer hours per worker, while having a negligible impact on the total labor hours used by the stores. The reduction in weekly hours would not only decrease the total wage compensation per worker but also reduce their eligibility for benefits. We also found that minimum wage increases would lead to less consistent work schedules. For every $1 increase in the minimum wage, these factors corresponded to a loss of welfare that would be equivalent to 11.6% of total wage compensation for an average worker, even when the overall employment at the stores stay unchanged.

2 Managing Multihoming Workers in The Gig Economy
Park Sinchaisri[1], Gad Allon[2], Maxime Cohen[3], Kenneth Moon[2], [1]University of California, Berkeley, Berkeley, CA, [2]University of Pennsylvania, Philadelphia, PA, [3]McGill University, Montreal, QC, Canada. Contact: parksinchaisri@haas.berkeley.edu
Gig economy workers prevalently "multihome" by dynamically allocating their services in real-time between multiple gig platforms. As a growing number of platforms access the same pool of workers to complete their gigs, the question of how workers choose between competing platforms has grown in salience. However, cross-platform multihoming behavior has been difficult to empirically trace and analyze. In this work, we study gig workers' multihoming decisions by using machine learning methods to estimate a structural model from a ride-hailing firm's proprietary data combined with publicly reported trip data. After recovering drivers' heterogeneous costs to work, we perform a number of counterfactual analyses.

3 Augmenting Algorithms with Human Input: Estimating The Value of Private Information with a Large-scale Field Experiment
Saravanan Kesavan[1], Tarun Kushwaha[2], [1]UNC Chapel Hill, Chapel Hill, NC, [2]George Mason University, Fairfax, VA, Contact: skesavan@unc.edu
In this paper, we propose and test a novel method of augmenting managers with algorithms to elicit their private information while minimizing biases and noise present in human judgment. We do so in the context of micro-merchandising decisions at an automotive spare parts retail chain. Our results show that such input augmentation increases profitability by up to 35% compared to the algorithmic automation model, where retail merchants were not involved.

4 Structuring Online Communities
Neha Sharma[1], Gad Allon[2], Achal Bassamboo[3], [1]Northwestern University, EVANSTON, IL, [2]University of Pennsylvania, Philadelphia, PA, [3]Northwestern University, Evanston, IL, Contact: neha.sharma@kellogg.northwestern.edu
We model the community as a multistage stochastic game, where users can ask questions and other more knowledgeable users can answer their questions. We study the users' decisions to join and participate in the community. We link the user participation decisions to the underlying network structure and theoretically show that only a core-periphery network structure can emerge in such communities. We explore community moderation, i.e., the cost of asking questions, as a lever to balance user participation (traffic) and user satisfaction. We find that while a high cost of asking reduces user participation, it improves the proportion of questions answered and consequently, user satisfaction. Finally, we show that number of active users in the community is non-monotonic in the user's cost of asking questions.

Tuesday, 8AM–9:15AM

TA78

M - Utah
Collaborations on Digital Platforms
General Session

Session Chair
Priyanga Gunarathne, University of Pittsburgh, Sewickley, PA

1 Social Media Warfare: Estimating the Extent of Harm (benefit) of Social Media Posts on Company Revenue

Donghwa Bae[1], Jason Chan[2], Tingting Nian[3], [1]University of California, Irvine, Irvine, CA, [2]University of Minnesota, Minneapolis, MN, [3]University of California, New York, NY

While consumers' use of social media to share their experiences with firms exploded recently, little research has empirically measured the effect on business outcomes. This study explores the extent of the harm (benefit) of social media posts on company revenue using the movement against Uber and positive sentiment on Lyft as a natural experiment. Uber faced backlashes due to its opportunistic attempt to capitalize on taxi drivers' protest against refugee ban and an employee's sexual harassment reporting. Meanwhile, Lyft drew support by pledging monetary aid to refugees. We conduct a DiD analysis by contrasting the number of Uber (Lyft) rides to the other ride-sharing companies. We find that the bad (good) social posts hurt (help) Uber (Lyft) business, and our subanalyses reveal that the effect varies depending on the consumers' perception of the incident's severity.

2 Automated Promotion? A Study of the Fairness-economic Tradeoffs in Reducing Crowdfunding Disparities via AI/ML

Lauren Rhue[1], Jessica Clark[2], [1]University of Maryland, Winston Salem, NC, [2]University of Maryland, College Park, MD, Contact: jmclark@umd.edu

Racial disparities in digital platforms result in myriad adverse consequences. Our research explores how to more equitably determine which projects should be promoted by the platform. Because human decisions can be biased, we examine whether an algorithmic-based approach to choosing which projects to promote can generate more equitable while resulting in equivalent economic outcomes. We perform an observational and simulated study on more than 100,000 projects gathered from crowdfunding platform Kickstarter.com to determine whether machine learning models would diversify the set of promoted projects. We find that ML-based models identify a more diverse set of projects to promote, thus diminishing disparities between racial groups. This equitable promotion scheme does not substantially negatively affect core business outcomes for the platform.

3 Prominence Reduction Vs. Banning: An Empirical Investigation of Content Moderation in Online Platforms

Maya Mudambi, University of Maryland

This study focuses on the impact of two types of content moderation strategies- prominence reduction and banning- on verbal aggression. These strategies can induce problematic users to multihome: creating accounts on laxer platforms while simultaneously using the stricter platform. We assess the effects of content moderation on multihoming vs. non-multihoming users.Findings show that prominence reduction has the adverse effect of increasing verbal aggression on a platform. Banning strategies induce multihoming users to decrease verbal aggression; they have no effect on non-multihomers.This suggests that prominence reduction produces negative spillovers, that multihoming has positive externalities, and that the efficacy of banning is limited for non-multihoming users. Future work will assess multihoming behavior on multiple external platforms.

4 Is Fair Advertising Good for Platforms?

Di Yuan[1], Manmohan Aseri[1], Tridas Mukhopadhyay[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: di.yuan@pitt.edu

There is sufficient empirical evidence that some groups, e.g., females, are less likely to see advertisements related to economic opportunities, such as employment ads or education degree program ads. More importantly, such biases in advertisements may not be due to any deliberate discrimination by advertisers. Instead, they may occur due to the nature of ad-auctions. For example, females are very lucrative customers for retailers like Macy's and Target; thus, these retailers place a very high bid in ad-auctions for female impressions and, therefore, win most of these impressions. In this paper, we analyze some popular methods of ensuring fairness in the outcome of ad-auctions on advertising platforms like Facebook. Specifically, we try to understand how these methods of fair advertising affect the incentives and welfare of various stakeholders.

Tuesday, 8AM–9:15AM

TA79

JWM - Room 201

Innovation in Different Industries

General Session

Session Chair

Zhi Chen, National University of Singapore, Singapore, Singapore.

1 Innovating Under Constraints: Open Innovation at SMEs

Cintia Kulzer-Sacilotto, Pascale Crama, Singapore Management University, Singapore, Singapore. Contact: pcrama@smu.edu.sg

Small and Medium Enterprises (SME) are often accused of being too conservative and unwilling to innovate. Nevertheless, as SMEs employ a substantial share of the workforce, policy-makers are keen to increase and support their innovativeness in the face of resource constraints and uncertain returns. We study how and when SMEs can tap on open innovation with publicly funded research centres or commercial partners to invest in R&D. We build a model that explores the impact of budget constraint, risk aversion and multiple partnering options on an SMEs ability to innovate. We provide policy recommendations to increase innovation without distorting incentives to innovate.

2 Persuading Skeptics and Fanatics: Information Design for New Experience Goods

Soudipta Chakraborty[1], Huseyin Gurkan[2], [1]University of Kansas, Lawrence, KS, [2]ESMT GmbH, Berlin, Germany.

Firms launching new experience goods often offer the product to a select group of expert opinion leaders and solicit their reviews. By choosing which experts to solicit reviews from, the firm controls how to publicly disseminate information about product quality to regular customers. Motivated by this phenomenon, we study the information design problem of a firm launching a product of unknown quality to a polarized market consisting of customers who have heterogeneous prior beliefs about quality. Besides the information revealed by the firm, customers can pay a cost and acquire additional information about quality from sources outside of the firm's reach. We use the Bayesian persuasion framework to characterize the firm's optimal information dissemination policy. We also investigate the effect of the additional sources of information on the firm and on the customers.

3 Peer Effects and Learning with New Technology

Deepanshi Bhardwaj[1], Bilal Gokpinar[1], Ashwini Chhatre[2], [1]UCL School of Management, London, United Kingdom; [2]Indian School of Business, Hyderabad, India. Contact: deepanshi.bhardwaj.20@ucl.ac.uk

We investigate peer effects in a knowledge-intensive work setting with individual-based competitive incentives, where service agents are introduced to a new technology. Using a granular data of 5.6 million transactions for 822 banking-service-agents, we find that agents that start working on the new technology with peers have a lower error-rate as compared to those without peers.

4 Learning by Failing: The Effect of Test Reporting on Autonomous Vehicle Training

Zhi Chen, Wenjie Xue, National University of Singapore, Singapore, Singapore. Contact: zhi.chen@nus.edu.sg

Autonomous vehicles (AVs) have great potentials to revolutionize the transportation industry. The success of AVs depends on its access to various real-world driving scenarios. To improve AVs' algorithms, firms send testing vehicles onto public roads to discover those rare complex driving scenarios ("edge cases"). While these edge cases are valuable for AVs' future improvements, they trigger failure of testing vehicles (called disengagement) each time an edge case is discovered. Using a game-theoretic model, we study how disengagement reporting requirements by regulators affects the testing strategies of AV firms.

Tuesday, 8AM–9:15AM

TA80

JWM - Room 202

MCDA: A Highway of Opportunities Lies Ahead!

General Session

Session Chair

Milosz Kadzinski, Poznan University of Technology, Poznan, Poland.

Session Chair

Marco Cinelli, Leiden University, The Hague, Netherlands.

1 Proper and Improper Uses of MCDM Methods in Energy Systems Analysis

Milosz Kadzinski[1], Marco Cinelli[2], Peter Burgherr[3], Roman Slowinski[1], [1]Poznan University of Technology, Poznan, Poland; [2]Leiden University, The Hague, Netherlands; [3]Paul Scherrer Institut, Villigen, Switzerland. Contact: milosz.kadzinski@cs.put.poznan.pl

We evaluate the Multiple Criteria Decision Making (MCDM) methods used in a few tens of case studies performing energy systems analysis. We find that close to 60% of these studies chose an MCDM method that was not the most adequate for the respective decision problem. In particular, this concerned the use of unsuitable weighting methods, sub-optimal selection of MCDA techniques for specific problem statements, improper dealing of different types of performances, and lack of handling of rather evident interactions in preference models. Our analysis demonstrates that these deficiencies can be overcome by using a recently developed methodology and software that support selecting the most suitable MCDA method for a given decision problem.

2 Bargaining over Treatment Choice Under Disagreement

Nabil Al-Najjar, Northwestern University, Evanston, IL

A group of experts with different prior beliefs must choose a treatment. A dataset is made public and leads to revisions of beliefs. We propose a model where the experts' disagreements are resolved through bargaining, using the Nash bargaining solution. Experts bargain after disclosure of the dataset. Bargaining may lead to an inefficient use of information in a strong sense: experts receive a lower payoff in every state, and for any prior belief (i.e., inadmissibility). Bargaining exhibits under-reaction to information as compared to the normative solution in which experts bargain ex ante on the procedure used to exploit the data.

3 The MCDA Methods Selection Software (MCDA-MSS): A Radar for Decision Analysts

Marco Cinelli[1,2], Milosz Kadzinski[2], Peter Burgherr[3], Michael Gonzalez[4], Roman Slowinski[2], [1]Leiden University, The Hague, Netherlands; [2]Poznan University of Technology, Poznan, Poland; [3]Paul Scherrer Institute, Villigen PSI, Switzerland; [4]U.S. Environmental Protection Agency, Ciincinnati, OH, Contact: m.cinelli@luc.leidenuniv.nl

In this research, we study the comprehensiveness of the decision-making features in the MCDA Methods Selection Software (MCDA-MSS), a newly developed system to recommend MCDA methods. This was achieved with three workshops that 20 MCDA analysts attended between April and June 2021. The talk will discuss the added value that the MCDA-MSS can provide decision analysts with, using the software as a radar to navigate the complexities of the selection process of MCDA methods.

4 Resilience/efficiency Tradeoffs and MCDA

Igor Linkov[1], Benjamin Trump[1], Jeffrey Cegan[2], Andrew Jin[3], [1]United States Army Engineer R&D Center, Concord, MA, [2]USACE, Concord, MA, [3]University of Southern California, Los Angeles, CA

I will argue that emphasis on the use of decision analysis to increase efficiency in the operation, management and outcomes of various systems has brought much of the world to rely upon complex, nested, and interconnected systems to deliver goods and services around the globe. While this approach has many benefits, the Covid-19 crisis shows how it has also reduced the resilience of key systems to shocks, and allowed failures to cascade from one system to others. I will discuss options of framing resilience-by-design (a system must be designed to recover its critical functions from disruption on its own) or by intervention (an external resource must be envisioned to enable a system to withstand cascading and systemic disruptions) utilizing decision analytics. I will provide specific recommendations on building resilient systems to address future systemic challenges.

Tuesday, 8AM–9:15AM

TA81

JWM - Room 203

OR/MS in Industry Practice - V

General Session

Session Chair

Srinivas Bollapragada, GE Global Research Center, Niskayuna, NY

1 Inbound Logistics Flows and Consolidation Operations: A Case Study

Mustafa Can Camur, Thanos Aristotelis, Onur Dulgeroglu, Srinivas Bollapragada, General Electric Research Center, Niskayuna, NY, Contact: Can.Camur@ge.com

General Electric (GE) Company's Power business sources parts for its gas turbines from multiple suppliers in Asia. These parts are transported to the USA using multiple modes of transportation including Full Container Load (FCL), Less than Container Load (LCL), and air-transport with varying lead times and costs. We present an optimization model and a novel heuristic approach to develop a parts transportation plan to minimize cost while ensuring that the parts arrive at the destination within their respective deadlines.

2 Optimal Scheduling of Field Resources for Power Plant Outages

Rajeev Namboothiri[1], Srinivas Bollapragada[2], [1]General Electric Research Center, India; [2]GE Research, Niskayuna, NY

GE Power performs periodic maintenance outages at customer power plants to ensure safe and efficient operations. These outages require field resources with specific skillset for a specific duration to perform maintenance tasks. A host of additional constraints restrict the eligibility and availability of field resources for outages. We developed a Field Resource Optimizer product to provide resource scheduling recommendations, minimizing the total cost associated with field service operations. The standard formulation of the field resource allocation problem results in a MILP that is too large to be solved. We developed a novel algorithm that iteratively solves a series of linear programs to achieve the optimal solution within a few minutes.

3 Optimizing Sourcing and Transportation of Wind Turbine Towers

Srinivas Bollapragada, GE Global Research Center, Niskayuna, NY

We will describe an algorithm and a software tool that we had developed for simultaneously generating near-optimal sourcing and logistics plans to procure wind turbine towers from suppliers across the world and deliver them to customer wind-farm sites to minimize the total direct material and logistics costs incurred. GE currently uses this tool for making sourcing and logistics decisions for wind turbine towers.

4 A Discrete-time Model for Batch Scheduling with Downtime and Skilled Labor Constraints in Multipurpose Environments

Ai Zhao, Johnson & Johnson Supply Chain Digital & Data Science, New Brunswick, NJ, Contact: azhao14@its.jnj.com

A discrete-time mixed-integer programming model is developed to schedule multiple batches on machines considering machine downtime and skilled labor. A state-task network representation is used to define tasks and states in multipurpose environments considering batch reentry. Algorithms are developed to accommodate machine downtime in processing time of each task on different machines and sequence-dependent changeover time. The size of the problem is reduced drastically through preprocessing of time sets to improve computational time in respect of sequence and labor. The MIP model based on STN representation is then developed to account for sequence, machine down time, sequence-dependent changeover time and skilled labor. Multiple case studies are used to illustrate the performance of the proposed model.

Tuesday, 8AM–9:15AM

TA83

JWM - Room 205

Optimization Applications

Contributed Session

Session Chair

Sara Amar, Liwa College of Technology, Abu Dhabi, United Arab Emirates.

1 Using Simulated Annealing and Multi-criteria Optimization for Redistricting

Blake Splitter, Matthew J. Saltzman, Clemson University, Clemson, SC, Contact: bsplitt@clemson.edu

Political redistricting is a complicated, multi-faceted process that requires consideration of many different metrics, including district population, compactness, conservation of political boundaries, and voting fairness. To account for these competing metrics, we utilize multi-criteria optimization and simulated annealing to build better political districts automatically. In our efforts to improve maps with respect to multiple objectives, we apply district recombination and precinct flips. By using multi-criteria techniques to gradually improve many maps simultaneously, we can produce many high-quality maps, which can then be candidates for implementation. Recent progress has been focused on refining the algorithm to produce a wider variety of high-quality solutions.

2 Economic Optimization of Lignin Valorization Biorefinery System with Biological Upgrading

Yajie Wu, Juliana Vasco-Correa, Penn State University, State College, PA

Lignin is one of the most abundant polymers with high industrial value. Biological conversion of lignin has developed as a promisingly significant solution for cost-effective lignin valorization. In this study, we develop and analyze the economic lignin valorization system with biological upgrading. We apply a superstructure optimization model to identify the optimal biorefining pathway. Integrated with techno-economic analysis, the objective is to select the optimal feedstock, process, and products derived from lignin to determine the process with the highest profit. The problem is formulated as a Mixed-Integer Programming (MIP) problem. The result presents the deterministic solution of the optimal lignin valorization pathway.The findings from this study will provide insights for mitigating climate change and helping to develop circular economies.

3 Computationally Efficient Sequential Change Detection Rule Under Sampling Constraint

Anamitra Chaudhuri, University of Illinois, Urbana Champaign, Champaign, IL, Contact: ac34@illinois.edu

The problem of sequentially detecting a change in the joint distribution of multiple information sources is considered when it is allowed to sample only a few of them at each time instance. The problem is to stop sampling as quickly as possible after the change while controlling the false alarm rate and without assuming any prior information on the post-change distribution. A simple and computationally efficient joint sampling and change-detection rule is proposed and its asymptotic relative efficiency is derived. Furthermore, it is shown that under some mild conditions this rule achieves the smallest possible worst-case conditional expected detection delay among all processes that satisfy the same constraints, to a first-order approximation as the false alarm rate goes to 0, for any possible post-change distribution.

4 **Fireworks Algorithm Applied to Facility Layout Design**

Sara Amar, Liwa College of Technology, Abu Dhabi, United Arab Emirates. Contact: sara.haddouamar@gmail.com

Facility Layout Design consists of defining the placement of facilities to answer the objectives of the decision maker while respecting several constraints. The focus of this study is the production and environmental criteria of the manufacturing facility. An application using fireworks algorithms is proposed to maximize the production and reduce the carbon footprint of the handling activities.

Tuesday, 8AM–9:15AM

TA84

JWM - Room 206

Simulation Applications in Supply Chain Management

General Session

Session Chair

Canan Gunes Corlu, Boston University, Boston, MA

1 **Using Agent-based Simulation to Design the Automated Parcel Lokers Network in the Last Mile Distribution in an Urban Area: Some Cases Presentation**

Javier Faulin[1], Adrian Serrano[1], Bartosz Sawik[2], Luis Cadarso[3], Angel A. A. Juan[4], [1]Public University of Navarre, Pamplona, Spain; [2]AGH University of Science & Technology, Krakow, Poland; [3]Rey Juan Carlos University, Fuenlabrada, Spain; [4]Technical University of Valencia, Alcoy, Spain. Contact: javier.faulin@unavarra.es

The popularity of e-commerce in the last three years, mainly spurred by the situation of pandemic worldwide, has requested a tremendous tension in the last-mile distribution actions to make the deliveries in the expected time. One of the solutions to this challenge in order to meet deadlines, reduce the environmental impact of the deliveries, and provide a good and standard service, is the use of the Automated Parcel Lockers (APLs). Thus, the use of a suitable APL network improves the last-mile distribution in urban zones by means of the reduction of transportation vehicles, the distances driven, and the delivery stops. Therefore, a bicriteria weighted-sum simulation-optimization model has been designed in order to design the APLs network structure in a generic city, obtaining meaningful results from different scenarios comparison.

2 **Simulating Intermittent-demand Inventory Replenishment for Public Transit System Repair Parts**

John Maleyeff, Yang Yuxin, Jia Fang, Jianbo Jiang, Jingran Xu, Boston University, Boston, MA, Contact: maleyeff@bu.edu

The warehouse that serves the Massachusetts Bay Transportation Authority includes tens of thousands of parts needed for repairs worth tens of millions in US dollars. Repairs can be rare (e.g., once or twice per year) and lead times for their procurement can be long (e.g., up to six months). Because a repair cannot take place until all parts are available, the cost of holding "other" parts must be considered during inventory policy determination. This presentation discusses the use of simulation to support deterministic and stochastic modeling by testing proposed inventory policies. It includes dashboards for performance metrics that balance part shortage delays, inventory holding costs, and other considerations.

3 **Experimental Evaluation of Chance-Constrained Models for a Capacitated Stochastic Production Inventory System**

Srinivasan Balan[1], Reha Uzsoy[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC, Contact: sbalan@ncsu.edu

We consider the problem of planning releases to a capacitated production-inventory system governed by queuing behavior and stochastic demand. We use a non-linear clearing function to represent the queuing behavior of the production system, and a shortfall-based chance-constrained (CC) model to obtain scalable approximate solutions. We use a dynamic adaptive decision rule to implement the results of the CC models and evaluate their performance using simulation.

4 **Dispatching Multi-capability AGVs Using Deep Reinforcement Learning**

Nitish Singh, Alp Akcay, Tugce Martagan, Ivo Adan, Eindhoven University of Technology, Eindhoven, Netherlands. Contact: n.singh1@tue.nl

Heterogeneous tasks, prevalent in the high-tech manufacturing sector, require specialized equipment for material handling. The advancement in AGV technology facilitates different capabilities of AGVs, such as lifting light or heavy loads and towing loads. A fleet of AGVs with varying capabilities can fulfil heterogeneous tasks. We develop artificial intelligence techniques which are shown to extract temporal and spatial patterns for decision making. Their ease of use and their robustness to changes make them an attractive alternative to simple dispatching rules. Thus, we develop an AI-based AGV fleet management algorithm to serve requests where the requests are serviced by a fleet of AGV, which is heterogeneous with a diverse set of capabilities and travel costs. Our algorithm is compared against a simple dispatching rule to prove its superiority.

Tuesday, 8AM–9:15AM

TA86

JWM - Room 208

Challenges in Advanced Air Mobility

General Session

1 **UAV Path Planning Under Weather Uncertainty and Environmental Impact Considerations**

Zhangchen Hu[1], Heng Chen[2], Eric Lyons[1], Senay Solak[1], Michael Zink[1], [1]University of Massachusetts Amherst, Amherst, MA, [2]University of Nebraska-Lincoln, Lincoln, NE, Contact: zhangchenhu@umass.edu

Unmanned aerial vehicles (UAVs) are expected to be widely used in the near future as an alternative transportation mode to mitigate congestion and pollution in a variety of applications. We design a dynamic and data-driven decision support system for UAV path planning through stochastic programming based implementation, where both weather uncertainty and environmental impacts are directly considered.

2 **Network Design for Autonomous Aerial Cargo Operations**

Geoffrey Ding, Hamsa Balakrishnan, Massachusetts Institute of Technology, Cambridge, MA

With the advent of advanced air mobility, passenger and cargo transporters alike must design their systems to fulfill customers' needs. As these systems are yet to be established, we contend that their implementation can and should consider factors beyond solely efficiency; these include, but are not limited to, privacy, noise, and reliability. We present a framework for system design based on existing demand information. Then, we discuss how the desire for network resilience may impact network design. Finally, we consider how the characteristics of different aircraft in a fleet may affect facility location.

Session Chair

Christopher Chin, Massachusetts Institute of Technology, Cambridge, MA

3 **Mechanisms for Cooperative Routing of Unmanned Aerial Vehicles**

Victor Qin, MIT, Cambridge, MA

Current FAA conceptions for the management of unmanned aerial vehicles (UAVs) proposes that private Unmanned Service Suppliers (USSs) will provide air traffic management and routing services for operators of UAVs in geographical areas. However, USSs will have to cooperate to safely route UAVs for which the origin and destinations are in different USS jurisdictions. Lax governance of inter-USS relationships can lead to byzantine traffic management scenarios, as evidenced by the complexity of bilateral peering relationships for Internet traffic routing. Instead, cooperation among USSs can be facilitated by revenue sharing mechanisms (particularly the Shapley Value) that encourage interconnection. We propose different revenue sharing models for USSs and investigate how these models affect individual revenues under different traffic patterns.

4 **AMU-LED: Integration and Demonstration of the Advanced Air Mobility System**

Arinc Tutku Altun, Cranfield University, Bedford, United Kingdom.

The current air transportation system is expected to transform into a more flexible, agile, accessible, dense, and integrated system to all users and extend its service capabilities to underserved/not-served areas under the vision of the Advanced Air Mobility (AAM) concept. Integrating diverse platforms and technologies under AAM system considering various topics such that infrastructure, technology, regulations, social and environmental impact, safety, resiliency, sustainability and making it a reality is not trivial. AMU-LED project deals with analysing, testing, and demonstrating the feasibility, integration, and development of the AAM concept. The purpose of the project is to explore the AAM itself and its use cases through co-simulations consist of real and simulated standard and high-performance vehicle (SPV & HPV) flights, manned and general aviation flights. This study focuses on the integration considerations of the AAM and outputs of the AMU-LED demonstrations at Cranfield University.

Tuesday, 8AM–9:15AM

TA87

JWM - Room 209

Applications of ML/OR in Supply Chain Risk Management and Agility

Panel Session

1 **Moderator**

Masoud Chitsaz, Kinaxis, Ottawa, ON, Canada.

Supply chains had to deal with many global disruptions during the last three years. Businesses had to carefully manage the risks and efficiently plan for their supply chain operations. Now more than ever, advanced analytics methods are being used in supply chain management. In this panel, we will discuss applications of machine learning and operations research in reducing the risk in supply chain management and making supply chains more agile.

2 **Panelist**

Anne G. Robinson, Kinaxis, Ottawa, ON, Canada.

3 **Panelist**

Warren Hearnes, Best Buy, Lilburn, GA

4 **Panelist**

Prabha Thanikasalam, Flex, Austin, TX

5 **Panelist**

Elcin Cetinkaya, Expedia Group, Seattle, WA

Tuesday, 9:45AM–10:45AM

TP

CC - Sagamore 5

Plenary: Patrick Jaillet

Plenary Session

Session Chair

Enver Yucesan, INSEAD, Singapore, NA, Singapore.

1 **Online Optimization and Learning for Sequential Decision-Making**

Jaillet Patrick, Massachusetts Institute of Technology, Cambridge, MA

resources allocated with incomplete knowledge of the future. It is not clear in this setting how to measure the quality of a proposed decision strategy. Online optimization compares the performance of a strategy that operates with no knowledge of the future (on-line) with the performance of an optimal strategy that has complete knowledge of the future (off-line). In some cases, probabilistic information about the future may be available or learned. In this talk, we provide an overview of some results obtained from that perspective on various classical sequential decision-making problems.

Tuesday, 11AM–12:15 PM

TB01

CC - Room 101

Accountable Algorithms and Social Justice

General Session

Session Chair

Brittany Green, University of Louisville, Louisville, KY

1 **Studying and Fixing Algorithmic Racial Bias in Medical Appointment Scheduling**

Michele Samorani, Santa Clara University, Santa Clara, CA

In an effort to increase clinic efficiency, state-of-the-art scheduling algorithms use patients' individual no-show predictions when scheduling medical appointments. By combining in such way machine learning and optimization, though, these algorithms inevitably result in undesirable racial disparities, because patients' race tend to be correlated with their no-show risk. Published and ongoing work shows, for example, that black patients are disproportionately placed in overbooked appointment slots, or that they are scheduled farther in the future than the rest of the patients. In this talk, I will give an overview of recent working and published papers that study and attempt to fix racial disparity in appointment scheduling.

2 **In Theory Not Practice: How Highlighting Equity Can Reduce It**

Lauren Rhue, University of Maryland, College Park, MD, Contact: lrhue@umd.edu

This paper asks, *what is the effect of equity-related platform interventions on donation behavior?* First, we examine how launching a new project attribute, "equity-focused", that identifies projects from schools in traditionally marginalized communities, affects donations. Second, we conduct an experiment in which donors were randomly assigned to receive emails with random or equity-focused projects. In both, the relative support for projects at equity-focused schools declined. We find that explicitly mentioning equity decrease donations to traditionally marginalized communities. This project contributes to the understanding of using digital platforms to address offline social inequalities.

3 On The Substance (or Lack Thereof) of Algorithms

Tayo Fabusuyi[1], Michael P. Johnson[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Massachusetts Boston, Boston, MA

Algorithms are rarely, if ever, value free and this shortcoming has significant implications for social justice. Could an OR approach that emphasize the context specific nature of the situation for which the algorithm is being deployed address this issue? We argue that the use of soft OR methodologies has the potential to bridge this gap and illustrate our approach using real life examples.

4 Social Justice, Marginalized Groups, and Mitigation Strategies: A Longitudinal Examination of Algorithmic Bias on Online Labor Markets

Brittany Green, Rui Sundrup, Manju K. Ahuja, University of Louisville, Louisville, KY, Contact: b0gree10@louisville.edu

Nearly 33 percent of workers surveyed from 19 countries rely on online labor markets (OLMs). Although general evidence of biases in OLMs exists, developing a nuanced understanding of the interaction among individual characteristics and AI sources of biases could provide guidance for designing OLMs that minimize the detrimental impact of such biases on marginalized social groups. Given this, our first objective is to examine the joint influence of individual characteristics and AI sources of bias in OLMs. The second objective of the study is to examine the longitudinal effects of these biases. Finally, we seek to empirically examine the role of a algorithmic audits in managing OLM bias in the short- and long- term. To investigate these questions, we build an agent-based simulation model (ABM) that implements an OLM with an AI matching algorithm using existing data.

Tuesday, 11AM–12:15 PM

TB02

CC - Room 102

Advances in Data-driven Decision Making in Operations Management

General Session

Session Chair

Yonggab Kim, 1</sup

1 A Multi-agent Reinforcement Learning for Horizontal Inventory Transshipments Under Non-stationary Customer Demand and Supply Capacity Loss

Byeongmok Kim, Jong Gwang Kim, Seokcheon Lee, Purdue University, West Lafayette, IN, Contact: kim3453@purdue.edu

Long-term disruption has simultaneously amplified uncertainties in customer demand and supply capacity loss. In order to make the supply chain adapt to the disruption, this study proposes a Decentralized Horizontal Inventory Transshipment System (DHITS). The DHITS utilizes a fictitious agent to determine horizontal inventory transshipment decisions between retailers behalf of them. Using the fictitious agent, we convert a jointly-managed horizontal inventory transshipment system to a decentralized one, reducing the number of dimensions in state-action space. Furthermore, to effectively learn the optimal inventory management policy for the DHITS, we propose a new multi-agent reinforcement learning algorithm called the Hetero-Maximax Q-learning.

2 A Hybridization of DNN-based Meta Model and Tabu Search for Single Intersection Traffic Signal Optimization

Seungyeop Lee[1], Younghoon Shin[2], Byung-In Kim[1], Donggu Choi[1], [1]Pohang University of Science and Technology (POSTECH), Pohang, Korea, Republic of; [2]Shinhan Card, Seoul, Korea, Republic of. Contact: sylee1509@postech.ac.kr

Smart traffic signal control can reduce traffic congestion, an important issue for smart city transportation planning. Simulation-based optimization approaches using microscopic simulators have been widely used to find efficient traffic signal patterns with consideration of realistic intersection characteristics such as intersection shape, number of lanes, connection between roads, and minimum crosswalk time. However, the approaches are difficult to apply in real-time environments because they require many time-consuming simulation runs. To overcome the computational cost of simulation-based optimization, we propose a hybrid approach, in which a deep neural network-based meta model is used to find a good initial solution and a tabu search to improve it. The proposed approach can be applied to any intersections with arbitrary topology and traffic demand.

3 DeepBike: A Deep Reinforcement Learning Based Model for Large-scale Dynamic Bike Share Rebalancing

Zhuoli Yin, Zhaoyu Kou, Hua Cai, Purdue University, West Lafayette, IN, Contact: zhuoliyin@purdue.edu

Bike share system (BSS) is an emerging environment-friendly mobility mode. BSS operators need to redistribute bikes among stations by rebalancing vehicles to accommodate imbalanced bike demands. Existing studies mainly generate rebalancing solutions from mixed-integer programming or heuristic methods. However, they are only designed for and evaluated on small-scale BSSs with small-size rebalancing fleets. How to produce real-time rebalancing solutions for large-scale BSS with multiple vehicles to minimize customer loss is still unsolved. We propose a deep reinforcement learning based model that trains a designed deep Q-network to learn the optimal strategy for dynamic bike share rebalancing. The evaluation results show that our proposed model outperforms the existing methods in reducing customer loss by 9.57% and improving the overall profits by 37.13%.

4 Conflict Resolution in Drone Delivery Problem

Yonggab Kim, Purdue University, WEST LAFAYETTE, IN, Contact: yonggabkim7@gmail.com

Drones operating in the current drone delivery system face a small amount of traffic. However, as the drone delivery system becomes popular as a last-mile delivery solution, the drone delivery operation will likely involve a larger volume of drone traffic. The drone traffic control system to manage a large number of drones becomes essential for operational efficiency and safety. This study proposes a new mathematical model to optimize the drone delivery system considering the drone's conflict resolution. A more realistic examination of operation cost and delivery time considering drone collisions is derived.

Tuesday, 11AM–12:15 PM

TB03

CC - Room 103

Machine Learning in Manufacturing Systems

General Session

Session Chair

Ali Kamali Mohammadzadeh, Detroit, MI

1 Physics-based Layer Time Optimization in Large Scale Additive Manufacturing

Lu Liu[1], Feng Ju[1], Eonyeon Jo[2], Seokpum Kim[2], [1]Arizona State University, Tempe, AZ, [2]Oak Ridge National Laboratory, Oak Ridge, TN

In the Large-Scale Additive Manufacturing (LSAM) printing process, over-cooled and heated surfaces usually cause quality issues. To avoid unnecessary cost during manufacturing, the optimal layer time needs to be considered carefully. Instead of using expensive experimental printing data and time-consuming FEA based simulation, this project intends to generate temperature cooling data by applying a simplified physics-based activation model for each given fixed layer time. The layer time optimization model will be performed to update the fixed layer time until layer time between fix and optimal converges.

2 An AI Driven Virtual Reality Platform for Human Robot Interaction

Ali Kamali Mohammadzadeh, WSU, Detroit, MI, Contact: alikamali@wayne.edu

In this study, by integrating a physics-based Unity model with Room-scale technology, a virtual reality-based immersive platform for human-robot interaction (HRI) is presented. The proposed platform provides an opportunity for safe data collection, to be fed into deep neural networks for intention classification and trajectory prediction.

3 A Machine Learning-Based Recommender System for CT-Scanner Parameter Selection

Neda Sayahi, Detroit, MI

Predicting Scan Quality: an ML-based Recommender System for CT-Scanner Parameter Selection: In this work, an ML-based recommender system for CT scanner parameter selection is proposed to recommend the scan parameters based on an ML model for scan feasibility prediction. The accuracy of four ML methods on predicting scan feasibility, given a set of parameters, are compared. The results indicated that multi-layer perceptron predicted the quality of scan with high accuracy and outperformed the other methods. Since multi-layer perceptron does not explain why the prediction model behaves the way it does, a game theoretic approach is utilized to explain the predictions provided by the model.

4 A Novelty Detection Based Monitoring Framework for Connected Vehicle Systems Under Imperfect Data

Mohammad Badfar, Ratna Babu Chinnam, Murat Yildirim, Hadi Abbas, Wayne State University, Detroit, MI, Contact: mohammadbadfar@wayne.edu

Shrinking product development cycles and increasing complexity of vehicles necessitate a new generation of monitoring and diagnostic algorithms that can demonstrate more autonomy and adaptivity. The architecture for the monitoring and diagnostic analytics pipeline should vary depending on the nature of the target system and the availability of sensors and data acquisition scheme. Conventional approaches, which make strict assumptions on data fidelity and failure ground-truth availability, face challenges in modern connected vehicle applications. We present the results for a novelty detection based autonomous monitoring framework that flags anomalies under sparse data and minimally labeled information from warranty-claims. Results from applying the proposed framework to 12-volt battery systems employed by different vehicle model lines are promising.

Tuesday, 11AM–12:15 PM

TB04

CC - Room 104

Coordinated Energy-information systems Integration Toward Low-carbon Future

General Session

Session Chair

Zhaohao Ding, 1</sup

Session Chair

Jianxiao Wang, 1</sup

1 E-scooter Rebalancing with En Route Charging Capability

Xiangyu Jin[1], Yufeng Cao[2], Yu Yang[3], [1]Shanghai Jiao Tong University, Shanghai, China; [2]Shanghai Jiao Tong University, [3]University of Florida, Gainesville, FL

E-scooter sharing systems have been emerging as an important part of shared mobility services. However, the growing fleet in an e-scooter sharing system imposes great challenges in the rebalancing and recharging for the system operator. In this work, we consider a novel approach to handle this issue and propose a mathematical optimization model to solve the problem. Using a truck equipped with battery charging capability, the system operator jointly makes the routing, waiting, and handling decisions in an e-scooter network. We formulate the integrated decision problem as a two-stage mixed-integer linear program. We show that the second stage of the problem can be solved efficiently by solving a linear program. We propose an effective algorithm to solve the integrated decision problem based on Benders decomposition. We validate our framework with numerical experiments.

Tuesday, 11AM–12:15 PM

TB05

CC - Room 105

Integrative Data Analysis in Operations Research

General Session

Session Chair

Kaizheng Wang, Columbia University, New York, NY

1 Overparameterized Learning Beyond The Lazy Regime

Mahdi Soltanolkotabi, University of Southern California, Los Angeles, CA

This talk focuses on demystifying the generalization and feature learning capability of modern overparameterized learning where the parameters of the learning model exceed the size of the training data. We will discuss our results for a variety of problems including asymmetric low rank reconstruction from a few measurements, linear neural networks and improved results for one-hidden layer neural nets with ReLU activations. Our result is based on an intriguing spectral bias phenomena for gradient descent, that puts the iterations on a particular trajectory towards solutions that are not only globally optimal but also generalize well. Notably this analysis overcomes a major theoretical bottleneck in the existing literature and goes beyond the "lazy" training regime which requires unrealistic hyperparameter choices (e.g. large initialization or wide models).

2 Statistical Perspectives on Federated Learning

Yuekai Sun, University of Michigan, Ann Arbor, MI, Contact: yuekai@umich.edu

We consider the federated learning problem from a statistical perspective. In particular, we consider the specification of global parameters in high-dimensional federated learning problems. We show that improperly specified global parameters may negate the statistical benefits of federated learning and explore alternative specifications (of global parameters) that avoids this issue.

3 A No-free-lunch Theorem for Multitask Learning

Steve Hanneke, Purdue University, West Lafayette, IN

Multitask learning addresses the setting where datasets from N related distributions P_t are to be combined towards improving performance on a target distribution D. A perplexing fact remains in the evolving theory on the subject: while we would hope for performance bounds that account for having more tasks, the vast majority of analyses result in bounds that improve at best in the number n of samples per task, but most often do not improve in N. We show there is good reason for this. Even in a seemingly favorable scenario where all tasks P_t share a common optimal classifier h*, and admit favorable *oracle rates* in terms of N and n, we show that no adaptive algorithm exists that can guarantee rates that improve with large N for n fixed. However, with additional information about relevance of each P_t to target D, we propose a simple rank-based procedure that achieves an optimal rate in N and n.

4 Analysis of Information Transfer from Heterogeneous Sources Via Precise High-dimensional Asymptotics

Hongyang Zhang, Northeastern University, Boston, MA, Contact: ho.zhang@northeastern.edu

We consider the problem of transfer learning -- gaining knowledge from one source task and applying it to a different but related target task. A fundamental question is whether combining the data of both tasks works better than using only the target task's data, i.e., whether a positive information transfer happens. We study this question in a linear regression setting where a two-layer linear neural network estimator combines both tasks' data. The estimator uses a shared parameter vector for both tasks and exhibits positive or negative information transfer by varying dataset characteristics. We characterize the precise asymptotic limit of the prediction risk of the above estimator in a high-dimensional setting. Then, we provide the exact condition to determine positive and negative information transfer in a random-effect model, leading to several theoretical insights.

Tuesday, 11AM–12:15 PM

TB06

CC - Room 106

Discovery of Causality in Physical Systems

General Session

Session Chair

Hyunwoong Ko, Mesa, AZ

1 CASUAL INFERENCE-BASED ANOMALY DETECTIOn and DIAGNOSIs for MELT POOL MONITORINg in LASER POWER BED FUSION

Jaehyuk Kim[1,2], Yan Lu[3], [1]Ph.d student/Pohang University of Science and Technology, Pohang, Korea, Republic of; [2]Associate/National Institute of Standards and Technology, Gaithersburg, MD, [3]Group leader/National Institute of Standards and Technology, Gaithersburg, MD, Contact: jaehyuk.kim@postech.ac.kr

Laser Powder bed fusion (LPBF) is one of the promising additive manufacturing methods for building 3D metal parts. Despite the advanced development of LPBF, process stability and part quality have been continually issued. To investigate the status of LPBF, melt pool monitoring (MPM)-based studies have been performed. However, the previous studies focused only on detection tasks that find abnormal melt pools related to unstable processes or low part quality. They are limited to interpreting and providing the abnormal melt pools ' causes that can be controlled for high part quality. To address this limitation, we propose a casual inference-based anomaly detection and diagnosis model. First, we introduce a structural causal graph for MPM. Second, we design a causal inference-based deep learning model. Lastly, we find the cause of the anomaly with the attention mechanism.

2 Explainable Machine Learning for Causality Analytics in Additive Manufacturing - a Review

Hyunwoong Ko, Arizona State University, Mesa, AZ, Contact: hyunwoong.ko@asu.edu

Machine learning (ML) provides additive manufacturing (AM) with high potential to extract newfound knowledge on the causality between its complex, dynamic, manufacturing processes and their impacts on the quality of the manufactured products. However, ML often leads to "black-box" models, which results in uncertainty regarding how ML extracts the causal knowledge. To tackle the challenge, this study addresses extraction of the causality from ML models for AM in the viewpoint of explainable AI. Specifically, this study focuses on a literature review to identify related methods and their potential in extracting the causal knowledge from real-world data and fusing it with a priori, physics knowledge for AM. This study casts light on ML for extraction of causal knowledge on complex, physical processes and transfer of the knowledge for various cyber-physical systems.

3 A Dynamic and Physical Shop-floor Model Based on Bricks and Smart Hubs for Education and Research

Yosep Oh, Kyonggi University, Suwon, Korea, Republic of.

Contact: yosep.oh@kgu.ac.kr
This presentation provides what a dynamic shop-floor model is and how it is implemented based on LEGO bricks and smart hubs. In addition, the presenter introduces how the physical shop-floor model can be used for education and research. A dynamic shop-floor model, also known as a GBC (Great Ball Contraption), is a machine that moves some balls from one module to another module. A capstone design class at Kyonggi University adopted the dynamic shop-floor model as an education tool. Over 70 students studying industrial engineering participated in this class and implemented 18 dynamic shop-floor models. Moreover, the presenter shows a research topic using the dynamic shop-floor models. The topic is automatically collecting manufacturing data based on multi-object tracking algorithms.

4 Quantum Deep Learning-based Fault Detection and Classification

Hyunsoo Lee, Kumoh National Institute of Technology, Gumi, Korea, Republic of. Contact: hsl@kumoh.ac.kr
Quantum computing and relevant technologies have changed contemporary optimization techniques and industrial engineering areas rapidly. In this manner, a number of optimization solvers have tried to embed relevant quantum computing techniques. This study shows how a type of quantum computing and quantum deep learning can be applied in fault detection and classification (FDC) areas. An industrial FDC example is provided, and quantum computing-based approach is compared with the existing statistical / machine learning techniques.

Tuesday, 11AM–12:15 PM

TB07

CC - Room 107

Operational Analytics: Exploring the Last Mile in an Organization’s Journey in Business Analytics

General Session

Session Chair

Benjamin T. George, University of Toledo, Toledo, OH

1 Innovative Heuristics to Improve The Latent Dirichlet Allocation Methodology for Textual Analysis and a New Modernized Topic Modeling Approach

Jamie T. Zimmermann, Lance Champagne, John Dickens, Air Force Institute of Technology, Dayton, OH, Contact: jamie.zimmermann@afit.edu
Topic modeling empowers managers with insight into unstructured textual data. Different topic modeling techniques have been developed and each require the user to provide inputs that can distort the output. Paradoxically, this requires the user to have prior insight into the data. To mitigate this paradox, we developed a novel process called the Zimm Approach. Our method employs a Coherent Utility Process to create a robust stopwords list, providing a better input to the model. This occurs during the preprocessing step of topic modeling. Once complete, the Zimm approach next utilizes eigenvalues to estimate the number of topics and the curvature of the loadings plot to determine how many words per topic. The Zimm Approach produces a more stable output without requiring the user to apriori select the number of topics nor the number of terms associated with each topic.

2 Operational Analytics: Exploring The Last Mile in An Organization’s Journey in Business Analytics

Benjamin T. George[1], Bart Hanus[2], [1]University of Toledo, Toledo, OH, [2]University of South Dakota, Vermillion, SD, Contact: benjamin.george3@utoledo.edu
Operational Analytics is a term that is growing in use in the academic and professional lexicon. This study explores the extant academic and professional literature to chronicle the term “Operational Analytics” usage and growth. Text mining techniques are applied to unstructured data from academic publication abstracts to investigate their underlying characteristics. Results and future directions will be discussed.

3 Big Data Analytics and Blockchain for Operational Efficiency

Md. Golam Kibria, Benjamin T. George, Vatsal Paghadal, Universtiy of Toledo, Toledo, OH
Firms generate a huge amount of operational data every day. These data contain insights. To get insights, firms invest in big data analytics (BDA). BDA using statistical models provides valuable insights to operational managers. However, big data pose some challenges such as data security and privacy issues and data sharing, which are detrimental to operational efficiency. These challenges faced by big data can be eliminated by the unique characteristics of blockchain technology such as decentralized storage, immutability, transparency, and consensus mechanism. This paper aims to investigate how big data analytics and blockchain can achieve operational efficiency in a synergistic way.

Tuesday, 11AM–12:30 PM

TB09

CC - Room 109

DAS Flash-Talks II

Flash Session

Session Chair

Eric Specking, University of Arkansas College of Engineering, Fayetteville

1 Optimal Dynamic Mechanism Under Customer Search

Yangge Xiao, National University of Singapore, Singapore, Singapore. Contact: yangge_xiao@u.nus.edu

This paper investigates the seller's revenue maximizing mechanism in face of a customer who searches for outside alternatives over a finite horizon. Under a customer's general recall function, we show that it is optimal for the seller to offer a menu of American options. When the customer can only recall a few recent outside alternatives, we further establish that the optimal mechanism converges to a posted price mechanism as the number of search opportunities increases to infinity. On the other hand, in the extreme case when the search cost exceeds the average value of outside alternatives, our optimal mechanism reduces to making a single exploding offer with monopoly price.

2 A New Algorithm for Real-time System Monitoring

Mingfei Li[1], Kai Huang[2], Jiaying Weng[1], Chao Wang[1], [1]Bentley University, Waltham, MA, [2]Florida International University, Miami, FL

There has been a consistent interest to use Artificial Intelligence (AI) algorithms for system monitoring automatically. For example, monitoring various infectious viruses is a routine task for officials in public health. In this study, we will propose a new AI algorithm as a decision support tool for real-time system monitoring. We generalize a published method for a single change to an adaptive learning process. Finally, we combine this new process and Hannan's type strategy to propose a new online learning algorithm to provide real-time monitoring of a system. In this study, we used both simulations and real data of influenza surveillance from the World Health Organization (WHO).

4 Herding in Probabilistic Forecasts

Ville Satopaa, INSEAD, Paris, France.

Under strong levels of herding, disclosure of public information may lower the accuracy of experts' point forecasts. In this work, we consider probabilistic forecasts under herding, find a closed-form expression for the first two moments of a unique equilibrium forecast, and show that the experts report too similar locations and inflate the variance of their forecasts due to herding. Furthermore, we show that the negative externality of public information no longer holds. Finally, we consider a one-shot setting with one forecast per expert and show that our model is identifiable up to an infinite number of solutions based on point forecasts, but up to two solutions based on probabilistic forecasts.

5 Designing a Research Study to Inform Management Decisions for Waterfowl and Wetlands

Marjorie R. Liberati, Scott R. Winterstein, David R. Luukkonen, Michigan State University, East Lansing, MI, Contact: LiberatiM@michigan.gov

Water control structures create wetland habitat for wildlife but are expensive to maintain, and many are past their intended lifespans in Michigan. Michigan's Wildlife Division wants to understand the wildlife and recreational benefits of managed wetlands so they can make strategic management decisions. Waterfowl and wetland experts participated in a decision analysis workshop to clarify their management challenges, identify and prioritize factors influencing decisions, and clarify uncertainties. The workshop informed a study design to evaluate waterfowl and recreational use of managed wetlands; fieldwork which is ongoing and that will be integrated into a decision-support tool.

6 An Equivalence Between Competitive Prediction Schemes and Fair-division Mechanisms

Rupert Freeman[1], David M. Pennock[2], Jennifer Wortman Vaughan[3], Jens Witkowski[4], [1]University of Virginia, Charlottesville, VA, [2]Rutgers University, Plainsboro, NJ, [3]Microsoft Research New York City, New York, NY, [4]Frankfurt School of Finance & Management gGmbH, Frankfurt Am Main, Germany. Contact: freemanr@darden.virginia.edu

We draw a mathematical equivalence between the class of allocation mechanisms for divisible goods studied in the context of fair division and the class of weakly budget-balanced wagering mechanisms designed for eliciting probabilities. The equivalence leads to theoretical advances and new practical approaches for both probability elicitation and fair division. In this talk, I will focus on the implications of interpreting strategy-proof allocation mechanisms without money as wagering mechanisms based on proper scoring rules. In particular, I will show how the equivalence can be used to strengthen previous characterizations of the fair division mechanism design space.

7 Modeling Driver-behavior Based on Inverse Reinforcement Learning

Qiong Hu, University of Colorado Denver, Denver, CO

Inverse reinforcement learning enables us to comprehend how drivers make the optimal decisions under various driving conditions. We can evaluate the relationship between the action and risk-related factors from a decision-making viewpoint by extracting the reward function. Furthermore, the reward function can be implemented in reinforcement learning to assist drivers in determining the best decision on the road, given the driving conditions.

8 Scalar Equilibria for Normal-Form Games

Herbert W. Corley, The University of Texas at Arlington, Arlington, TX, Contact: corley@uta.edu

A scalar equilibrium (SE) is an alternative equilibrium concept for an N-person normal-form game. An SE assigns pure strategies to the players by maximizing an appropriate utility function, and no player can increase this maximum value by changing strategies. SEs are formally defined, and examples are given. In a greedy SE, the players want the largest possible individual payoffs. In a compromise SE, the players want fair payoffs. In a parity SE, the players want equal payoffs. In a satisficing SE, each player wants a target payoff level. In a weighted SE, each player contributes specified degrees of his own payoff to the others. These SEs are Pareto optimal and computable in linear time complexity.

9 Flash Paper

Abraham Sen, [1</sup]

Tuesday, 11AM–12:15 PM

TB10

CC - Room 110

Reinforcement Learning for OR

General Session

Session Chair

Zhiwei Qin, DiDi Labs, San Jose, CA

1 A Contextual Multi-armed Bandit Framework for Decision Support in Target Search Application

Carlos Hurtado, M. Amin Rahimian, University of Pittsburgh, Pittsburgh, PA, Contact: CAH259@pitt.edu

Reinforcement learning (RL) can be applied to target search tasks to learn optimal policies by obtaining feedback from environments after many episodes; however, when applying RL to mission-critical applications one does not have the luxury of learning from m examples. Thus, we propose an online contextual multi-armed bandit algorithm to decide the best direction of movement during a target search task. The agent has to learn the best direction of movement using the binary signals provided by the environment, subject to noise and uncertainty. We use a generalized linear model that maps the context into a binomial random variable and analyze the performance of Thompson sampling to choose the best direction of movement at each epoch. We supplement our online algorithm with regret guarantees as a function of the search environment and the agent's sensing capabilities.

2 Reinforcement Learning for Active Screening of Recurrent Infectious Diseases

Han-Ching Ou, Haipeng Chen, Jabbari Shahin, Milind Tambe, Harvard University, Cambridge, MA, Contact: hpchen@seas.harvard.edu

Recurrent infectious disease is a type of infectious disease that can be re-infected after being cured. Examples are Influenza and Tuberculosis. These transmissive diseases pose huge threats to human life's quality and safety. Active screening, or contact tracing, has been a major method to fight against the spread of transmissive diseases. However, the screening resources are usually limited, and therefore only a subset of people will be selected for screening. In this talk, I show how this active screening problem is formulated as a sequential stochastic combinatorial optimization problem, which is challenging because of stochasticity, sequential decision-making, and its combinatorial nature. Then, I present a novel reinforcement learning solution to it, where the key idea is a technique that I call "sequence-of-sequence" decomposition.

3 Data-pooling Contextual Bandit with Application to Treatment Program Allocation in Criminal Justice

Shanwen Pu[1], Xinyun Chen[2], Pengyi Shi[3], [1]Shanghai University of Finance and Economics, Shanghai, China; [2]Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [3]Purdue University, West Lafayette, Contact: 2019212802@live.sufe.edu.cn

We investigate personalized intervention for treatment program allocation in criminal justice via reinforcement learning. In particular, we apply contextual bandit to assign personalized interventions according to individual features. To deal with model misspecification and improve sample efficiency, we develop a data-pooling method for contextual bandit with provable reduced regret bound.

Tuesday, 11AM–12:15 PM

TB11

CC - Room 111

Making Sense of AI

General Session

Session Chair

John Lalor, University of Notre Dame

1 Survival of The Fittest: How Does Recession Influence Firm Patent Activity?

Zhaoqi Cheng, ALLSTON, MA

How do business cycle influence innovation production? Common wisdom stipulates that companies speed up breakthrough innovation during the economic downturn while others suggest firms turn to monetizable, combinational innovations. To answer the question, we merge firms' SEC filings with PatentsView data since 1976 from the US Patent and Trademark Office. When then compare financial and patent profiles of firms across different sectors, and document changes in terms of patent significance, volume and direction after the recession.

2 Fast Sparse Classification for Generalized Linear and Additive Models

Jiachang Liu[1], Chudi Zhong[2], Margo Seltzer[3], Cynthia Rudin[4], [1]Duke University, Durham, NC, [2]Duke University, Durham, NC, [3]University of British Columbia, Vancouver, BC, Canada; [4]Duke University, Durham, NC, Contact: jiachang.liu@duke.edu

We present fast classification techniques for sparse generalized linear and additive models. The techniques can handle thousands of features and thousands of observations in minutes, even in the presence of many highly correlated features. For fast sparse logistic regression, our speed-up over other best-subset search techniques owes to linear and quadratic surrogate cuts for the logistic loss that allow us to efficiently screen features for elimination, as well as use of a priority queue that favors a more uniform exploration of features. As an alternative to the logistic loss, we propose the exponential loss, which permits an analytical solution to the line search at each iteration. Our algorithms are generally 2 to 5 times faster than previous approaches. They produce interpretable models that have accuracy comparable to black box models on challenging datasets.

3 Let Clickstream Talk: A Graph Neural Network Approach to Sales Forecasting

Zihan Chen[1], Rong Liu[2], Feng Mai[1], Xuying Zhao[3], [1]Stevens Institute of Technology, Hoboken, NJ, [2]Stevens Institute of Technology, Hoboken, NJ, [3]University of Notre Dame, Notre Dame, IN, Contact: zchen61@stevens.edu

Clickstream data contains comprehensive records of how customers interact with e-commerce platforms and can provide valuable insight into their purchasing behavior. However, research on how best to use it to forecast sales is rather limited. We propose a novel graph neural network (GNN) that incorporates the history of product sales and cross-product association. By representing the relationship between products using a graph structure, GNN learns patterns from each product and its related products. Furthermore, our model includes static and dynamic attention mechanisms that capture both long-term and short-term relationships between products. We show that our model outperforms benchmarks on a real-world dataset, and we provide an intuitive interpretation of how forecasts are made.

4 On-the-fly Difficulty Estimation for Deep Neural Networks

John Patrick Lalor, University of Notre Dame, Notre Dame, IN

Deep learning models perform very well across a wide variety of tasks. However, they are susceptible to over-confidence and to being tricked by out-of-domain or adversarial examples. In this work, I propose a joint learning framework for example class and example difficulty. This framework combines supervised learning with methods from psychometrics. An amortized encoder allows for estimating the difficulty of previously unseen examples. This way the classifier can focus on correct classification, and the difficulty estimator outputs a clearly interpretable difficulty value. I empirically evaluate the framework across several tasks, including outlier detection, adversarial example detection, and confidence calibration.

Tuesday, 11AM–12:15 PM

TB12

CC - Room 113

ISR Solution Approaches and Game Theoretical Models for Security

General Session

Session Chair

Manish Bansal, Virginia Tech., Blacksburg, VA

Session Chair

Sunghoon Park, 1</sup

1 **Strategic Allocation of Heterogeneous Resources for Network Security**

Bobak McCann[1], Mathieu Dahan[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: bmccann6@gatech.edu

We consider a network inspection game, in which a defender positions heterogeneous detectors according to a probability distribution in order to detect multiple attacks caused by a strategic attacker. We assume the defender has access to multiple types of detectors that can potentially differ in their accuracy and cost, and that the attacker has access to multiple types of attack units that can potentially differ in their effectiveness. The objective of the defender (resp. attacker) is to minimize (resp. maximize) the expected number of undetected attacks. We provide a polynomial algorithm to compute Nash Equilibria for this game under the assumption that each component in the network can be monitored from a unique detector location. Then, we determine the optimal detector investment for the defender that guarantees a target detection level in the worst case.

2 **Optimal Location of Rapid-Response Teams: An Application of Game Theory and Location Theory to Counter-Terrorism**

Lotte van Aken[1], Loe Schlicher[1], Marco Slikker[2], [1]Eindhoven University of technology, Eindhoven, Netherlands; [2]Eindhoven University of technology, Eindhoven, Netherlands. Contact: l.v.aken@tue.nl

Over the past years terrorism has claimed hundreds of lives. Improving the protectability against terrorism is therefore an important societal concern. To address this concern, several countries decided to deploy so-called rapid-response teams. These are heavily-armed and highly-trained teams located at high-potential attack regions being capable to respond to terrorist attacks within minutes. The aim of the government is to carefully position these rapid-response teams. Inspired by this setting, we develop a game theoretical model in which a government needs to position protective resources on a line segment. We provide some insights on optimal rapid-response teams locations.

3 **Algorithms for Telerobotic Camera Frame Placement for Surveillance and Reconnaissance**

Sunghoon Park[1], Manish Bansal[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech., Blacksburg, VA, Contact: seonghun@vt.edu

Telerobotic cameras installed on Unmanned Ground or Aerial Vehicles enable multiple autonomous agents on the battlefield to interact with a remote physical environment using shared resources. Thus, the efficient and effective positioning of camera frames is one of the challenges for telerobotic camera systems. In this talk, we present exact and approximation algorithms for the system with single and multiple cameras, respectively, with continuous-resolution and rectangular shape of request. We also propose an exact algorithm for multiple cameras with a one-dimensional shape of request. We provide results of our computational experiments and case study.

4 **Maximally Informative Underwater Sensor Placement**

Robert Bassett, Jefferson Huang, Erik Vargas, Naval Postgraduate School, Monterey, CA

We consider the problem of placing a given number of sensors among a finite set of candidate locations using a mutual information criterion, where the distribution of measurements at candidate locations is multivariate Gaussian. For this NP-hard problem, we propose a novel semidefinite relaxation and associated objective function bounds that are useful for designing effective branch-and-bound algorithms for the original problem. We describe a detailed application in the context of underwater acoustic sensing, where the placed sensors are part of a passive sonar network designed to detect surface vessels.

Tuesday, 11AM–12:15 PM

TB13

CC - Room 114

Frontiers in Intelligent Cyber Analytics

Joint Session

Session Chair

Marc Chale, AFIT, Dayton, OH

Session Chair

Nathaniel D. Bastian, Army Cyber Institute, U.S. Military Academy, Chester, NY

1 **Deep Classifiers are Vulnerable to Realizable Adversarial Attack in The Cyber Domain**

Marc Chale[1], Nathaniel D. Bastian[2], John Pavlik[3], Elie Alhajjar[3], [1]AFIT, Dayton, OH, [2]Army Cyber Institute, U.S. Military Academy, Chester, NY, [3]Army Cyber Institute, U.S. Military Academy, West Point, NY, Contact: marc.chale@afit.edu

Deep learning has yielded network intrusion detectors that provide 99.9% true positive detection of malicious cyber packets. We explore cutting-edge detection strategies including synthetic training data, intelligent feature engineering, and raw packet training. Next, we address the challenges of implementing adversarial machine learning to evade classifiers in cyber domain, where there are special constraints on realizable adversarial examples. A meta-heuristic is developed to perturb units in the payload code of malicious packets to optimally fool a surrogate detector. This formulation enforces constraints on the perturbations so that the resulting payload code produces the same malicious effect as the original. With certain assumptions met, the perturbed payloads can pass through test classifiers undetected.

2 Application of Creative GAn to Network Packets to Generate Novel Potentially Malicious Payloads for Data Augmentation

John Pavlik[1], Nathaniel D. Bastian[2], Elie Alhajjar[3], Marc Chale[4], [1]Army Cyber Institute, U.S. Military Academy, West Point, NY, [2]Army Cyber Institute, U.S. Military Academy, Chester, NY, [3]Army Cyber Institute, West Point, NY, [4]AFIT, Dayton, OH, Contact: john.pavlik@westpoint.edu

We use a Creative Generative Adversarial Network (GAN) architecture trained on malicious payload data from network packets in order to generate new synthetic payloads that also appear malicious. We use those new synthetic payloads to augment the training of a network intrusion detection system and see if the network is better at identifying real-world malicious payloads that were not seen during training.

3 Reinforcement Learning for Defensive Cyber Operations Playbooks

David A. Bierbrauer[1], Nathaniel D. Bastian[2], John M. Stockdale[3], [1]Army Cyber Institute, U.S. Military Academy, West Point, NY, [2]Army Cyber Institute, U.S. Military Academy, Chester, NY, [3]United States Army, Fort Huachuca, AZ, Contact: david.bierbrauer@westpoint.edu

Machine learning techniques increasingly achieve advancements in cyber operations. However, traditional cyber tactics are relatively fixed and fail to adapt to dynamic environments. Playbooks for Defensive Cyber Operations contain attack scenarios and recommended response steps. Unless updated by experts, these playbooks cannot adequately adjust to current challenges. Within the context of a rogue device on a network, we aim to revolutionize cyber playbooks using reinforcement learning (RL) methods. RL facilitates the advancement of basic principles to teach an autonomous agent the optimal policy for a given state of the environment, and the use of supervised methods and analytics serve to better inform policy adaptation to changing environments. The policy developed equips cyber operators with the necessary information to efficiently secure the network.

4 A Survival Analysis Approach to Detect a Classifier's Novelty Detection

Elie Alhajjar[1], Taylor Bradley[1], Nathaniel D. Bastian[2], Marc Chale[3], david Beirbraeur[4], John Pavlik[5], John Pavlik[5], jiji jiji[5], John Pavlik[6], John Pavlik[7], [1]Army Cyber Institute, U.S. Military Academy, West Point, NY, [2]Army Cyber Institute, U.S. Military Academy, Chester, NY, [3]AFIT, Dayton, OH, [4]USMA, Highland Falls, NY, [5]USMA, West Point, NY, [6]USMA, Ft Montgomery, NY, [7</sup]

Machine learning techniques have become an increasingly useful tool in detecting various types of cyber threats such as Denial-of-Service attacks, SQL injection, malformed packets, etc. Traditional Intrusion Detection Systems (IDS) implement such ML-based approaches to detect anomalous system behavior that can potentially indicate malicious cyber activities. However, these systems are trained to recognize and classify known threats. Open-World Learning (OWL) focuses on novelty detection (among other things): learning and classifying unknown/unseen classes. Our goal is to analyze intrusion detection systems via ML algorithms to better understand how OWL novelty detection could play a key role in detecting new network attacks. We use survival analysis to help better understand what causes these algorithms to fail.

Tuesday, 11AM–12:15 PM

TB15

CC - Room 120

Analytics for Emergency Care

General Session

Session Chair

Retsef Levi, MIT, Cambridge, MA

Session Chair

Christopher Sun, Massachusetts Institute of Technology, Cambridge, MA

1 Fairness-Efficiency Tradeoff in Public Defibrillator Placement

K.H. Benjamin Leung[1], Gareth Clegg[2], Diane Lac[2], Timothy Chan[3], [1]University of Toronto, Toronto, ON, Canada; [2]University of Edinburgh, Edinburgh, United Kingdom; [3]University of Toronto, Toronto, ON, Canada. Contact:

benkh.leung@mail.utoronto.ca
Integer linear programming can be used to determine optimal locations of public defibrillators for out-of-hospital cardiac arrest. Prior research has focused on maximizing spatial coverage of new defibrillators for nearby cardiac arrests; however, this can lead to allocations that are inequitable and unfair across neighborhoods in practice. We introduce formulations of the maximum coverage location problem (MCLP) that incorporate fairness in the objective and/or constraints, and compare the results of the standard and fairness-included MCLPs on historical cardiac arrests in four cities across Scotland.

2 Survival Optimization Models for Emergency Medical Services

Dmitry Anokhin, Miguel Lejeune, George Washington University, Washington, DC, Contact: danokhin@gwu.edu
Out-of-hospital cardiac arrest is a significant public health issue and a leading cause of death among adults in the United States. We propose modeling and algorithmic methods allowing for the design of an EMS network that maximizes a patient's survival probability while considering the uncertainty regarding ambulance availability and medical treatment delays.

3 Capacity Management in a Pandemic with Endogenous Patient Choices and Evolving Severities

Lavanya Marla[1], Sanyukta Deshpande[2], Alan Scheller-Wolf[3], Siddharth Prakash Singh[4], [1]U of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]Tepper School of Business, Pittsburgh, PA, [4]University College London, London, United Kingdom.
We consider a healthcare provider that operates both an Emergency Department (ED) and a Clinic, and aims to effectively allocate capacity to minimize costs from patients' deaths or defections. Patients call the provider via phone or present directly at the ED; and can then be directed to the ED or be offered a clinic/video appointment depending on severity (which may evolve over time). Patients join or leave facilities based on risk and wait times. We use a fluid approximation to model the system over multiple periods. While the feasible space is very complex, it is amenable to decomposition into regions that can be analyzed separately. The global optimum for both the single period and multi-period problems can be found through parsimonious enumeration via provably simple computational methods. We discuss look-ahead policies and tradeoffs over different pandemic profiles.

Tuesday, 11AM–12:15 PM

TB16

CC - Room 121
Health Policy Modeling for Big Public Health Challenges
General Session

Session Chair
Shan Liu, University of Washington, Seattle, WA

1 Association Between Mental Health Disorders and Covid-19 Outcomes

Nasrin Alizadeh[1], Osman Ozaltin[1], Julie Simmons Ivy[1], Maria Esther Mayorga[1], Kristen Miller[2], William Garmoe[2], [1]North Carolina State University, Raleigh, NC, [2]MedStar, Washington, D.C., DC
This study evaluates the impact of COVID-19 on patients with severe and mild mental health disorders. We use multivariate logistic regression to get the odds ratios of each mental health disorder and control the effect of the factors that can be associated with COVID-19 outcomes (e.g. demographic and pre-existing conditions) in the model. We carried out the analysis on adult patients from MedStar, a health organization located in Baltimore-Washington metropolitan area. The data contains the information of the patients from January 2019 to December 2020. The risk of infection, hospitalization, severity and mortality associated with COVID-19 has been reported for each mental health disorder.

2 Higher Sensitivity Monitoring of Reactions to Vaccines Using Smartwatches: Evidence from a Large-scale Prospective Study

Grace Guan[1], Merav Mofaz[2], Gary Qian[1], Tal Patalon[3], Erez Shmueli[2], Dan Yamin[4], Margaret L. Brandeau[1], [1]Stanford University, Stanford, CA, [2]Tel Aviv University, Tel Aviv, Israel; [3]Maccabi Healthcare Services, Tel Aviv, Israel; [4]Tel Aviv University Iby and Aladar Fleischman Faculty of Engineering, Rehovot, Israel. Contact: gzguan@stanford.edu
More than 10 billion COVID-19 vaccinations have been administered to date, but information from active surveillance about vaccine safety is limited. We studied participants in Israel who received their second or third Pfizer COVID-19 vaccination. We compared post-vaccination Garmin smartwatch heart rate data with data from daily patient questionnaires. We identified considerable changes in smartwatch measures even among participants who reported no side effects in the questionnaire. Wearable devices were

also more sensitive than questionnaires in determining when participants returned to baseline levels. Overall, wearable devices can detect physiological responses following vaccination that may not be captured by patient self-reports. More broadly, the ubiquity of smartwatches provides an opportunity to gather improved data on patient health.

3 Fair Allocation of Opioid Settlement

Qiushi Chen, Rob Newton, Paul Griffin, Pennsylvania State University, University Park, PA, Contact: qxc35@psu.edu

In July 2021, four major pharmaceutical manufacturers and distributors reached a proposed settlement agreement of $26 billion to address their liabilities in fueling the opioid epidemic in the US. It raises important questions about how to allocate the settlement funds among sub-state municipal entities within the state such that these entities are willing to participate. To inform the settlement allocation in Pennsylvania, we developed a novel optimization formulation for solving an equitable and evidence-based allocation strategy that generated a formula with an interpretable and simple form. We also considered a “top-up” approach in the allocation strategy to ensure a minimum amount for small (rural) counties and to promote the equity of allocation in these counties.

Tuesday, 11AM–12:15 PM

TB17

CC - Room 122

Health Applications Flash Session

Flash Session

Session Chair

Thomas Breugem, INSEAD, Fontainebleau, France.

1 ICU-BERT - Transformer for Structured EHR ICU Data with Applications for Early Adverse Event Prediction

Gaurav Jetley[1], Deepti Singh[2], [1]Colorado State University, Fort Collins, CO, [2]California State University - Long Beach, Long Beach, CA, Contact: gaurav.jetley@colostate.edu

Early signals of Adverse Events in ICU can help in early intervention. Recently, BERT models have shown success in predictive tasks with massive structured historical visit level EHR data. We propose ICU-BERT for contextualized embeddings for limited ICU data. Pretrained on small amount of ICU stays, experiments for early AE detection (1 - 24 h) show large increases against state-of-the-art models in ROC-AUC (4.21 - 8.22%) and PR-AUC (15.66 - 100.74%). It also shows large performance increases in multiple other experiments. ICU-BERT has flexible architecture, shows high performance using small pretraining and finetuning data and can benefit prediction research in healthcare and other domains.

2 Trajectory Analysis of Concussion Symptoms

Caroline Turner[1], Anna Svirsko[2], Gian-Gabriel Garcia[3], Spencer Liebel[4], [1]United States Navy, Phoenixville, PA, [2]United States Naval Academy, Annapolis, MD, [3]Georgia Institute of Technology, Atlanta, GA, [4]University of Utah School of Medicine, Salt Lake City, UT, Contact: svirsko@usna.edu

Concussions are a common brain injury, affecting millions of Americans each year. Following a concussion, patients frequently experience a wide range of consequences including changes in neurocognitive function and psychological symptoms. As a result, symptom resolution varies from patient to patient with some patient have symptoms resolve and return to normal activity within 5 days while other patients experience symptoms for months. This research develops network models that examine the relationships among these variables over time and performs trajectory analysis to understand the differences in these relationships as a result of symptom resolution.

3 Pay-for-performance Schemes and Hospital HIT Adoption

Ningning Cheng[1], Hongfei Li[1], Youngsok Bang[2], [1]The Chinese University of Hong Kong, N.T., Hong Kong; [2]Yonsei University, Seoul, Korea, Republic of. Contact: chengnn@link.cuhk.edu.hk

Pay-for-performance (P4P) schemes are implemented to incentivize hospitals for better caregiving and thus expected to promote health information technology (HIT) adoption since the latter contributes to better healthcare. However, P4P schemes could also discourage HIT adoption by taking away resources initially allocated for it. This paper is the first to empirically investigate such double-edged role of P4P schemes. We leverage a natural experiment in the US healthcare system and reveal an unintended side effect wherein P4P schemes might impede HIT adoption and have a negative spillover effect on nonparticipating hospitals in the same multihospital system as participating ones.

4 Life Cycle Assessment of Bangladesh’S Lead-acid Battery Supply Chain and Alternative Battery Types to Assess Public Health & Economic Feasibility

Gregory Forbes, Stanford University, Stanford, CA, Contact: gforbes@stanford.edu

Lead exposure is a widespread problem that ceaselessly affects vulnerable groups in Bangladesh, where the lead-acid battery (LABs) is a main contributor. The risks of lead exposure are profound, leading to neurodevelopmental damage and high blood pressure. Our work carries out a life cycle assessment to assess the environmental impacts of lead exposure of the domestic LAB supply chain, with an emphasis on informal recycling. In the interpretation of these results, we assess the public health consequences of these impacts. Last, we compare the LAB supply chain with other battery types to assess their benefits to public health while studying their economic feasibilities.

5 Deep Reinforcement Learning in Decision Making for Extubation

Maotong Sun, Jingui Xie, Technical University of Munich, Heilbronn, Germany. Contact: maotong.sun@tum.de

Weaning patients from mechanical ventilators is a critical decision in intensive care units (ICUs), significantly affecting patient outcomes and the throughput of ICU, especially during the COVID-19 pandemic. We are interested in Deep Reinforcement Learning's potential in the extubation decision making for ICU patients. We provide a rigorous performance evaluation of DRL applied in extubation decision making for ICU patients based on the MIMIC-IV dataset. We model the extubation decision making problem as an MDP and apply several DRL algorithms. We compare the performance of DRL algorithms with that of other approximate dynamic programming methods. Our study provides evidence that DRL can effectively and accurately solve extubation decision-making problems for ICU patients. This is especially promising when problem-dependent heuristics are lacking.

6 Gender Biases in Online Physician Ratings: Female Doctors Evaluated More Harshly by Patients

Margret V. Bjarnadottir[1], David Anderson[2], Julia Barnett[3], [1]University of Maryland, College Park, MD, [2]Villanova University, Villanova, PA, [3]Northwestern, evanston, IL

Prior research has highlighted gender differences in online physician reviews; however, to date no research has linked online ratings with quality of care. We fill this gap and show significant differences in the sentiment and emotion of reviews for male and female physicians. Numerical ratings are lower and the sentiment in text reviews is more negative for women who will be sanctioned than for men who will be sanctioned; sanctioned male doctors are still associated with positive reviews. Given the growing impact of online reviews on demand for physician services, platforms must revisit their design.

7 Operational Models for Mobile Diagnostic Laboratories in Non-emergency Deployment

Thomas Breugem, INSEAD, Fontainebleau, France. Contact: thomas.breugem@insead.edu

Mobile labs are a promising approach to improving access to health. Although there is a variety of use cases for mobile labs, their usage has been primarily in emergency deployment. This means mobile labs are at risk of being idle if not used in non-emergency settings. We analyse operational models for non-emergency mobile lab deployment. Our results show substantial impact can be generated and help inform decision-making regarding pathogen prioritization and operational models.

Tuesday, 11AM–12:15 PM

TB18

CC - Room 123

Selected Topics in Healthcare Operations

General Session

Session Chair

Amin Khademi, Clemson University, Clemson, SC

1 Model Based Approaches for Actionable Healthcare Analytics

Yonatan Mintz, University of Wisconsin Madison, Madison, WI

Ubiquitous technologies such as smart phones, wearable devices, and smart sensors have allowed for the collection of large amounts of patient level data. However, these highly personal data sources provide not just methodological challenges but also socio-technical challenges in terms of equity, transparency, and privacy that come with automated decision making. In contrast to classical methods of operations research and machine learning that may be predictive or prescriptive, these challenges require us to develop new methods for actionable analytics. In this talk we will discuss some of the recent research advances tackling these challenges. We will highlight the various applications of machine learning and artificial intelligence to providing personalized care in several healthcare contexts.

2 A Tolerance-based Approach to Lexicographic Multi-objective Partially Observed Markov Decision Processes

Sun Ju Lee[1], Gian-Gabriel P. Garcia[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology,

Atlanta, GA, Contact: julee@gatech.edu
Sequential screening and treatment problems in medical decision-making often involve multiple competing objectives that must be balanced in order to find the optimal policy under uncertainty with a Partially Observed Markov Decision Process (POMDP) model. We propose a lexicographic ordering method with tolerance to solve a finite-horizon multi-objective POMDP and apply it to a disease screening problem. We show that our approach can aid in the interpretation of optimal policies according to varying preferences and can facilitate a personalized and patient-centered decision-making process better aligned with the priorities of individual patients.

3 Adaptive Seamless Dose-Finding Trials

Amin Khademi[1], Ningyuan Chen[2], [1]Clemson University, Clemson, SC, [2]University of Toronto, Mississauga, ON, Canada. Contact: khademi@clemson.edu
We propose a nonparametric framework to conduct early-stage dose-finding clinical trials adaptively with simultaneous consideration of efficacy and toxicity. It has two major benefits: Efficient use of patient responses and immunity to model misspecifications. First, unlike most Phase I trials, which only keep track of the toxicity, our framework makes efficient use of patient responses and infers the efficacy of each dose at the same time. Second, our framework utilizes application-specific structures of the dose-efficacy and dose-toxicity curves without imposing any parametric forms.

4 Robust Multi-stakeholder Preference Elicitation and Aggregation for Treatment Prioritization During The Covid-19 Pandemic

Caroline Johnston, Simon Blessenohl, Phebe Vayanos, University of Southern California, Los Angeles, CA, Contact: cmjohnst@usc.edu
During the COVID-19 pandemic, triage committees must make ethically difficult decisions that are complicated by diverse stakeholder interests. We propose an automated approach to support group decisions by recommending a policy to the group - a compromise between potentially conflicting individual preferences. To identify a policy to best aggregate individual preferences, our system elicits preferences by asking a moderate number of strategically selected queries, each taking the form of a pairwise comparison posed to a specific stakeholder. We propose a novel multi-stage robust optimization formulation of this problem. Formulating this as an MILP, we evaluate our approach on the issue of recommending policies for allocating ICU beds to patients with COVID-19. We show that our method recommends a policy with higher utility than various methods from the literature.

Tuesday, 11AM–12:15 PM

TB19

CC - Room 124
Staff Scheduling
Contributed Session

Session Chair
Oluwasegun Olanrewaju, University of Miami, Dallas, TX

1 Optimal Assignment of Cross-trained Nurses in a Healthcare System

Tong Zhang[1], Tugce Isik[2], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, Contact: tzhang5@g.clemson.edu
Motivated by the need to solve the nursing shortage problem, we model an inpatient surgery facility as a tandem clearing queueing system and formulate a Markov decision process to optimize the nurse allocation decisions. We investigate policies that minimize total holding costs and explore the structure of the optimal policies, both numerically and analytically. We also explore the impact of having cross-trained nurses at different skill levels on system efficiency. We conclude that idling servers can be optimal if the holding costs are very imbalanced across tasks. Our results also show that it is beneficial to assign faster servers to upstream stations to yield lower total costs. Under different business rules for patients and nurses, we consider the problem with various types of flexibility structures, for instance, task and station flexibility.

2 Staffing and Patient Allocation in ICU Networks with Stepdown Units

Silviya Valeva[1], Guodong Pang[2], Andrew J. Schaefer[2], [1]Saint Joseph's University, Philadelphia, PA, [2]Rice University, Houston, TX
Hospital networks are complex systems with multiple interactions between units in a highly dynamic and uncertain environment. As such, decisions on where patients should go once stable after an ICU stay and how step-down units can be utilized to alleviate some of the pressure on ICUs are of critical importance. This work's focus is on devising implementable patient allocation policies derived from convex mathematical optimization models that account for the hospital network topology, resource sharing, and expected demand.

3 Physician Scheduling for Emergency Telemedicine Across Multiple Facilities

Oluwasegun G. Olanrewaju[1], Murat Erkoc[2], [1]University of Miami, Miami, FL, [2]University of Miami, Hialeah, FL, Contact: ogo2@miami.edu

This research focuses on the provision of telemedicine for stroke patients across multiple hospital emergency wards. A central service provider operating 24/7 responses to emergency cases by providing physician support. Physicians remotely attend to emergency patients based on their credentialing portfolios. A novel mixed integer programming model is proposed for obtaining physicians schedules with optimal mix of credentials and coverage across multiple hospitals. Two fast acting heuristic-based solution approaches are developed for real-life size problems and their computational performances were demonstrated via numerical analyses.

Tuesday, 11AM–12:15 PM

TB20

CC - Room 125

Consumer Decisions Involving Social Media, E-commerce, or Live Commerce

General Session

Session Chair

Qi Yan, Irvine, CA

Session Chair

L. Robin Keller, University of California - Irvine, Irvine, CA

1 How Emotions Affect Information Diffusion Associated with Mental Health Coping Strategies on Social Media Platforms During The Covid-19 Pandemic? a Twitter Study

Dezhi Wu[1], Tianjie Deng[2], Youyou Tao[3], [1]University of South Carolina, Columbia, SC, [2]University of Denver, Denver, CO, [3]Loyola Marymount University, Los Angeles, CA, Contact: dezhiwu@cec.sc.edu

In this study, we investigate how emotions disclosed in tweets affect information diffusion patterns on Twitter and user coping strategies to handle their mental health issues during the COVID-19 pandemic. We collected over three million tweets related to COVID-19 on Twitter, before and after the outbreak of the pandemic. Using text mining and social network analysis techniques, our study will provide an evidence-based implication to inform the public health decision-makers to justify current substance use and health-related disparity policies.

2 Humanizing Brand-to-Consumer Social Media Communication

Kihyun Hannah Kim, Rutgers Business School, Newark, NJ, Contact: kh.kim@business.rutgers.edu

Brands are increasingly having conversations with consumers on social media. Although there is a wealth of brand-to-consumer social media communication research, prior studies have largely ignored a critical component of brand-to-consumer communication, personality. In practice, brands frequently adopt human qualities in communication to enhance the efficiency of brand communication. Therefore, in this research, we focus on personality in communication to help researchers and managers understand the value of adopting human-like personality dimensions in brand-to-consumer communication. We employ a methodology involving empirical analyses and lab experiments. We believe the proposed approach can be generalized for brand communication with consumers across different contexts.

3 Consumer Aversion to Price Volatility: Implications to Airbnb Smart Pricing

Jiaqi Shi[1], Jinan Lin[1], Tingting Nian[1], Mingyu Joo[2], [1]University of California-Irvine, Irvine, CA, [2]University of California-Riverside, Riverside, CA, Contact: jiaqis@uci.edu

To maximize profits, firms are now adopting machine learning-based pricing algorithms, wherein product prices are adjusted frequently and in response to continually changing market demands. While it has been well-documented that pricing algorithms enable increases in the platforms' revenue, little attention has been paid to the consumers' aversion in this area. Our empirical study demonstrates that while low-frequency price volatility can increase Airbnb listings' booking rates, consumers' perceptions of algorithmic pricing strategies remain unfavorable in cases of high price volatility. Price change frequencies, when occurring at rates below certain thresholds, increase the booking rates of properties accordingly. However, the booking rate decreases if the price volatility is too high.

4 A Study of Product Returns in The China Live Commerce Industry

Qi Yan, L Robin Keller, University of California, Irvine, Irvine, CA

In traditional e-commerce, customers need to read the long text descriptions of the product and try to understand the instructions of usage. In live commerce, consumers can just watch the streamers showing them the size, color, and functions of products. Our project connect the customer return behavior to this new way of shopping by examining different aspects of live commerce. We found that the contents, the people, the shopping purposes and the brands have significant influences on the return rate.

Tuesday, 11AM–12:15 PM

TB21

CC - Room 126
Voting and Elections
General Session

Session Chair
Charles Thraves, University of Chile, Santiago, Chile.

1 **Combatting Gerrymandering with Social Choice: The Design of Multi-member Districts**
Nikhil Garg[1], Wes Gurnee[2], David Rothschild[3], David B. Shmoys[4], [1]Cornell Tech, New York, NY, [2]MIT, Cambridge, MA, [3]Microsoft Research, New York, NY, [4]Cornell University, Ithaca, NY, Contact: david.shmoys@cornell.edu
Every representative democracy specifies a mechanism by which voters choose their reps. The US standard, winner-take-all single-member districts, enables partisan gerrymandering and constrains fair redistricting, preventing proportional representation in legislatures. We study the design of multi-member districts (MMDs), in which each district elects multiple reps, potentially through a non-winner-takes-all voting rule. We present empirical analyses for the US House of Reps under MMDs with other social choice functions, under algorithmically generated maps optimized for either partisan benefit or proportionality. We find that with 3-member districts using Single Transferable Vote, independent commissions can achieve proportional outcomes in each state up to rounding, and advantage-seeking partisans have their power to gerrymander greatly curtailed.

2 **Parametric Estimation Under Diffuse Observations: An Application on Election Polls**
Charles Thraves, Sebastián Morales, University of Chile, Santiago, Chile. Contact: cthraves@dii.uchile.cl
Most techniques to estimate distributions consider observations as a single-point. However, there are several applications in which observations have some degree of uncertainty which is known. We propose a way in which Maximum Likelihood Estimation methods can effectively incorporate this noise dimension of the data. We show that the log-likelihood expression in this more general setting can be expressed in a tractable expression. We show a case study in the US President Election of 2020, in which polls are pooled at each state in order to estimate the distribution of votes in the election day. The proposed method shows to outperform current techniques such as classical MLE.

3 **Optimal Consolidation of Polling Locations**
Adam Schmidt[1], Laura A. Albert[2], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI, Contact: laura@engr.wisc.edu
Many logistical and financial challenges cause election officials to consolidate polling locations. We formalize the set of constraints and criteria election officials should follow as the polling location consolidation problem (PLCP). We introduce an integer programming model to determine when it is necessary to consolidate polling locations and how to do so optimally. The model simultaneously selects polling locations to in an upcoming election, reassigns voter precincts to polling locations, and allocates critical resources to the selected polling locations. We evaluate the model using a case study of Richland County, South Carolina to demonstrate the value of the PLCP and investigate implications for practice.

4 **Congressional Apportionment: A Multi-Objective Optimization Approach**
Steven Shechter, University of British Columbia, Vancouver, BC, Canada.
Due to population changes, after every decennial US census, the 435 seats in the House of Representatives are re-apportioned across the 50 states. Integer requirements mean that exact proportional representation is never achieved, and the best way to round the fractional quotas has been debated for nearly 250 years. I provide an overview of different historical methods, optimality criteria they each satisfy, as well as other fairness concepts none of them guarantees. This motivates a multi-objective, mixed-integer optimization approach. Pareto curves from historical censuses and simulations demonstrate opportunities for improvement in some criteria at little sacrifice to others.

Tuesday, 11AM–12:15 PM

TB22

CC - Room 127
Public Transportation
Contributed Session

Session Chair
Si Liu, McMaster University, Hamilton, ON, Canada.

1 **Spatio-temporal Trip Pattern Typology Analysis for a Regional Bus Network**

Mohammed Mohammed[1], Jimi Oke[2], [1]University of Massachusetts Amherst, Amherst, MA, [2]University of Massachusetts Amherst, Amherst, MA, Contact: Mamohammed@umass.edu

Understanding bus user trip patterns enables transit agencies to plan equitably, especially in response to disruption. Current systems do not gather full behavior data. Thus, we build an enhanced framework that exploits big data from mobile ticketing to extract travel patterns. We applied our method to 3000 Pioneer Valley bus passengers in an 8-month period in 2021, with 311000 tap-ins. We computed the dissimilarity of 2D trip series via sparse dynamic time warping and clustered them. We obtained 4 spatio-temporal typologies, analyzing them based on demographics and trip metrics. 3 typologies denoted commuters, separated by boarding time; the 4th denoted leisure or other activities. Our method can aid future decision-making in similar areas with minimal data availability.

2 **Negotiating Travel Schedule and Mode in Mobility Services for Transportation-disadvantaged Individuals**

Shijie Chen, Yanshuo Sun, FAMU-FSU College of Engineering, Tallahassee, FL

Transportation-disadvantaged populations reply on Dial-A-Ride (DAR). While the DAR problem has been extensively studied, we aim to investigate the so-called travel negotiation problem during pre-scheduling, which is greatly overlooked. As advance trip requests arrive, an operator must confirm, in a timely manner, the type of vehicle to accommodate the request (e.g., DAR vs taxi, called mode negotiation) and the expected pickup time (i.e., schedule negotiation). We embed column generation in a rolling horizon framework so that negotiation plans are generated and optimized efficiently. Numerical studies based on real-world data demonstrate the effectiveness of the negotiation method.

3 **Clustering and Routing for The Hybrid Flexible Transit System with Dynamic Checkpoint Strategy**

Dahye Lee[1], Luca Quadrifoglio[1], Kai Yin[2], [1]Texas A&M University, College Station, TX, [2]Expedia Group, Austin, TX, Contact: dahyelee1991@tamu.edu

This study explores a dynamic checkpoint strategy for an on-demand flexible transit service called Mobility Allowance Shuttle Transit with Dynamic Checkpoint. A sequential iterative two-phase heuristic model first clusters to minimize customers' walking distance and routes second to minimize vehicle distance traveled. The clustering is performed using memetic differential evolution-based algorithm, and the routing solves a traveling salesman problem. An analytical model is developed to provide a lower bound estimate for the dynamic number of checkpoints and an upper bound estimate for the customers' average walking distance. The parametric simulation experiment is conducted to explore the impact of system parameters on the number of dynamic checkpoints and customers' walking distance and validate the robustness of the analytical model.

4 **Designing Dynamic Pricing Strategies for The Smart Mobile Lockers in Tandem with City Buses**

Si Liu[1], Elkafi Hassini[2], [1]McMaster University, Hamilton, ON, Canada; [2]McMaster University, Hamilton, ON, Canada. Contact: lius278@mcmaster.ca

This paper aims to prove the financial feasibility of deploying smart mobile lockers in tandem with city buses (SML-CB) which serve the last-mile e-commerce delivery. In addition, it investigates pricing strategies for SML-CB stakeholders. A multi-level model is developed and solved due to different optimization objectives of various SML-CB stakeholders, including locker operating platform, public transit system, customers, etc. The model links the pricing strategy to operational drivers, such as the scheduling of lockers and customer pick-ups, etc., and designs the pricing strategy under different demand and supply scenarios.

Tuesday, 11AM–12:15 PM

TB23

CC - Room 128

Innovations in Immigration

General Session

Session Chair

Geri Dimas, Worcester Polytechnic Institute, Worcester, MA

1 **Modeling The United States Immigration Court System Via Data Science and Discrete Event Simulation**

Geri Dimas, Andrew C. Trapp, Renata Alexandra Konrad, Worcester Polytechnic Institute, Worcester, MA, Contact: gldimas@wpi.edu

There is a significant and growing backlog in the United States immigration court system with nearly 1.5 million cases waiting to be heard. Due to large influxes of immigrants, together with design limitations and scarce resources, the court system struggles to manage this growing backlog, resulting in delays that unnecessarily tax governmental and community resources. We leverage data science to model the intricacies of this court system, deconstructing associated elements and their respective complexity through discrete event simulation. We study possible improvements to the simulated system by adjusting properties such as assignment of cases to judges, queuing discipline and priority queues, and observing performance indicators.

2 Risk-Averse Placement Optimization in Refugee Resettlement

Narges Ahani[1], Fatemeh Farajzadeh[2], Osman Ozaltin[3], Andrew C. Trapp[4], [1]Bank of America, Charlotte, NC, [2]Worcester Polytechnic Institute, WORCESTER, MA, [3]North Carolina State University, Raleigh, NC, [4]Worcester Polytechnic Institute, Worcester, MA, Contact: atrapp@wpi.edu

Intentionally designed analytical approaches are being used to resettle refugees into communities. The refugee resettlement software Annie™ MOORE estimates refugee-locality match quality scores using predictive modeling of past refugee placement and outcomes data to generate likelihoods of employment for incoming refugees. These estimated scores are used for offline optimal matching of arriving refugees in subsequent placement periods, however, inherent uncertainty exists with respect to the quality score estimation. This uncertainty can lead to different optimized outcomes that risks placing vulnerable refugees in communities with lower employment likelihoods. We develop new methods that hedge against this risk for refugee outcomes. Our methods are able to substantially reduce this risk while retaining a majority of the total expected employment.

3 Matching Refugees to Stable Employment Opportunities Via Many-to-many Optimization

Marcela S. G. Vasconcellos, Andrew C. Trapp, Worcester Polytechnic Institute, Worcester, MA, Contact: msvasconcellos@wpi.edu

Millions of refugees and displaced persons are in vulnerable situations due to a lack of permanent solutions for their inclusion in host countries. We consider the challenge of securing stable employment for at-risk refugees, presently handled in a manual, cumbersome manner. We formulate the problem of matching many refugees to many job opportunities via integer optimization, delivering generated solutions as recommendations within a job matching platform. Our model considers refugee preferences and needs, as well as job requirements. We investigate the advantage of this approach as a means to improve outcomes for more vulnerable candidates. We consider the effect of varying bounds and adding elasticity to constraints on the quality of match recommendations. Limited testing revealed high satisfaction for resulting recommendations to both refugees and companies.

Tuesday, 11AM–12:15 PM

TB24

CC - Wabash 1
DecisionBrain / MathWorks
Technology Tutorial

1 Quickly deploy your optimization models to the Cloud with DBOS!

Issam Mazhoud, DecisionBrain, Paris, France. Contact: issam.mazhoud@decisionbrain.com

DecisionBrain Optimization Server (DBOS) is designed to help build and deploy fully scalable optimization-based applications. It enables optimization developers to focus on their models, benchmark them and allows them effortlessly to deploy those models in production in a context that will support multiple parallel runs on dedicated resources.To achieve this, DBOS lets you encapsulate any computational module (optimization solvers, analytics modules, etc.) into so-called "Workers." Workers can be deployed on dedicated resources (local, private, or public cloud) to ensure the best execution time. When deployed on Kubernetes, Workers may be activated on-demand to reduce cloud costs.
DBOS can be used in a stand-alone mode to run computations or it can also be integrated with existing applications to let them provide scalable and on-demand optimization capabilities and powerful monitoring capabilities.
DBOS also has a benchmarking functionality that allows you to benchmark your optimization engine across versions, different datasets, or models.
In this presentation, we will demonstrate how this technology can be used to:

- Encapsulate an optimization model in a Worker
- Deploy this Worker on a Kubernetes cluster using resources only on-demand
- Monitor Real-time Executions
- Benchmark models and datasets

2 Optimizing Manufacturing Production Processes with MATLAB

Sean de Wolski, MathWorks, Natick, MA, Contact: sdewolsk@mathworks.com

Manufacturing processes tend to be capital intensive, operate with thin profit margins, and face continued pressure to minimize environmental impact and waste. Process modeling tools are critical for analyzing and designing efficient processes. In this tutorial, we will discuss how you can optimize manufacturing production processes with MATLAB, across industry applications such as semiconductor manufacturing, pharmaceutical manufacturing, and chemical blending. Using a manufacturing process example, we will see how to assemble discrete-event simulation models. With a model of sufficient fidelity assembled, we will explore what-if scenarios, and then answer "how many?" or "how much?" type questions with a global optimization method to maximize throughput or minimize cost.

Tuesday, 11AM–12:15 PM

TB27

CC - Room 138

Improving Operations in Health and Beyond

General Session

Session Chair

Georgia Perakis, Massachusetts Institute of Technology, Belmont, MA

1 Optimizing Treatment of Sepsis to Inform Resource Allocation in The ICU

Lien Le[1], Angela Lin[2], Dessislava Pachamanova[3], Georgia Perakis[4], Omar Skali Lami[4], [1]Newton Wellesley Hospital, Newton, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Babson College, Boston, MA, [4]Massachusetts Institute of Technology, Cambridge, MA, Contact: aglin@mit.edu

Sepsis is a dysregulated response to infection leading to organ failure with a high (30-50%) mortality rate. Treating sepsis is difficult, costly, and can require limited ICU resources. In addition, timely identification and treatment is critical for patient outcomes. In this work, we make sequential decisions for treating septic patients in the ICU in order to optimally allocate the ICU's resources. Our team used data from a hospital database to train an interpretable machine learning model that uncovers the dynamics of septic patient trajectories in the ICU. The predictions from this model are incorporated into an optimization framework for scarce resource management in the ICU.

2 Robust Document Classification Using Noisy External Information

Evan Yao[1], Retsef Levi[2], Josh Wilde[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: evanyao@mit.edu

We study a unique document classification setting where rather than having labels, we are provided with external resources describing the desired labels. We develop a methodology for assigning labels to each document using the external resources in a way that is robust against noise in the external resources. We apply this methodology to a pharmaceutical manufacturing setting, where deviations to the manufacturing process need to be categorized into the process steps that they occurred in by leveraging the abundance of documentation on the manufacturing process. We also apply our methodology to classic news classification datasets using Wikipedia as an external source. We show that our methodology produces reasonable accuracy for a setting with no given labels and that our algorithm's robustness optimization leads to a 1.5-5% gain in accuracy over simpler approaches.

3 End-to-end Learning for Decision Optimization Via Constraint-enforcing Approximators

Rares Christian[1], Pavithra Harsha[2], Georgia Perakis[3], Brian Quanz[4], Ioannis Spantidakis[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]IBM Research, Pleasantville, NY, [3]Massachusetts Institute of Technology, Belmont, MA, [4]IBM, Yorktown Heights, NY, Contact: yspant@mit.edu

In many applications, prediction problems are used to forecast inputs for downstream optimization tasks. The goal is to make forecasts that will minimize the final task-based objective. We focus on two-stage stochastic linear optimization tasks with uncertain parameters, which are intractable for most existing end-to-end methods. The primary difficulty in minimizing the task-based objective is in differentiating the output with respect to the forecasted parameters. In this paper, we propose a neural network approach that can learn to approximately solve the underlying linear optimization formulation, and ensure its output satisfies the feasibility constraints. We show this method can solve important supply chain problems, not only tractably, but also more accurately than existing approaches.

4 A Granular Approach to Optimal and Fair Patient Placement in Hospital Emergency Departments

Maureen Canellas[1], Dessislava Pachamanova[2], Georgia Perakis[3], Asterios Tsiourvas[4], Omar Skali Lami[4], [1]UMass Memorial Hospital, Worcester, MA, [2]Babson College, Boston, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, [4]MIT, Cambridge, MA, Contact: oskali@

mit.edu

Prolonged emergency department (ED) length of stay (LOS) is associated with detrimental effects on patient care and quality. In this work, we describe our efforts to improve the patient prioritization and placement aspect of ED. We present a novel MILP predictive-prescriptive formulation that incorporates a breakdown of predicted patient LOS into actionable pieces and allows for a granular model of ED operations. To deal with uncertainty, we propose a sampling-based solution. Our solution increases throughput by 50% and decreases the average waiting time by 75% compared to current hospital practice. Finally, our approach shows potential for addressing hidden biases in patient waiting times.

Tuesday, 11AM–12:15 PM

TB28

CC - Room 139

Topics in Empirical Health Care Operations

General Session

Session Chair

Hummy Song, University of Pennsylvania, Philadelphia, PA

1 Learning from Quality Signal to Improve Public Policy Fairness: Evidence from The Hospital Readmissions Reduction Program

Mohamad Soltani[1], Robert Batt[2], Hessam Bavafa[2], [1]Alberta School of Business, University of Alberta, Edmonton, AB, Canada; [2]Wisconsin School of Business, University of Wisconsin-Madison, Madison, WI, Contact: soltani@ualberta.ca

Policy makers often employ quality indicators to evaluate the performance of an organization. However, a specific quality indicator may not truly reflect the quality that is attributed to the performance of the organization. We explore the effects of the Hospital Readmissions Reduction Program (HRRP) on 30-day readmissions in over 2,000 hospitals with wide geographical coverage within the U.S. Whereas the policy is indifferent between readmission reduction during the 30-day time window, we find that the level of improvement depends on the timing of readmission. We attribute this difference to the control that hospitals have over readmissions. This finding shows that the policy is not fair toward hospitals that treat low-income patients with limited access to care. We suggest an alternative quality indicator that provides a fairer measurement of hospitals performance.

2 Workforce Composition as a Key Determinant of Continuity of Care in Primary Care

Michael Freeman[1], Harshita Kajaria-Montag[2], [1]INSEAD, Singapore, Singapore; [2]University of Cambridge, Leamington Spa, United Kingdom. Contact: michael.freeman@insead.edu

Maintaining an ongoing relationship between a patient and provider, referred to as continuity of care (COC), is advocated as a cornerstone of primary care. While COC in primary care is known to confer many clinical and operational benefits, what remains less clear is which factors affect a primary care practice's ability to provide COC to its patients? This paper examines this question from an operations management perspective by exploring the relative importance of workforce related operational factors that may explain variation in rates of COC between practices and over time.

3 Expanding Healthcare Services in Underserved Rural Areas

Rodney P. Parker[1], Kurt M. Bretthauer[1], Jonathan Eugene Helm[1], Masoud Kamalahmadi[2], Gregory Katz[3], [1]Indiana University, Bloomington, IN, [2]University of Miami, Miami, FL, [3]Richard L. Roudebush VA Medical Center, Indianapolis, IN, Contact: rodp@indiana.edu

We explore the effect of expanding healthcare services in underserved rural areas of the U.S. on their residents' access to care and utilization of healthcare services. Using data from a large healthcare system, we show that opening healthcare clinics improves access to care and affects demand in the entire network.

4 "I Quit": Schedule Volatility as a Driver of Voluntary Employee Turnover

Alon Bergman, Guy David, Hummy Song, University of Pennsylvania, Philadelphia, PA, Contact: hummy@wharton.upenn.edu

We examine how employer-driven volatility in workers' schedules impacts their decision to voluntarily leave their job. Using time-stamped work log data of home health nurses, we construct and study a novel measure of schedule volatility. This measure may be endogenous to the worker's decision to quit. Hence, we instrument for schedule volatility using time off taken by coworkers. We find that higher levels of schedule volatility substantially increase workers' likelihood of quitting. Through policy simulations, we illustrate how schedule volatility, and employee turnover, could be mitigated. We conclude by discussing the generalizability of our results to other industries.

Tuesday, 11AM–12:15 PM

TB29

CC - Room 140
Blockchain and Crypto Tokens
General Session

Session Chair
Jingxing (Rowena) Gan, Cox School of Business, Southern Methodist University, Dallas, TX

1 Tokenvendor Problem: Inventory and Investment Strategies in The Presence of The Tokenized Market and Exchange Platform

Ye Liu, Washington University in St. Louis, St. Louis, MO

We investigate the application of tokenomics in the secondary market. We model the token's operational versus financial values. We show that a good platform even increases the token price, attracts the firm to hold more tokens but reduces the inventory. We also find that good secondary markets make the firm value the operational value of tokens more. It decreases the inventory level, increases the holdings, and further increases the token prices.

2 Overcoming The Coordination Problem in New Marketplaces Via Cryptographic Tokens

Hanna Halaburda, NYU Stern, New York, NY

We study the use of platform-specific tradable cryptographic tokens to solve the coordination problem that is common in adopting new platforms. We show that certain characteristics of platform-specific tokens, specifically their tradability, can help overcome the coordination problem and can support equilibria favorable to the new platforms. Compared to other mechanisms, such as subsidies of early users and promises of refunds or buy-backs if the platform fails, platform-specific cryptographic tokens are less likely to favor established or larger firms with established reputation and financial resources. We find that tokens allow a marketplace to tradeoff future revenue for present revenue, which then can be used to address the coordination problem. On the other hand, the ability to trade out of the platform results in a smaller future network and lower total profit.

3 An Investigation on The Impact of Counterfeiting and Traceability in The Secondary Market

Hubert Pun[1], Jay Swaminathan[2], Jing Chen[3], [1]The University of Western Ontario, London, ON, Canada; [2]University of North Carolina, Chapel Hill, NC, [3]Dalhousie University, Halifax, NS, Canada.

We use a two-period game to study the impact of blockchain for combating counterfeits in the secondary market. In the first period, a manufacturer sells a new product to customers. At the end of the first period, some of these customers would sell their product as used good to an authentic used goods reseller. In the second period, there is a secondary market that has two firms: the used goods reseller and a deceptive counterfeiter. Customers know that new products from the manufacturer are genuine, but they are uninformed about authenticity information in the secondary market. The manufacturer has the option to implement blockchain to reveal product information.

4 Accounts Receivable Tokenization in Multitier Supply Networks

Jing Hou[1], Burak Kazaz[2], Fasheng Xu[2], [1]Nanjing University, Nanjing, China; [2]Syracuse University, Syracuse, NY

Accounts receivable can be turned into digital assets that program ownership and the flow of cash into transferable tokens that can either be sold on at a discount via factoring or be passed on to the upstream of the supply chain as a payment instrument. This paper investigates how accounts receivable tokenization impacts the multitier supply chain's decisions and profits under different configurations and contractual forms.

Tuesday, 11AM–12:15 PM

TB30

CC - Room 141
On-demand Mobility Services and Platforms
General Session

Session Chair
Saif Benjaafar, University of Minnesota, Minneapolis, MN

Session Chair
Xiaotang Yang, University of Minnesota, Minneapolis, MN

1 Surge Pricing and Dynamic Matching for Hotspot Demand Shock in Ridehailing Networks

Philipp Afèche[1], Zhe Liu[2], Costis Maglaras[3], [1]University of Toronto, Toronto, ON, Canada; [2]Imperial College Business School, London, -, United Kingdom; [3]Columbia Business School, New York, NY, Contact: Philipp.Afeche@rotman.utoronto.ca

We study a ride-hailing platform that matches price- and-delay sensitive riders with strategic drivers in the presence of an unpredictable demand shock at a hotspot. Our model captures the interplay of nonstationary demand, geographically distributed strategic supply, and delayed and risky supply response and incentives. We consider dynamic policies that jointly determine surge prices for riders, surge wages for drivers, and the spatial matching of riders to drivers. We characterize the structure and compare the performance of various policies that differ in terms of three attributes, temporal differentiation, spatial differentiation and risk sharing. Our results identify how system performance depends on the key timescales of rider patience and demand shock duration.

2 Stall Economy: The Value of Mobility in Retail on Wheels

Junyu Cao[1], Wei Qi[2], [1]The University of Texas at Austin, Austin, TX, [2]McGill University, Montreal, QC, Canada.

Urban open space emerges as a new territory to embrace retail innovations. Transition into such a "stall economy" paradigm is being spurred by the rapidly advancing self-driving technologies. Motivated by this transformation, this paper provides models, theory, and insights of spatial queueing systems in which one server moves around to meet mobile customers/machines and in which the "last 100 meters" is expensive. Specifically, we study two service modes i) on-demand and ii) spatially and temporally pooling customer demands. Our main finding is that the stall economy potentially profits more than stationary retail because of the mobility of stalls as well as its operational flexibilities that allow for avoiding the "last 100 meters" and pooling demands. In a broader sense, this work looks toward an expanded scope of future retail empowered by self-driving technologies.

3 Mapping Now or Later: Dynamically Building up a Network for Autonomous Mobility-on-demand Systems

Layla Martin[1], Ho-Yin Mak[2], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]University of Oxford, Oxford, United Kingdom. Contact: l.martin@tue.nl

Recently, autonomous mobility-on-demand (AMoD) systems have begun operations. Driverless vehicles can only travel quickly on previously mapped streets and otherwise must drive slowly or detour. Thus, operators must create maps either prior to their launch or during operations. During operations, construction, infrastructure changes, or regulations require operators to eventually "relearn" streets. We model the AMoD operator's decisions as a two-stage problem. The first stage addresses decisions prior to launch, i.e., selecting which roads to map ahead of time. The second stage considers the day-to-day operations, i.e., deciding whether, and on which sufficiently short path, to serve a customer, balancing mapping and service.

4 Do Workers and Customers Benefit from Competition Between On-demand Service Platforms?

Saif Benjaafar[1], Shihong Xiao[1], Xiaotang Yang[2], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota-Twin Cities, Minneapolis, MN, Contact: yang4767@umn.edu

We describe a game-theoretical model to study the effect of competition between on-demand service platforms. The platforms compete for both workers and customers by deciding on wages to pay workers and prices to charge customers. We show that competition does not necessarily lead to higher worker welfare and higher consumer surplus. Our results could be useful for policy makers and platform managers as they consider the implications of competition between on-demand service platforms on social welfare and profit.

Tuesday, 11AM–12:15 PM

TB31

CC - Room 142

Innovations in Middle-/last-mile/same-day Deliveries

General Session

Session Chair

Linwei Xin, University of Chicago, Chicago, IL

1 Regional Planning Model for Low-Cost Same-Day Delivery at Scale

Tolga Cezik[1], Daniel Chen[2], R. Ravi[1,3], [1]Amazon.com, Seattle, WA, [2]Amazon.com, Singapore, Singapore; [3]Carnegie Mellon University, Pittsburgh, PA, Contact: chonglic@amazon.com

Providing a better service to e-commerce customers involves making same-day delivery widely available. However, large networks require careful planning to offer same-day delivery at a sustainable cost. We propose a regional planning model to reconfigure an existing fulfillment network into neighborhoods that fulfill most same-day demand locally. The model uses an integer program (IP) to assign fulfillment centers, demand sites and sortation hubs to neighborhoods, maximizing local same-day flow while respecting capacity constraints. At Amazon's scale, the IP is too large, so we propose a method that first solves the IP over smaller regions, then solves the full IP after partially fixing some neighborhoods derived from the regional solutions. Preliminary results suggest this model is able to find neighborhoods enabling low-cost same-day delivery.

2 Sparse Graph Design with An Application to Middle-mile Transportation Management

Rene A. Caldentey[1], Yifan Feng[2], Linwei Xin[3], Yuan Zhong[4], [1]The University of Chicago, Chicago, IL, [2]NUS Business School, Singapore, Singapore; [3]University of Chicago, Chicago, IL, [4]University of Chicago / Booth School of Business, Chicago, IL, Contact: yuan.zhong@chicagobooth.edu

Given an input graph G, we consider the problem of designing a sparse subgraph that supports a large matching after some nodes in G are randomly deleted. We study three families of sparse graph designs (namely, Clusters, Rings, and Erdos-Renyi graphs) and show both theoretically and numerically that their performance is close to the optimal one achieved by a complete graph. Our interest in the stochastic sparse graph design problem is primarily motivated by a collaboration with a leading e-commerce retailer in the context of its middle-mile delivery operations. We test our theoretical results using real data from our industry partner and conclude that adding a little flexibility to the routing network can significantly reduce transportation costs.

3 Fulfillment Decisions and Route Selection for Online Retailing

Pin-Yi Chen, Stephen C. Graves, Massachusetts Institute of Technology, Cambridge, MA, Contact: sgraves@mit.edu

Order fulfillment for online retailing includes deciding from where to source the inventory for each order and how to route the order from the source to the customer. This research considers only the routing decision for a context in which the retailer has multiple routing options. These options can include third-party carriers, as well as the retailer's own transportation resources, which may be capacity constrained. To make these decisions in real time, we propose computing shadow prices on the constrained transportation resources, in order to have a way to compare the (imputed) cost of the routing options. We illustrate the approach and the trade-offs on a very simple fulfillment network and then discuss how the approach scales to more realistic networks.

4 The Benefits of Delay to Online Decision-making

Yaqi Xie[1], Will Ma[2], Linwei Xin[1], [1]University of Chicago, Chicago, IL, [2]Columbia University, New York City, NY, Contact: linwei.xin@chicagobooth.edu

Real-time decisions are usually irrevocable in many contexts of online decision-making. One common practice is delaying real-time decisions so that the decision-maker can gather more information to make better decisions (for example, in online retailing, there is typically a time delay between when an online order is received and when it gets picked and assembled for shipping). However, decisions cannot be delayed forever. In this paper, we aim to theoretically characterize the benefits of delaying real-time decisions. We prove that for a broad family of online decision-making problems, the gap between the proposed online algorithm with delay and the offline optimal hindsight policy decays exponentially fast in the length of delay. We also conduct extensive numerical experiments. Our theoretical and empirical results suggest that a little delay is all we need.

Tuesday, 11AM–12:15 PM

TB32

CC - Room 143

Sustainable Operations

General Session

Session Chair

Adem Orsdemir, University of California-Riverside, Riverside, CA

1 On The Toxic Trade-offs in Ship-recycling

Qinghe Sun, Mabel C. Chou, National University of Singapore, Singapore, Singapore.

In 2021, near 100% of the gross tonnage of the world's retired vessels dismantled globally were broken down by hand on beaches in the South Asian ship recycling yards. Apart from the detrimental environmental impact, this business is also plagued with problems of child labour, workplace death and injuries, ocean pollution, carbon emission and habitat degradation, etc. Many regulations have been proposed to encourage more responsible ship recycling choices, but none seemed to work. We develop an equilibrium framework for analyzing and explaining the trade-offs in the end-of-life (EOL) recycling decision and offer insights into why the regulations that forbid unethical ship recycling were ineffective and why many stakeholders in the shipping community seemingly shut their eyes to the deaths and pollution caused by the beaching practice in the ship recycling business.

2 The Impact of Plastic Bag Laws on Waste

Hai Che[1], Sungjin Kim[2], Adem Orsdemir[3], [1]NULL, Torrance, [2]University of Hawaii at Manoa, Hanolulu, HI, [3]University of California-Riverside, Riverside, CA, Contact: orsdemir@ucr.edu

We empirically study the impact of single-use plastic bag bans on consumer solid waste generation. Using panel data and difference-in-differences analysis with a staggered adoption, we find that plastic bag bans lead to less waste generation.

3 Effects of Mobile Farming on Agricultural Yield: Evidence from India

Campbell Clarkson, Necati Tereyagoglu, Sriram Venkataraman, University of South Carolina, Columbia, SC, Contact: campbell.clarkson@grad.moore.sc.edu

Advancing information and communications technologies (ICTs) provide great opportunity to farmers in developing countries. Ever-increasing demand for food renders services that help improve agricultural production crucial to meeting said demand. ICTs are known to improve market efficiency and price dispersion, but the effects of ICTs on production are less clear. In this paper, we examine the implications of introducing one such ICT platform on agricultural production using quasi-experimental data from India.

4 Optimal Subsidy Policy for Innovation: Technology Push and Demand Pull

Myeonghun Lee[1], Hyun-Soo Ahn[2], Hakjin Chung[3], Sang Won Kim[4], [1]KAIST, Seoul, Korea, Republic of; [2]University of Michigan, Ann Arbor, MI, [3]Korea Advanced Institute of Science and Technology, Seoul, Korea, Republic of; [4]KAIST College of Business, Seoul, Korea, Republic of.

We study how the government should utilize a mix of (R&D) push and (purchase-) pull subsidies to populate beneficial technologies such as electric vehicles and solar panels. We examine how these subsidies and technology spillovers influence the firm's R&D and production strategies, and provide the optimal design of the subsidy policy.

Tuesday, 11AM–12:15 PM

TB33

CC - Room 144

Improving Supply Chains through Game Theory

Contributed Session

Session Chair

Akhil Singla, Northwestern University, Evanston, IL

1 Multi-agent Optimization Using General Sum Stochastic Games in Supply Chains

Peeyush Kumar, Microsoft, Redmond, WA, Contact: peeyush.kumar@microsoft.com

For decision making in a multi-agent supply chain we formulate a stochastic game model that addresses three key features: 1) network-structured player interactions, 2) pair-wise mixed cooperation and competition among players, and 3) limited global information. These features pose significant challenges for black box approaches taken by deep learning-based multi-agent reinforcement learning (MARL) algorithms. We formulate a networked stochastic game with pair-wise general sum objectives & asymmetrical information structure, and empirically explore the effects of information availability on the outcomes from various MARL paradigms. We study some problems associated with solving these networked stochastic games with MARL and discuss its implications for actor critic type algorithms.

2 Additive Manufacturing Processes in An Uncertain Supply Chain During Crisis

Aram Bahrini[1], Robert Riggs[1], Maryam Esmaeili[2], [1]University of Virginia, Charlottesville, VA, [2]Alzahra University, Tehran, Iran, Islamic Republic of. Contact: ab4pn@virginia.edu

Additive manufacturing reduces the uncertainty of yield and demand in a supply chain during a crisis, can respond to the turbulent change in technologies and customer tastes, and satisfies the demand promptly. We consider a supply chain that includes a manufacturer that switches from conventional to a hybrid system and faces random yield and a retailer with random demand influenced by the selling price. We model the interaction between them as a non-cooperative (static and sequential) game and a cooperative game and obtain the optimal value of the key parameters for each model. We propose two incentive contracts to have a coordination between the manufacturer and retailer; revenue sharing and additive manufacturing cost, and provide numerical examples and compare the results.

3 Product-Variety Portfolio Depth in Competitive Environments

Sleiman Jradi[1], Alejandro Lamas[2], Mozart Menezes[3], [1]NEOMA Business School, Mont-Sain-Aignan, France; [2]NEOMA Business School, Mont-Saint Aignan, France; [3]NEOMA Business School, Mont-Saint-Aignan, France. Contact: sleiman.jradi@neoma-bs.fr

We study duopolies where firms compete in terms of their product portfolio sets. We derive analytical results for settings where firms decide portfolio sets simultaneously or in a leader/follower structure (Stackelberg game).

Taking monopolist setting as a benchmark, we prove that this type of competitive environments constitutes a barrier for the proliferation of products. We extend our analysis and conclusions to markets consisting of more firms and to settings of incomplete information for one of the competitors. Moreover, we demonstrate that a firm can benefit from the incomplete information hold by its competitor, in particular, by revealing real or false information of improvements in its production technology.

4 Tactical and Strategic Risks from Supply Chain Disruptions

Wallace J. Hopp[1], Seyed Iravani[2], Zigeng Liu[3], Akhil Singla[2], [1]University of Michigan, Ann Arbor, MI, [2]Northwestern University, Evanston, IL, [3]University of Wisconsin-Madison, Jersey City, NJ, Contact: akhilsingla@u.northwestern.edu

Supply chain disruptions can lead to both tactical (loss of short-term sales) and strategic (loss of long-term market share) consequences. In this paper, we model the impact of regional supply disruptions on competing supply chains. We describe generic strategies that consist of two stages: (1) *preparation*, which involves investment prior to a disruption in dedicated backup capacity, and (2) *response*, which involves post-disruption purchase of shared (non-dedicated) backup capacity for a component whose availability has been compromised. Using expected loss of profit due to lack of preparedness as a measure of risk, we characterize the conditions that pose the greatest risk and suggest ways to reduce risk exposure.

Tuesday, 11AM–12:15 PM

TB34

CC - Room 145

Water Quality and Associated Issues

Contributed Session

Session Chair

Sandra Buzon-Vargas, Texas A&M University, College Station, TX

1 Monitoring and Controlling Water Quality in Commercial and Institutional Buildings

Kiarash Ghasemzadeh[1], Pitu Mirchandani[1], Treavor Boyer[2], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, AZ, Contact: kghasemz@asu.edu

One of the main health needs of the human body is drinking water of sufficient quality. The water that is considered safe for drinking has defined limits for its contaminants which are federally imposed by the Environmental Protection Agency. The water usually takes a long time to reach the end-user, possibly degrading the initial water quality, thus, can end up being unsafe for drinking. This further motivates the need for developing a predictive feedback control system that assures that the water contaminants to always be within the regulatory limits. Therefore, this research, first, investigates the functions that can be used to predict the water quality, then, creates a feedback control system that proactively maintains and controls the water quality by making optimal control decisions on additives, filtering, flushing, and other available control actions.

2 Investigating Observability and Controllability of Water Quality Dynamics in Water Networks

Salma ElSherif[1], Ahmad Taha[2], [1]Vanderbilt University, Nashville, TN, [2]Vanderbilt University, Nashville, TN, Contact: salma.m.elsherif@vanderbilt.edu

Water distribution networks (WDN) are considered vulnerable to health violations and contamination events. To better predict such events, a real-time dynamic model—based on PDEs that capture transport and reaction of contamiants and disinfectants—can be instrumented. Such model is essentially a dynamic- and network-theoretic representation of water quality (WQ) states throughout a WDN. Although this model has been thoroughly studied in the recent literature, its control-theoretic properties (stability, controllability, and observability) are neither studied nor understood. Consequently, the objective of this work is to investigate and understand control-theoretic properties of WQ models in drinking WDN. This understanding yields improved placement of decontamination stations, WQ sensors, and ultimately better real-time regulation of water quality.

3 Optimal Production Policy when Considering Environmental Regulation and Social Conflict

Sandra Buzon-Vargas[1], Harry Neil Geismar[2], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: sbuzon@mays.tamu.edu

Given the use of natural resources, extractive industries face recurring community pressures. While the causes of environmental hurdles vary, the most common causes of conflict are pollution and access to natural resources. Such conflicts directly affect a company's financial performance by increasing operational costs. Although company-community disputes can incur the same costs as technical, contractual, regulatory, or environmental issues, such incidents do not receive the same attention. By using an optimal control model, this research aims to analyze a firm's optimal production planning decisions, considering regulatory water pollution limits and the impact of conflict with the community.

Tuesday, 11AM–12:15 PM

TB36

CC - Sagamore 2
INFORMS Prize
Award Session

1 **2022 INFORMS Prize: Wayfair**
Ali Vanderveld, Scott Collins, Rudi Natarajan, Wayfair, Boston, MA
Wayfair believes everyone should live in a home they love. Through technology Wayfair makes it possible for shoppers to quickly and easily find exactly what they want from a selection of more than twenty-two million items. Today, algorithmic models are utilized across a spectrum of functions, and in this talk we'll cover three areas Wayfair is leveraging advanced algorithms: In our Marketing, in how we recommend products to customers, and in how we empower suppliers and our marketplace with product information extraction and accelerate winning products.

Tuesday, 11AM–12:15 PM

TB37

CC - Sagamore 6
Optimization Techniques for Decision Making under Risk
General Session

Session Chair
Ashish Chandra, Illinois State University, Normal, IL

1 **Machine Learning Informed Optimization of Cvar**
Junyao Yang[1], Alexander Vinel[2], [1]Auburn University, Auburn, AL, [2]Auburn University, Auburn, AL
We consider the problem of portfolio optimization with Conditional Value-at-Risk (CVaR), that is further informed by an available predictive model. Using financial portfolio optimization as the main example, we propose a way to incorporate asset return forecast into optimization. We demonstrate that the proposed approach shows a promising computational performance in a case study based on historic data.

2 **A Deep Reinforcement Learning Approach to Solving The Multidimensional Knapsack Problem**
Sabah Bushaj[1], Esra Buyuktahtakin Toy[2], [1]SUNY Plattsburgh, Plattsburgh, NY, [2]New Jersey Institute of Technology, Newark, NJ
We address the difficulty of solving the multidimensional knapsack problem (MKP) by presenting a novel deep reinforcement learning (DRL) framework. We combine dimension reduction techniques and heuristics to simplify large instances. We then propose a Deep Reinforcement Learning (DRL) framework where we aim to train different agents compatible with a discrete action space for sequential decision making while still satisfying any resource constraint of the MKP. Our DRL framework shows that it can solve medium-sized instances at least 45 times faster in CPU solution time and at least 10 times faster for large instances with a maximum solution gap of 0.28% compared to the performance of CPLEX. Furthermore, at least 95% of the items are predicted in accordance with the CPLEX solution.

3 **Learning to Solve Multistage Optimization Problems with An Expendable Framework**
Dogacan Yilmaz, Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Newark, NJ, Contact: dy234@njit.edu
We present an integrated learning-optimization framework to solve decision-making problems in a multistage setting. We utilize a local attention-based neural machine translation architecture to learn from and predict the optimal solutions to NP-hard problems. We propose an iterative strategy to eliminate infeasible predictions and present computational results for two fundamental combinatorial optimization problems: multistage knapsack and capacitated lot-sizing. We compare our framework with other exact and heuristic approaches and show that the solution time can be reduced by four orders of magnitude with a very small optimality gap. Our framework can be used to speed up the solutions of NP-hard problems significantly where problems with similar structures are solved repeatedly.

4 **SASA+: Adaptive Fixed-step Stochastic Gradient**
Raghu Pasupathy, Purdue University, West Lafayette, IN
A folklore \emph{adaptive fixed step} stochastic gradient algorithm works as follows. Execute SG with a fixed step $\eta >0$ until the iterates approach stationarity, then

re-execute SG starting from last iterate of the previous execution but with the revised fixed step $\eta \leftarrow \beta_0\eta, \beta_0 <1$ until the iterates again approach stationarity, and so on. This restart scheme is attractive because (i) it is simple to implement, and (ii) each execution of SG attains stationarity \emph{exponentially fast}. A particular version of this scheme was originally conceived by Georg Pflug in 1983, and enhancements, e.g., SASA~(Lang et al., 2019), during 2018--2021 have reported surprisingly positive numerical results. We build on these variations by constructing a mechanism to rigorously detect when each execution of fixed step SG attains stationarity.

Tuesday, 11AM–12:15 PM

TB38

CC - Sagamore 7

Theory, Algorithms, and Applications of Multistage Optimization II

General Session

Session Chair

Shixuan Zhang, Georgia Institute of Technology, Atlanta, GA

Session Chair

Andy Sun, MIT, Catonsville, MD

1 SDDp and Model Predictive Control

Andy Philpott, Dominic Keehan, University of Auckland, Auckland, New Zealand.

The Stochastic Dual Dynamic Programming algorithm (SDDP) has evolved to become a popular approach to computing approximate solutions to convex stochastic optimal control problems with stagewise independent noise. In SDDP, a sample average approximation yields a massive finite convex program that is solved approximately using sampling and cutting planes. SDDP solutions are defined as policies, i.e. functions of observed state variables. In contrast, model predictive control (MPC) takes expectations of random variables and solves the resulting deterministic control problem. MPC solutions are implemented in a rolling horizon framework, and their simplicity makes them popular in practice. We explore some settings in which MPC solutions perform well out-of-sample for the stochastic problem, in an attempt to provide some further grounds for this popularity.

2 Planning Under Uncertainty with Emphasis on Risk and Markov Decision Processes

Golbon Zakeri, University of Massachusetts - Amherst, Amherst, MA

Long, medium and short term stochastic processes underpin many real world operations research problems. Examples include forestry applications as well as energy planning and operations. The latter is increasingly difficult to model and solve to optimality, given the varying granularity of time scales involved and the increasing uncertainty (as we strive towards zero emission goals, more volatile renewable generation is absorbed into the grid). In this presentation we will discuss reconciliation of long term planning and short term operations in energy with emphasis on Markov Decision Processes.

3 Deterministic Upper Bounds for Risk-averse Multistage Stochastic Programs

Bernardo Freitas Paulo da Costa[1], Vincent Leclere[2], [1]UFRJ, Rio de Janeiro, Brazil; [2]Ecole des ponts ParisTech, Berkeley, France. Contact: bernardofpc@im.ufrj.br

Risk-averse multistage stochastic programs appear in multiple areas and are challenging to solve. Stochastic Dual Dynamic Programming (SDDP) is a well-known tool to address such problems under time-independence assumptions.
We show how to derive a dual formulation for these problems and apply an SDDP algorithm, leading to converging and deterministic upper bounds for risk averse problems. We will present examples comparing this method to other approaches proposed in the literature.

4 Dual Dynamic Programming for Data Driven Distributionally Robust Multistage Convex Optimization

Shixuan Zhang[1], Andy Sun[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]MIT, Catonsville, MD

In this talk, we consider distributionally robust multistage convex optimization (DR-MCO) with Wasserstein ambiguity sets constructed from stagewise independent empirical distributions. We show that the DR-MCO models have favorable out-of-sample performance guarantee and adjustable level of in-sample conservatism. Then we extend the dual dynamic programming algorithm for the data driven DR-MCO with complexity analysis based on single stage subproblem oracles, for which we provide two possible implementations exploiting convexity or concavity of the uncertain cost functions. Numerical experiments on inventory control problems and hydrothermal energy system planning problems are conducted to show the effectiveness of our DR-MCO, in comparison with the widely used risk-neutral and risk-averse multistage stochastic optimization approaches.

Tuesday, 11AM–12:15 PM

TB39

CC - Room 201
Using Optimization to Maximize Equity
General Session

Session Chair
Drew Horton, [1</sup]

1 Modeling Equity for Park Access: A Case Study of Asheville, North Carolina

Emily L. Tucker[1], Anisa Young[1], Mariela Fernandez[2], Robert Bookover[2], David White[2], Brandon Harris[3], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, [3]University of Arizona, Tucson, AZ, Contact: etucke3@clemson.edu

The current allocation of parks and green spaces is not equitably distributed. Platforms currently exist to identify the geographical areas whose marginalized residents lack sufficient access to parks. However, these platforms do not yet integrate the variety of environmental, health, demographic, infrastructural, monetary, and dimensional factors to guide decisions of future park locations. To support park and government agencies in their aims to improve the distribution and quality of green spaces, we propose a mixed-integer program that maximizes park access across different dimensions of equity. We present a case study of park selection in Asheville, NC.

2 Quantifying and Minimizing The Inequality of Election Locations

Josh Murrell, Naval Postgraduate School, Monterey, CA

Polling locations can be unequally distributed even if there is intent to improve access. We develop a facility location integer program to decide where to open precincts with the objective of minimizing the Kolm-Pollak Equally Distributed Equivalent (EDE) - an inequality aversion metric that captures the benefits of a statistical mean and standard deviation in a single statistic. We develop a linear proxy for the EDE that allows us to optimize the EDE exactly with the same computational burden as minimizing the population-weighted average distance. We employ the EDE in two ways: to compare the impact of a vital Supreme Court ruling, and to optimize precinct locations in select cities. Computational experiments demonstrate that optimizing over the EDE results in a much more equitable distribution while maintaining a nearly-optimal population-weighted average distance.

3 Optimizing for Equity

Drew Horton[1], Josh Murrell[2], Daphne Skipper[3], Emily Speakman[1], [1]University of Colorado Denver, Denver, CO, [2]Naval Postgraduate School, Monterey, CA, [3]United States Naval Academy, Annapolis, MD, Contact: skipper@usna.edu

In the environmental justice literature, the Kolm-Pollak Equally Distributed Equivalent (EDE) is the preferred metric for quantifying the experience of a population. This metric, which incorporates both the center and the spread of a distribution, captures the experience of an "average" individual more accurately than the population mean. We present models and discuss implementation details for optimizing over the nonlinear Kolm-Pollak EDE in a few practical contexts. Computational results demonstrate that optimizing over the Kolm-Pollak EDE in a standard facility location model has the same computational burden as optimizing over the population mean. Moreover, it often results in solutions that are significantly more equitable while having little impact on the mean of the distribution, versus optimizing over the mean directly.

4 Hungry for Equality: Fighting Food Deserts with Optimization

Drew Horton[1], Daphne Skipper[2], Tom Logan[3], Emily Speakman[4], [1]University of Colorado Denver, Denver, CO, [2]United States Naval Academy, Annapolis, MD, [3]University of Canterbury, Christchurch, New Zealand; [4]University of Colorado Denver, Denver, CO

Facility location models are well-studied problems which find the optimal locations to place a given number of facilities so that the cost to serve the customer population is minimized. Traditionally, we define cost as the total distance from each member of the population to their closest open facility. However, in modern applications, such as optimizing new supermarket locations to mitigate food deserts, a different measure of cost is needed. This is because we care not only about the average distance someone must travel to a grocery store but also the variance in that distribution. In this talk, we demonstrate how the Kolm-Pollak equally-distributed equivalent can be used as the objective function in a facility location formulation to minimize both average distance and inequity in the distribution. We present results for grocery store location in various major US cities.

Tuesday, 11AM–12:15 PM

TB40

CC - Room 202
Algorithms for Semidefinite Programming and Applications to Machine Learning

General Session

Session Chair
Georgina Hall, INSEAD, Fontainebleau, France.

1 **Worst-Case Analysis of Neural Networks Using Semidefinite Programming**
Mahyar Fazlyab, John Hopkins University
Neural Networks have become increasingly effective at many difficult machine-learning, optimization, and control tasks. However, the nonlinear and large-scale nature of neural networks makes them hard to analyze, and, therefore, they are mostly used as black-box models without formal guarantees. In this talk, we present a novel framework based on quadratic constraints and semidefinite programming that can provide certificates of stability, safety, and robustness for neural networks.

2 **Sums of Separable and Quadratic Polynomials**
Georgina Hall[1], Amir Ali Ahmadi[2], Cemil Dibek[2], [1]INSEAD, Fontainebleau, France; [2]Princeton University, Princeton, NJ, Contact: georgina.hall@insead.edu
We consider in this talk separable plus quadratic (SPQ) polynomials, i.e., polynomials that are the sum of univariate polynomials in different variables and a quadratic polynomial. Motivated by the fact that nonnegative separable and nonnegative quadratic polynomials are sums of squares, we answer two questions around SPQ polynomials: namely, whether nonnegative SPQ polynomials are (i) the sum of a nonnegative separable and a nonnegative quadratic polynomial, and (ii) a sum of squares. We also present applications of SPQ polynomials to upper bounding sparsity of solutions to linear programs and a generalization of Newton's method which incorporates separable higher-order derivative information.

3 **Block Factor-width-two Matrices and Their Applications to Semidefinite and Sum-of-squares Optimization**
Yang Zheng[1], Aivar Sootla[2], Antonis Papachristodoulou[2], [1]University of California San Diego, San Diego, CA, [2]University of Oxford, Oxford, United Kingdom. Contact: zhengy@eng.ucsd.edu
Semidefinite and sum-of-squares (SOS) optimization are fundamental computational tools in many areas. However, the scale of problems that can be addressed reliably and efficiently is still limited. In this talk, we introduce a new notion of block factor-width-two matrices and build a new hierarchy of inner and outer approximations of the cone of positive semidefinite (PSD) matrices. This notion is a block extension of the standard factor-width-two matrices and allows for an improved inner approximation of the PSD cone. In the context of SOS optimization, this leads to a block extension of the scaled diagonally dominant sum-of-squares (SDSOS) polynomials. By varying a matrix partition, the notion of block factor-width-two matrices can balance a trade-off between the computation scalability and solution quality for solving semidefinite and SOS optimization problems.

4 **Random Projection of Linear and Semidefinite Problem with Linear Inequalities**
Pierre-Louis Poirion[1], Bruno Lourenço[2], Akiko Takeda[3], [1]RIKEN, Tokyo, Japan; [2]The Institute of Statistical Mathematics, Tachikawa-Shi, Japan; [3]University of Tokyo, Tokyo, Japan. Contact: pierre-louis.poirion@riken.jp
The Johnson-Lindenstrauss Lemma allows projecting a set of points of a vector space into a space of much lower dimension such that the Euclidean distance between these points is approximately preserved. This lemma has been previously used to prove that we can randomly aggregate, using a random matrix whose entries are drawn from a zero-mean sub-Gaussian distribution, the equality constraints of a Linear Program (LP) while preserving approximately the value of the problem. In this talk, we extend these results to the inequality case by introducing a random matrix with non-negative entries that allows to randomly aggregate inequality constraints of an LP or a SDP while preserving approximately the value of the problem.

Tuesday, 11AM–12:15 PM

TB41

CC - Room 203
Algorithm and Inference for Modern Data Science
General Session

Session Chair
Ethan Xingyuan Fang, Pennsylvania State University, University Park, PA

1 **Pessimism in The Face of Confounders: Provably Efficient Offline Reinforcemet Learning in Pomdps**
Miao Lu[1], Yifei Min[2], Zhaoran Wang[3], Zhuoran Yang[2], [1]Peiking University, Beijing, China; [2]Yale University, New Haven, CT, [3]Northwestern University, Evanston, IL
We study offline reinforcement learning (RL) in partially observable Markov decision processes. In particular, we aim to learn an optimal policy from a dataset collected

by a behavior policy that possibly depends on the latent state. Such a dataset is confounded in the sense that the latent state simultaneously affects the action and the observation, which is prohibitive for existing offline RL algorithms. To this end, we propose the Proxy variable Pessimistic Policy Optimization (P3O) algorithm, which addresses the confounding bias and the distribution shift between the optimal and behavior policies in the context of general function approximation. At the core of P3O is a coupled sequence of pessimistic confidence sets constructed via proximal causal inference, which is formulated as minimax estimation and enables us to prove a $\sqrt{n}$-suboptimality bound.

2 When Will You Become The Best Reviewer of Your Own Papers? a Truthful Owner-assisted Scoring Mechanism

Weijie Su, University of Pennsylvania, Philadelphia, PA

Alice owns a few items and has knowledge of the underlying quality of her items. Given noisy grades provided by independent agents, can Bob obtain accurate estimates of the ground-truth grades of the items by asking Alice a question? This talk addresses this when the payoff of Alice is additive convex utility over all her items. First, if Alice would truthfully answer the question because by doing so her payoff is maximized, we show that the questions must be formulated as pairwise comparisons between her items. Moreover, if Alice is required to provide a ranking of her items, which is the most fine-grained question via pairwise comparisons, we prove that she would be truth-telling. Using the ranking, we show that Bob can obtain an estimator with the optimal squared error. Finally, we conclude the talk with several extensions and some refinements for practical considerations.

3 Random Graph Matching: Fundamental Limits and Efficient Algorithms

Sophie Yu[1], Cheng Mao[2], Yihong Wu[3], Jiaming Xu[4], [1]Duke University, Durham, NC, [2]Georgia Institute of Technology, Atlanta, GA, [3]Yale University, New Haven, CT, [4]Duke University, Durham, NC, Contact: haoyang.yu@duke.edu

This talk focuses on the detection and recovery problems of matching two Erdos-Renyi random graphs. For detection, we aim to decide whether the two observed graphs are independent, or edge-correlated under some latent node correspondence. For recovery, our goal is to recover the latent node correspondence, given the two graphs are edge-correlated. In the dense graph regime, we prove that both detection and recovery exhibit an "all-or-nothing" phase transition at a sharp threshold. For sparse graphs, we identify the information-theoretic threshold within some constant factor. Meanwhile, we propose new algorithms for both detection and recovery problems based on counting the co-occurrences of signed trees for a family of non-isomorphic trees. Our algorithms significantly improve the prior work in terms of statistical accuracy, running time, and graph sparsity.

4 Adaptive Diffusion-based Deep Generative Models

Mingyuan Zhou, University of Texas-Austin, Austin, TX

Deep generative models (DGMs) have achieved impressive results in synthesizing photorealistic images. In this talk, I will describe two adaptive diffusion-based strategies to build DGMs that are not only stable to train but also fast to generate. To address the issues of diffusion models, we have developed truncated diffusion probabilistic models that incorporate adversarial training to substantially shorten the reverse diffusion chain while maintaining high generation quality. To address the issues of GANs, we have developed adaptive diffusion to optimize the operating conditions of the GAN discriminator and induce model- and domain-agnostic differentiable data augmentation, boosting the performance of several recently proposed GANs. I will present example results on data generation to demonstrate the working mechanisms and advantages of adaptive diffusion.

Tuesday, 11AM–12:15 PM

TB42

CC - Room 204

Optimization and Surrogate Methods for Black-box Systems I

General Session

Session Chair

Hadis Anahideh, University of Illinois at Chicago, Chicago, IL

1 GOSS RBF Optimization Algorithm for Higher Dimensionalexpensive Multimodal Blackbox Functions , Christine Shoemaker and Limeng Liu

Christine Annette Shoemaker, Limeng Liu, National University of Singapore, Singapore, Singapore.

GOSS is a new algorithm Surrogate optimization algorithm , that solves problems with box constraints and a computational expensive, black box objective function. GOSS has a radial basis function (RBF) based surrogate method that focuses on higher dimensional and computationally expensive objective functions that can be multimodal. GOSS introduces three new techniques, not previously used in combination in earlier RBF algorithms, including using the surrogate's gradient information, coordinates' knowledge level, and fewer initial sampling points. Numerical results on a test set including 14 test problems with 36, 48 and 60 dimensions show that GOSS outperforms two recently published cutting edge algorithms RBFOpt and TuRBO and an earlier RBF algorithm. GOSS algorithm also has good performance on a real-world optimization problems.

2 Surrogate Model Based Optimization for Finding Robust Deep Learning Model Architectures

Juliane Mueller, Vincent Dumont, Xiangyang Ju, Lawrence Berkeley National Lab, Berkeley, CA, Contact: juliane.mueller2901@gmail.com

Deep Learning (DL) models are increasingly used throughout the sciences. However, their performance and usefulness depend greatly on their architecture which is defined by hyperparameters such as the number of nodes, layers, the learning rate, etc. Tuning these hyperparameters is time-consuming because evaluating their performance requires a lengthy training step. Stochastic optimizers used in training lead to performance variability and potentially prediction reliability issues. In this talk, we will describe an automated optimization method based on surrogate models and active learning strategies for tuning DL model architectures. We take into account the prediction variability with the goal to identify architectures that make reliable and robust predictions. We demonstrate our developments on an application arising in particle physics.

3 EUBO: A Principled Decision-Theoretic Acquisition Function for Preferential Bayesian Optimization

Raul Astudillo, California Institute of Technology, Pasadena, CA, Contact: ra598@cornell.edu

Preferential Bayesian optimization (PBO) is a framework for optimizing a decision maker's (DM's) latent utility function using preference feedback. This work introduces the expected utility of the best option (EUBO) as a novel acquisition function for PBO. When the DM's responses are noise-free, we show that EUBO is one-step Bayes optimal and thus equivalent to the popular knowledge gradient acquisition function. We also show that EUBO enjoys an additive constant approximation guarantee to the one-step Bayes optimal policy when the DM's responses are corrupted by noise. In numerical experiments, EUBO significantly outperforms the state-of-the-art acquisition functions for PBO. Enjoying a superior performance, simple computation, and a grounded decision-theoretic justification, EUBO positions as a promising acquisition function for PBO.

4 Learning The Hyperparameters for Surrogate Optimization

Nazanin Nezami[1], Hadis Anahideh[2], [1]University of Illinois at Chicago, CHICAGO, IL, [2]University of Illinois at Chicago, Chicago, IL, Contact: nnezam2@uic.edu

Surrogate Optimization (SO) algorithms for expensive Black-Box functions involve many hyperparameters that are associated either with the sampling core and/or the surrogate fitting steps. In this project, we first aim to investigate the impact of such hyperparameters on the performance of various surrogate optimization algorithms and their challenges over a wide range of problems. We then introduce a novel approach that learns the hyperparameters for SO algorithms. Given a specific problem and a SO approach, our proposal can adaptively adjust the hyperparameters and learn the underlying mapping between the hyperparameters and the algorithm outcome. The goal is to make these algorithms more accessible to SO practitioners by automating the choice of hyperparameters while ensuring the effectiveness and faster convergence of SO algorithms.

Tuesday, 11AM–12:15 PM

TB43

CC - Room 205

Decision-making Under Uncertainty

General Session

Session Chair

Vishal Gupta, University of Southern California, Los Angeles, CA

Session Chair

Michael Huang, University of Southern California, Los Angeles, CA

1 Assessing External Validity over Worst-Case Subpopulations

Hongseok Namkoong, Columbia University, New York, NY

Typical study populations come from limited points in space and time, and marginalized groups are underrepresented. To assess the external validity of randomized and observational studies, we propose and evaluate the worst-case treatment effect (WTE) across all subpopulations of a given size, which guarantees positive findings remain valid over subpopulations. We develop a semiparametrically efficient estimator for the WTE that analyzes the external validity of the augmented inverse propensity weighted estimator for the average treatment effect. Our method leverages flexible ML-based estimates of nuisance parameters and achieves central limit rates even when nuisance estimates converge more slowly. In real examples where external validity is of core concern, our framework guards against brittle findings invalidated by unanticipated subpopulation shifts.

2 Overbooking with Bounded Loss

Daniel Freund[1], Jiayu Zhao[2], [1]MIT, Cambridge, MA, [2]MIT, Chengdu Sichuan, China. Contact: dfreund@mit.edu

We study a classical problem in revenue management: quantity-based single-resource revenue management with no-shows. In this problem, a firm observes a sequence of T customers requesting a service. Each arrival is drawn independently from a known distribution of k different types, and the firm needs to decide irrevocably whether to accept or reject requests in an online fashion. The firm has a capacity of resources B, and wants to maximize its profit. Each accepted service request yields a type-dependent revenue and has a type-dependent probability of requiring a resource once all arrivals have occurred. If the number of accepted arrivals that require a resource at the end of the horizon is greater than B, the firm needs to pay a fixed compensation for each service request that it cannot fulfill. We provide the first algorithm with a uniform additive loss bound for this problem.

3 Optimal Product Replacement with Pair Cross-effects

Manuel Moran-Pelaez[1], Georgia Perakis[2], Tamar Cohen-Hillel[3], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]UBC Sauder School of Business, Vancouver, BC, Canada. Contact: mmoranp@mit.edu

Fast fashion retailers perform very frequent product replacements in what they offer to their customers to quickly adapt to new trends, and to create product scarcity. We will focus on the product replacement problem in order to develop optimal policies for the two main decision makers in this problem: the headquarters (central decisions in the supply chain) and the store managers (responsible for each store). The retailer sends new items to the stores frequently with the expectation that store managers will immediately make room and display these new products on the floor of the store. We develop interpretable policies that are robust against predictable behaviors of the other decision maker, and that consider product cross-effects.

4 Policy Evaluation and Learning in Small-data, Weakly-coupled Settings

Michael Huang[1], Vishal Gupta[1], Paat Rusmevichientong[2], [1]University of Southern California, Los Angeles, CA, [2]USC Marshall School of Business, Los Angeles, CA, Contact: huan076@usc.edu

For optimization problems in small-data, large-scale settings, leveraging problem structure is crucial to learning effective, data-driven policies. We propose a novel debiasing method for policy evaluation and learning tailored to weakly-coupled problems and policies in small-data, large-scale settings. Unlike cross-validation, our method does not sacrifice training data for policy evaluation. We prove our method is asymptotically optimal as the problem size grows, even if data are limited. Our results illuminate how the degree of coupling in the problem affects our method's performance. We illustrate our results for a general class of angular, linear optimization problems.

Tuesday, 11AM–12:15 PM

TB44

CC - Room 206

Generalized Submodularity in Optimization

General Session

Session Chair

Kim Yu, 1</sup

1 Sequential Competitive Facility Location: Exact and Approximate Algorithms

Mingyao Qi[1], Ruiwei Jiang[2], Siqian Shen[2], [1]Tsinghua University, Shenzhen, China; [2]University of Michigan, Ann Arbor, MI, Contact: ruiwei@umich.edu

We study a competitive facility location problem (CFLP), in which two firms sequentially select locations of new facilities, in order to maximize their market shares of customer demand that follows a probabilistic choice model. This process is a Stackelberg game and admits a bilevel mixed-integer nonlinear program (MINLP) formulation. Through integer programming methods, we derive an equivalent, single-level MINLP reformulation. In addition, we exploit the problem structures and derive two classes of valid inequalities, one based on submodularity and the other based on concave overestimation. We apply these inequalities in a branch-and-cut algorithm to find a globally optimal solution to CFLP. Furthermore, we propose an approximation algorithm for solving CFLP that is computationally more effective. This algorithm admits a constant approximation guarantee.

2 A Spatial Branch-and-bound Approach for Global Maximization of Monotone Continuous Dr-submodular Functions

Hugh Medal[1], Izuwa Ahanor[2], [1]University of Tennessee, Knoxville, TN, [2]The University of Tennessee, Knoxville, TN, Contact: hmedal@utk.edu

We study how to find the globally maximizer of a non-decreasing continuous submodular function subject to box constraints. We first develop a description of the hypograph of such functions and develop a cutting plane algorithm that finds approximate solutions and bounds. Next, we develop a spatial branch-and-bound approach that utilizes the approximate cutting plane algorithm to form an outer approximation and obtain upper bounds for a region. We present computational results for several continuous submodular functions and compare our method with a state-of-the-art solver.

3 Fast First-order Methods for Monotone Strongly Dr-submodular Maximization

Omid Sadeghi, Maryam Fazel, University of Washington, Seattle, WA, Contact: omids@uw.edu

Continuous DR-submodular functions are a class of functions that satisfy the Diminishing Returns (DR) property, which implies that they are concave along non-negative directions. In many applications, e.g., computing the stability number of graphs, the DR-submodular function has the additional property of being *strongly* concave along non-negative directions that could be utilized for obtaining faster convergence rates. In this talk, we first introduce and characterize the class of *strongly DR-submodular* functions and show how such a property implies strong concavity along non-negative directions. Then, we study smooth monotone strongly DR-submodular functions that have bounded curvature, and we show how to exploit such additional structure to obtain algorithms with improved approximation guarantees and faster convergence rates for the maximization problem.

4 On Constrained Mixed-integer DR-submodular Minimization

Qimeng Yu, Simge Kucukyavuz, Northwestern University, Evanston, IL

Submodular set functions play an important role in integer programming and combinatorial optimization. Increasingly, applications in resource allocation and machine learning have led to generalized submodular functions defined over integer or continuous domains. In our study, we focus on the notion of Diminishing Returns (DR) submodularity and the problem of minimizing DR-submodular functions over mixed-integer feasible sets defined by box constraints and monotonicity constraints. We derive the full convex hull description of the epigraph of DR-submodular functions under the aforementioned constraints, which does not rely on pseudo-polynomial expansions that are commonly used in the existing literature. We provide an exact separation algorithm for our proposed inequalities and first establish the polynomial time complexity of this class of problems.

Tuesday, 11AM–12:15 PM

TB45

CC - Room 207

First Order Methods, Machine Learning, and Beyond

General Session

Session Chair

Shuvomoy Das Gupta, MIT, Cambridge, MA

Session Chair

Bart Paul Gerard Van Parys, MIT Sloan School of Management, Cambridge, MA

1 Branch-and-bound Performance Estimation Programming: A Unified Methodology for Constructing Optimal Optimization Methods

Shuvomoy Das Gupta[1], Bart Paul Gerard Van Parys[2], Ernest K. Ryu[3], [1]MIT, Cambridge, MA, [2]MIT, Cambridge, MA, [3]Seoul National University, Seoul, Korea, Republic of. Contact: sdgupta@mit.edu

We present the Branch-and-Bound Performance Estimation Programming (BnB-PEP), a unified methodology for constructing optimal first-order methods for convex and nonconvex optimization. BnB-PEP poses the problem of finding the optimal method as a nonconvex but practically tractable quadratically constrained quadratic optimization problem and solves it to certifiable global optimality using a customized branch-and-bound algorithm. BnB-PEP offers significantly more flexibility and removes the many limitations of the prior methodologies. Our customized branch-and-bound algorithm outperforms the latest off-the-shelf implementations by orders of magnitude. We apply BnB-PEP to several important setups and obtain methods improving upon prior state-of-the-art results. Finally, we apply BnB-PEP to systematically generate analytical convergence proofs.

2 Non-nesterov Acceleration Methods in First-order Optimization

Ernest Ryu, Seoul, Seoul, Korea, Republic of. Contact: ernestryu@snu.ac.kr

In this talk, we present recent advances in accelerated methods for making gradients small in convex optimization, fixed-point iterations, and convex-concave minimax optimization. These acceleration mechanisms are distinct from Nesterov's acceleration. We will discuss the interaction between the computer-assisted performance estimation problem methodology and the non-computer-assisted Lyapunov analyses utilized in the discovery and analysis of these methods.

3 Universal Regression with Adversarial Responses

Moise Blanchard, Patrick Jaillet, Massachusetts Institute of Technology, Cambridge, MA, Contact: moiseb@mit.edu

We provide algorithms for regression with adversarial responses under non-iid instance sequences, on general spaces, with *provably minimal* assumptions. We consider *universal consistency* which asks for strong consistency of a learner without restrictions on value responses. Our analysis shows that this is achievable for a much larger class than stationary processes, and unveils an important dichotomy between value spaces: whether finite-horizon mean-estimation is achievable or not. We then provide *optimistically universal* algorithms: such that if they fail to achieve universal consistency, any other algorithm will fail as well. For unbounded losses, we propose an integrability condition under which there exist algorithms for adversarial regression. In addition, we provide algorithms for general adversarial mean-estimation without any moment assumptions.

4 Holistic Robust Machine Learning and Data-driven Decision-making

Amine Bennouna[1], Bart Paul Gerard Van Parys[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]MIT Sloan School of Management, Cambridge, MA, Contact: amineben@mit.edu

We analyze how to robustify machine learning models against the most common sources of ``overfitting'' which prevent good generalization performance. We identify three sources: statistical error, noise, and misspecification. Existing formulations are typically robust only against one of these three sources while ignoring the others and hence fail to provide holistic protection against overfitting. We design a novel data-driven formulation which is robust against these three sources of overfitting simultaneously. We furthermore prove that our formulation is an essentially optimal formulation as far as protection against the identified overfitting sources is concerned. Our formulation is based on distributionally robust optimization and more specifically on a novel combination of Kullback-Leibler and Levy-Prokhorov ambiguity sets.

Tuesday, 11AM–12:15 PM

TB46

CC - Room 208

Decentralized Traffic Signal Control and Management

General Session

Session Chair

Liu Hao, Penn State

1 Ped-mp: A Pedestrian-friendly Distributed Network Signal Control Policy

Te Xu[1,2], Yashveer Bika[3], Michael Levin[1], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, [3]University of Minnesota, Minneapolis, MN

Max-pressure signal control has been analytically proven to maximize the network throughput and stabilize queue lengths whenever possible. However, previous work on max-pressure signal control does not include pedestrian access, which may increase pedestrians' travel time and delay or even encourage some dangerous behaviors, like jaywalking. In this paper, we propose a pedestrian-friendly max-pressure signal control named Ped-MP that considers pedestrian access in an urban network to achieve maximum stability for private vehicles and a safe walking experience. Simulation results indicate that the pedestrians' travel time and delay can be reduced.

2 A Travel Delay Based Max Pressure Algorithm

Hao Liu[1], Vikash Gayah[2], [1]The Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, Contact: hfl5376@psu.edu

The implementation of Max Pressure algorithm in traffic signal control problems has been vastly studied recently due to its ease of implementation and scalability to large network scenarios. Although travel delay is one of the most commonly used measures of effectiveness in traffic control problems, the study of using travel delay to define pressure, which determines signal timing, is not sufficient. This paper considers a travel-delay-based Max Pressure algorithm for control of transportation networks with signalized intersections. The proposed model is shown to outperform several benchmark Max Pressure variants in simulation tests. Lastly, the proposed algorithm can be implemented in a Connected Vehicle (CV) environment. The results show the proposed model generates lower delay with non-full penetration rate than the benchmark models with full penetration rate.

3 Distributed Traffic Light Control in Connected Urban Street Networks with Partial Connected Vehicle Information

Ali Hajbabaie[1], SMA Bin Al Islam[2], [1]North Carolina State University, Raleigh, NC, [2]Amazon, Seattle, WA
This study presents a distributed methodology to optimize signal timing parameters in urban street networks in real-time. The approach integrates connected vehicle data with loop detector data to improve observability in transportation networks. The approach distributes a network-level problem to several intersection-level subproblems to reduce computational complexity and creates effective coordination among them to promote system optimal decision making. Numerical results show that the approach is efficient and the solutions are effective.

Tuesday, 11AM–12:15 PM

TB47

CC - Room 209
TSL Mid-career and Lifetime-award Session
Award Session

Session Chair
Anna B. Nagurney, University of Massachusetts-Amherst, Amherst, MA

Session Chair
Jan Fabian Ehmke, University of Vienna, Wien, Austria.

Stella Dafermos Mid-Career Award Presentation

Award Presenter, IN
The winner of the Stella Dafermos Mid-Career Award will provide an overview of their work. The winner will be announced at the TSL Business Meeting. More details on the award can be found here: https://connect.informs.org/tsl/awards/dafermos-application

Robert Herman Lifetime Achievement Award Presentation

Warren B. Powell, Princeton University, Princeton, NJ
The winner of last year's Herman Lifetime Achievement Award, Prof. Warren Powell, will provide an overview of his work and recent trends in transportation research. More details on the award can be found here: https://connect.informs.org/tsl/awards/lifetime-application

Tuesday, 11AM–12:15 PM

TB48

CC - Room 210
Revenue Management and Pricing
Contributed Session

Session Chair
Jose Lopez, MIT, Cambridge, MA

1 Price Discrimination with Robust Beliefs

Jun Han, Thomas A. Weber, EPFL, Lausanne, Switzerland. Contact: jun.han@epfl.ch
We consider the problem of price discrimination when the type distribution is unknown or specified by an ambiguity set. As robustness measure, a performance index, equivalent to relative regret, is proposed to quantify the worst-case attainment ratio between actual payoff and ex-post optimal payoff. We also provide a simple representation of this performance index, as the lower envelope of two extremal performance ratios, and prove a unique optimal robust belief. For a standard linear-quadratic specification of the robust screening model, a worst-case performance index of 75% guarantees that the robust product portfolio exhibits a profitability that lies within a 25%-band of an ex-post profit, over all possible model parameters and beliefs. Finally, a numerical comparison benchmarks the robust solution against a number of alternative belief heuristics.

2 Quality Learning in a Dynamic Mutual Data Exchange Model

Ebru Kasikaralar[1], John R. Birge[2], [1]University of Chicago, Chicago, IL, [2]University of Chicago, Chicago, IL, Contact: ebrukasikaralar@chicagobooth.edu
Companies heavily rely on consumer data to make successful operational decisions in the current economy. However, policies restricting firms' access to consumers' data are expected to become prevalent due to increased privacy concerns. Instead, giving the property rights of their data to the consumers would give them the necessary control. With the consumers' full ownership of their data, we introduce a model where the myopic consumers and a monopolistic firm directly interact in product and data markets. There is a costly dynamic data exchange between the firm and the consumers, where the firm offers incentives to its consumers to sell their data and learn from them. We find that under certain privacy conditions, social welfare increases. From a differential privacy perspective, we highlight the tradeoff between preserving privacy and increasing the speed of learning.

3 A Bargaining Model for Vehicle Transportation Contract Pricing

Kaylie Ann Butt, SUNY University at Buffalo, Buffalo, NY, Contact: kayliebu@buffalo.edu

A relatively new market in vehicle sales consists of dealer-to-dealer sales through a broker. One issue plaguing this market is the high cost paid to third-party carriers who transport vehicles on contract. To reduce vehicle transportation contract pricing, a Rubinstein-Stahl inspired bargaining model is proposed and consists of one auctioneer (broker) and a finite number of bidders (carriers). The best strategy and optimal discount rate per bid for the auctioneer are identified based on a given bargaining range and starting bid. Numerical examples demonstrating the utility of this model will be presented.

4 The Hidden Cost of Hidden Fees: A Model of Operational Transparency Decisions

Jose L. Lopez, MIT, Cambridge, MA, Contact: jllopez@mit.edu

Recent work in operations management has shown that firms can create value for themselves and their customers by increasing cost transparency, while research on the effects of price salience continues to show that price partitioning and obfuscation can generate additional sales and increased revenues for firms, which persist beyond the first purchase. This tension is evidenced across industries, and is especially salient in online retail, where few companies have moved to increase cost transparency. We build a model of firm and consumer behavior to study the mechanisms that drive a firm's choice for increased transparency, and can explain resulting sustained performance differences.

Tuesday, 11AM–12:15 PM

TB50

CC - Room 212

New Technologies and Platforms

General Session

Session Chair

Fujie Jin, Kelley School of Business, Indiana University, Bloomington, IN

1 How Does The Platform's Self-preferencing Algorithm Affect Third Party Sellers' Business Strategy in The Marketplace?

Hao Hu, Georgia Institute of Technology, Atlanta, GA

More and more e-commerce platforms are acting both as intermediaries that match third-party sellers and consumers, and as sellers that sell their own products. In this paper, we study how platform entry affects third-party sellers' business using data from a large marketplace in the US. We find the opposite effects of the entries: when the platform becomes a seller of an existing product, the third-party seller price decreases in the short term but recovers in the long run. Also, the platform's entry crowds out the low rating sellers and increases the product's rating and sales. However, when the platform launches its own products, prices of products in the same category do not change in the short run but decrease in the long run. Furthermore, we find that the design of newly added products becomes less innovative, which reduces the variety in the affected category.

2 Merging Advantages of Online Shopping with Offline Retail: Can In-store Mobile Technologies Increase Offline Consumer Expenditures?

Tian Lu[1], Tingting Song[2], Xianghua Lu[3], [1]Arizona State University, Phoenix, AZ, [2]Shanghai Jiao Tong University, Shanghai, China; [3]Fudan University, Shanghai, China. Contact: songtt@sjtu.edu.cn

Merging the features of online and offline channels (OMO) may have unpredictable effects on consumer expenditures due to the potential *information attention reallocation effect* and *shopping journey expediting effect*. The effect of implementing OMO technologies on consumer spending is empirically investigated with a unique data set. We reveal that OMO technologies do not cause increases in consumer spending but reshape shopping behavior. Further analyses suggest that OMO technology results in consumer purchasing items from 2.5% more product categories and placing 8.8% more orders with expensive items. However, using OMO technologies also decreases impulsive purchases by 8.6% and reduces shopping time by 18%; reduced spending on non-OMO orders results in no net change on overall expenditures at the consumer level.

3 Internet Governance Through Sites Shutdown: The Impact of Shutting Down Two Major Commercial Sex Advertising Sites

Helen Zeng[1], Michael D. Smith[2], Brett Danaher[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Chapman University, Orange, CA, Contact: shuxuanz@andrew.cmu.edu

In two weeks after the U.S. Congress passed a package of anti-sex trafficking bills on March 21, 2018, two of the largest online commercial sex advertising platforms ceased operation. On March 23, Craigslist voluntarily removed their personals section, which had been dominated by advertisements for commercial sex. And on April 6, the Department of Justice seized Backpage.com. Our research examines the impact of these shutdowns on a variety of important outcome variables, notably prostitution arrests and violence against women-variables the prior literature has shown were impacted by the introduction of commercial sex advertising platforms. We employ a generalized difference-in-difference model by exploiting cross-city variation in the pre-shutdown usage of the two shuttered sites. We find no causal effect of the shutdowns on any of the outcome variables we measure.

Tuesday, 11AM–12:15 PM

TB51

M - Santa Fe

Water Operations and Planning under Evolving Market, Technologies, Water Availability, Generation Portfolio and Regulation

General Session

Session Chair

Nathalie Voisin, Pacific Northwest National Lab., Seattle, WA

1 Water Scarcity Vulnerabilities for Stakeholders in Institutionally Complex River Basins Under Uncertainty

Antonia Hadjimichael, Penn State University, State College, PA, Contact: hadjimichael@psu.edu

The Colorado River is the largest river in the southwestern United States with several thousand diversions supporting agricultural, municipal, industrial and electricity generation activities. Increasing climatic stress and demand for water have these users vying for this limited resource, in a competition intrinsically shaped by the seniority of their rights and their location in the basin. Through the use of exploratory modeling approaches, we investigate a large ensemble of potential future changes that could take place in a sub-basin of the Colorado and analyze how they might impact the degree of water shortages experienced by the basin's multitude of users. We investigate both cross-sectoral impacts in the basin, as well as how the large heterogeneity in potential impacts to water users, in terms of the timing, magnitude, and frequency of shortages.

2 Power Portfolio Optimization: Combining Hydropower and Production Cost Models

Timothy M. Magee, Edith Zagona, University of Colorado, Boulder, CO

Jointly optimizing hydropower with other generation sourcesis a challenging problem because two different optimization methods arerequired. Accurate representation of hydropower optimization requires includingmany non-power considerations such as flood control, recreation, environment,navigation, and water demand and is best solved with a goal programmingapproach. Production cost models (PCM) optimize multiple types of generationassets with transmission, load, and security constraints. PCMs typicallyrequire both integer variables and nonlinear functions. We present a noveliterative approach to jointly optimizing a portfolio of these generation assetswhile retaining the use of the individual solvers. The approach has been testedat the Tennessee Valley Authority and is expected to be used in the near futurefor production scheduling of their portfolio of generation assets.

3 Building Back Better: Power Grid Expansion Models to Address Societal and Infrastructure Challenges

Gul Culhan Kumcu[1], Mark Rodgers[2], Maryam Mahdikhani[3], Arim Park[4], [1]Rutgers Business School, Newark, NJ, [2]Rutgers Business School, Newark, NJ, [3]College of Charleston, Charleston, SC, [4]North Carolina A&T State University, Greensboro, NC, Contact: gc649@business.rutgers.edu

Hydroelectric dams are critical to the infrastructure of the U.S. economy, as these renewable, non-emitting energy resources support emissions reduction goals aligned with climate change mitigation strategies. These hydroelectric dams also help protect communities from floods, and serve irrigation, water supply and even recreational purposes. Given the significance of these resources to society, it is necessary to ensure that preventative maintenance policies are adopted. In this project, we will leverage supervised learning methods to identify and establish key classifications (or clusters) of Texas counties. Based on our findings, we will propose optimization model to improve the infrastructure that address the socio-economic challenges of each cluster in efforts to pursue ethical solutions that enhance social welfare.

4 A DP Model for Quantifying The Value of Streamflow Forecasts in Multi-objective Dam Operations

Sean Turner[1], Nathalie Voisin[2], Daniel Broman[3], [1]Pacific Northwest National Lab, Seattle, WA, [2]Pacific Northwest National Lab., Seattle, WA, [3]Pacific Northwest National Lab, Richland, WA

As the availability and quality of flow forecast products continues to expand, increasing research effort must be directed toward understanding the value of those forecasts—

and the costs of forecast error—in operational settings. In this work we develop a simple method for evaluating the value of forecasts for hourly hydropower operations constrained by weekly non-powered objectives. The approach combines a weekly data-driven reservoir operations model (STARFIT) with a Dynamic Programming formulation that resolves each week's forecast-guided hourly generation schedule with fast computation in the order of seconds. We apply the method across a diverse set of dams in the United States, revealing key factors that control the value of flow forecasts and cost of forecast errors.

Tuesday, 11AM–12:15 PM

TB52

M - Lincoln
Scheduling II
General Session

Session Chair
Nicholas G. Hall, Ohio State University, Columbus, OH

1 Autonomous Scheduling in Back-end Semiconductor Manufacturing
Jelle Adan, Eindhoven University of Technology, Eindhoven, Netherlands.
Production scheduling decisions have a large impact on efficiency and output, especially in complex environments such as those with sequence- and machine-dependent setup times. In practice, these scheduling problems are usually solved for a fixed time ahead, and given the dynamics of the environment, it is commonly observed that a schedule is no longer optimal soon after it is made. Here, we propose rescheduling heuristics that can mitigate the effect of these deviations from the schedules. A simulation model, which is built and validated using real-world data, represents the dynamics of the shop floor as well as its interaction with the upper management level and enables us to evaluate the effect of the rescheduling heuristics. By comparing the results to the case without rescheduling, it is shown that rescheduling can significantly improve relevant performance measures.

2 Optimizing Charging Schedules and Vehicle Assignment for Electric Bus Fleets
Rito Brata Nath[1], Akshay Kadwe[1], Tarun Rambha[2], [1]Indian Institute of Science, Bangalore, India; [2]Indian Institute of Science, Bangalore, India. Contact: ritonath@iisc.ac.in
Eco-friendly public transportation systems involving electric bus fleets often face the problem of determining optimal charging schedules. These decisions are influenced by the assignment of buses to trip schedules, availability of chargers, and rate of charging. In this research, we formulate a joint integer programming model that assigns vehicles to trips and determines when and where to charge them, assuming a fixed supply of chargers and linear charging rates. We propose local-search based heuristics that iteratively optimize the vehicle to trip assignment and the charging schedules and compare its performance with the integer program for medium-sized transit networks.

Tuesday, 11AM–12:15 PM

TB53

M - Denver
Pricing
Contributed Session

Session Chair
Yunke Li, University of Miami, Coral Gables, FL

1 Selling Hope with Uncertain Pricing
Yongqin Lei, Ivey Business School, Western University, London, ON, Canada. Contact: ylei.phd@ivey.ca
I present a model of uncertain pricing in which the price is ex ante uncertain to consumers and revealed sequentially. I show that regardless of consumers' beliefs about the uncertain price, uncertain pricing strictly dominates uniform pricing, where a single price is charged for all consumers. Moreover, the upper bound of potential profit from uncertain pricing is 225% of that from uniform pricing.

2 Product and Ancillary Pricing Optimization: Market Share Analytics Via Perturbed Utility Model
Changchun Liu, National University of Singapore, Singapore, Singapore. Contact: oralc@nus.edu.sg
Consider a firm that sells some primary and ancillary products (services) to heterogeneous customers. The challenge is to determine the prices for all the products and services simultaneously, to optimize profits to the firm. We demonstrate how we can obtain a good approximation to the PUM using an additive perturbed utility model (APUM). This allows us to establish a set of closed-form relationships between prices, expected market shares, and interestingly, expected slacks in the constraint matrix of the customer choice problem. This opens up a new way to calibrate

the APUM using market share shift information obtained from varying the prices of the products and services. Using piecewise linear approximation, we show that the resulting data-driven pricing problem can be solved as mixed integer linear programs.

3 Feature Centralized Multiproduct Newsvendor with Substitution

Alba V. Olivares Nadal, University Pablo de Olavide, Sevilla, Spain. Contact: avolinad@upo.es

In this paper we aim to improve the decisions taken in a Centralized Multiproduct Newsvendor problem by making use of information provided by exogenous features while allowing for substitutions between products in case of scarcity. In particular, we build decision rules that minimize the empirical risk and we show that these rules are also optimal to a continuous quadratically constrained quadratic program. We propose a linear approximation and prove that the optimality gap depends on the violations of the optimal direction of the substitution demand flow. We rely on dual theory and the well-known kernel trick in order to account for nonlinearities and interactions between features. The numerical results show that the approaches proposed in this paper provide statistically significant performance improvements in comparison with the benchmark methods.

4 Event Ticket Pricing with Capacity Constraints and Price Restrictions

Yunke Li[1], Harihara Prasad Natarajan[2], Xin Geng[2], [1]University of Miami, Coral Gable, FL, [2]University of Miami, Coral Gables, FL, Contact: yxl1601@miami.edu

Motivated by the ticket pricing problem for the live entertainment industry, we study constrained optimization models that adopt the vertical and horizontal differentiated demand, respectively. Under some reasonable assumptions, we adopt the convex optimization approach to characterize the optimal solutions under different demand settings. In addition, we study two extensions of the pricing problem with additional considerations and show how the optimal sales, prices, and revenue are affected by the possible collection of ticket category adjustment or capacity reallocation. Among other applications, our results can provide useful insights for live entertainment promotion planners to optimize the sales of the offered event tickets with capacity constraints and price restrictions.

Tuesday, 11AM–12:15 PM

TB54

M - Marriott 1

Markov Lecture

General Session

1 Combinatorial Statistics: A Discussion of Elchanan Mossel's Markov Lecture

Miklos Racz, Princeton University, Princeton, NJ

We will discuss some natural inference problems on random graphs through the lens of Elchanan Mossel's Markov Lecture. We will discuss recent progress and open problems, and highlight Elchanan's influence.

2 Stochastic Models of Information on Networks and Their Inference

Elchanan Mossel, MIT, Cambridge, MA

The talk will overview some of the models on information on networks studied in statistical physics, the social sciences, biological sciences and theoretical computer science. The talk will emphasize the role of the mathematical properties of these models in studying their inference.

Tuesday, 11AM–12:15 PM

TB55

M - Marriott 2

Applied Probability and Decision Making

General Session

Session Chair

Neil Walton, University of Manchester, Manchester, United Kingdom.

1 Tradeoffs in Online Decision Making

Sean Sinclair, Cornell University, Ithaca, NY

Managing and optimizing the operations of complex systems often involves making tradeoffs between different objectives such as fairness, risk, accuracy, and efficiency. These problems are exacerbated in online settings where uncertainty propagates through objectives differently. How these criteria interact is often not well understood or characterized, and there typically does not exist a single objective function that determines which tradeoffs are better than others. We will discuss tradeoffs through two different settings. First is studying fairness and efficiency tradeoffs in sequential resource allocation, providing impossibility and algorithmic results under a wide range of utility models, arrival distributions, and perishing times. Second is bias-variance tradeoffs in designing reinforcement learning algorithms for operations domains.

2 New Approach to High-dimensional Optimal Stopping and Control

David Goldberg[1], Yilun Chen[2], [1]Cornell University, ORIE, Ithaca, NY, [2]Columbia University, New York, NY

The problem of high-dimensional optimal stopping is central to many fields. Modern approaches, relying on ADP, simulation, and/or duality, have limited rigorous guarantees, and the traditional understanding is that stronger guarantees require either stronger assumptions, or a runtime exponential in either the dimension or horizon T. We overcome this obstacle by devising simple data-driven algorithms that can trade-off between accuracy and runtime through a parameter epsilon controlling the performance guarantee. The complexity achieved is polynomial in T (and effectively independent of the dimension) for any fixed epsilon, in contrast to past methods. We will also discuss connections to the theory of network flows and stochastic optimization, generalizations to control broadly, RL, and relevant lower bounds.

3 Greedy Algorithm for Multiway Matching with Bounded Regret

Varun Gupta, University of Chicago Booth School of Business, Chicago, IL

We propose a simple greedy algorithm for a finite horizon online resource allocation/matching problem, when the corresponding static planning linear program (SPP) exhibits a non-degeneracy condition called the general position gap (GPG). The decision maker wants to combine resources from a finite set of types into feasible configurations where each configuration is specified by a multiset of resources and a reward. Resources are further subdivided into offline, online-queueable, and online-nonqueueable. We prove that our greedy algorithm gets bounded any-time regret of O(1/□) for reward where □ is a measure of the GPG. By considering the three types of resources, our matching framework encompasses several well-studied problems such as dynamic multi-sided matching, network revenue management, online stochastic packing, and multiclass queueing systems.

4 Parallel Server Systems with Cancel-on-completion Redundancy

Alexander Stolyar, University of Illinois at Urbana-Champaign, Urbana, IL

A large-scale parallel server system with multi-component jobs, under so-called cancel-on-completion redundancy, is considered. This system is in general non-work-conserving -- this poses the main challenges for its analysis. We consider the mean-field asymptotic regime where the number of servers goes to infinity with the job arrival rate per server remaining constant. The main results provide some sufficient conditions for the steady-state asymptotic independence of server workloads to hold. Our analysis relies almost exclusively on two fundamental properties of the model: monotonicity and the property that, on average, "new arriving workload prefers to go to servers with lower workloads."

Tuesday, 11AM–12:15 PM

TB57

M - Marriott 4

Bayesian Methods in Reliability Analysis

General Session

Session Chair

Refik Soyer, George Washington University, Washington

Session Chair

Atilla Ay, George Washington University, Arlington, VA

1 Bayesian Modeling of Power Outages Using Markov Modulated (multiple) Compound Processes

Atilla Ay[1], Fabrizio Ruggeri[2], Refik Soyer[3], [1]James Madison University, Harrisonburg, VA, [2]CNR-IMATI, Milan, Italy; [3]George Washington University, Washington

In this paper our objective is to model power outages and their consequences in multiple locations by measuring the total number of households affected in each location. In so doing, we assume that the power distribution systems in those locations operate under a common environment. For each location, we consider a compound Poisson process to model the number of affected households, whose jump rate (outage rate) and jump size (the number of households affected by each outage) change with the changing state of the common environment, which is a latent Markov process. Therefore, we refer to this model as Markov modulated multiple compound Poisson processes. We use the simulated and real power outage data of five counties in northern Virginia to illustrate the proposed model and the methodology.

2 A Bayesian Framework for Reliability Growth Test and Evaluation for Multistage Systems

Thomas A. Mazzuchi[1], Valeriya Malobrodskaya[2], [1]George

Washington University, Washington, [2]George Washington University, Washington, DC

This research describes a methodology to overcome computation and prediction challenges in development testing of a multistage single-shot system. It proposes the incorporation of existing test data with expert judgment in a Bayesian framework that allows point and interval estimation of current and future reliability values, as well as addressing important managerial questions regarding optimal amount of testing and number of remaining defects. The proposed framework enables continuous updating of predicted reliability values, removing the dependence on the estimates formed at the initial stage of testing.

3 Adversarial Aspects of Software Testing

Refik Soyer, George Washington University, Washington, DC, Contact: soyer@gwu.edu

An important problem in software testing during the development phase is to decide when to terminate the testing process and to release the software. In addition to trade-offs associated with cost of testing and reliability of the released product, the problem is further complicated due to presence of adversaries. We present an adversarial risk analysis framework to address this problem and consider a few different scenarios. In so doing, we develop formulations to incorporate different adversarial aspects and discuss implementation issues.

Tuesday, 11AM–12:15 PM

TB58

M - Marriott 5

Statistical Process Monitoring of Complex Data

General Session

Session Chair

Xiulin Xie, University of Florida, Gainesville, FL

1 High-dimensional Dynamic Process Monitoring by Pca-based Sequential Learning

Xiulin Xie[1], Peihua Qiu[2], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL

Sequential process monitoring has broad applications. Due to the fast progress in data acquisition techniques, statistical process control (SPC) research for monitoring high-dimensional processes is in rapid development in recent years. In this paper, we develop a novel SPC chart for monitoring high-dimensional dynamic processes. The new method is based on nonparametric longitudinal modeling for describing the longitudinal pattern of the process under monitoring, principal component analysis for dimension reduction, and a sequential learning algorithm for developing an effective decision rule. It can well accommodate time-varying IC process distribution, serial data correlation, and nonparametric data distribution. Numerical studies show that it is effective for monitoring high-dimensional dynamic processes in various cases considered.

2 Spatio-Temporal Process Monitoring Using Exponentially Weighted Spatial LASSO

Kai Yang[1], Peihua Qiu[2], [1]Medical College of Wisconsin, Milwaukee, WI, [2]University of Florida, Gainesville, FL, Contact: kayang@mcw.edu

Spatio-temporal process monitoring has received a considerable attention due to its broad applications. Because spatio-temporal data often have complicated structure, effective monitoring of spatio-temporal processes is a challenging research problem. In practice, distributional shifts in a spatio-temporal process often start in small regions that are spatially clustered. This kind of spatial feature has not been considered in the existing methods yet. In this talk, we introduce a new method that takes into account this spatial feature of the shift in its construction. The new method combines the ideas of exponentially weighted moving average in the temporal domain for online process monitoring and spatial LASSO in the spatial domain for accommodating the spatial feature of a shift. It can also accommodate the complicated spatio-temporal data structure well.

3 Water Resource Surveillance for The Salton Sea in California by Adaptive Sequential Monitoring of Its Landsat Images

Fan Yi, Peihua Qiu, University of Florida, Gainesville, FL, Contact: yifan@ufl.edu

Gradual loss of water resource in the Salton Sea has got much attention for its damage to the local environment and ecosystems for human beings, animals and plants. To monitor the water resource of the lake, researchers usually obtain certain water resource indices manually from databases such as the satellite images of the region. In this paper, we develop a new method to monitor the area of the Salton Sea automatically. The lake is first segmented properly from each satellite image by an image segmentation procedure, and then its area is computed by a numerical algorithm. The sequence of lake areas computed from satellite images taken at different time points is then monitored by a control chart from the SPC literature. Because the lake area changes gradually over time, the control chart designed for detecting process mean drifts is used for the water resource surveillance.

4 Dynamic Disease Screening by Joint Modeling of Survival and Longitudinal Data

Peihua Qiu[1], Lu You[2], [1]University of Florida, Gainesville, FL, [2]University of South Florida, Tampa, FL

Sequential monitoring of dynamic processes is an active research area because of its broad applications. It has been shown that dynamic screening system (DySS) is a powerful tool for disease screening. To detect screen diseases, DySS methods first estimate the regular longitudinal pattern of disease predictors, and then compare the longitudinal pattern of the observed disease predictors of the patient with the estimated regular longitudinal pattern. In practice, a dataset containing longitudinal observations of the disease predictors is often available in advance, from which it is possible to explore the relationship between the disease occurrence and the longitudinal pattern of the disease predictors. This relationship should be helpful for disease screening. In this presentation, a new DySS method will be introduced based on this idea.

Tuesday, 11AM–12:15 PM

TB59

M - Marriott 6

Federated Analytics and Recent Advances

General Session

Session Chair

Xubo Yue, University of Michigan, Ann Arbor, Ann Arbor, MI

Session Chair

Seokhyun Chung, University of Michigan, Ann Arbor, MI

1 Personalized Pca: Decoupling Shared and Unique Features

Naichen Shi[1,2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI

One major challenge in federated learning is heterogeneity. Heterogeneous features in datasets slow down federated learning and result in degraded predictive performance. Although a few works are proposed to tackle heterogeneity through personalization, many of them are based on intuitions and lack theoretical guarantees. In this work, we present a personalized FL model to model heterogeneity through principal component analysis (PCA). The personalized PCA model can provably disentangle unique and shared features from federated datasets. Also, we show that personalized PCA has a wide range of applications beyond federation, for example, in signal processing.

2 Federated Multi-output Gaussian Process Regression

Seokhyun Chung, University of Michigan, Ann Arbor, MI, Contact: seokhc@umich.edu

In this paper, we propose *FedMGP*, a general framework to learn a multi-output Gaussian process (MGP) model in a decentralized manner that utilizes edge computing power to distribute model learning efforts. Specifically, we propose a hierarchical modeling approach where an MGP is built upon shared global latent functions. We then develop a variational inference-based federated analytics algorithm that overcomes the need to share raw data. Instead, collaborative learning is achieved by only sharing global latent function statistics. Comprehensive simulation studies and the case study on renewable energy highlight the superior predictive performance and versatility of *FedMGP*, achieved while distributing computing and storage demands, reducing communication burden, fostering privacy, and personalizing analysis.

3 Federated Gaussian Process: Convergence, Automatic Personalization and Multi-fidelity Modeling

Xubo Yue[1], Raed Al Kontar[2], [1]University of Michigan, Ann Arbor, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI

In this paper, we propose FGPR: a Federated Gaussian process (GP) regression framework that uses an averaging strategy for model aggregation and stochastic gradient descent for local client computations. Notably, the resulting global model excels in personalization as FGPR jointly learns a global GP prior across all clients. The predictive posterior then is obtained by exploiting this prior and conditioning on local data which encodes personalized features from a specific client. Theoretically, we show that FGPR converges to a critical point of the full log-likelihood function, subject to statistical error. Through extensive case studies we show that FGPR excels in a wide range of applications and is a promising approach for privacy-preserving multi-fidelity data modeling.

Tuesday, 11AM–12:15 PM

TB60

M - Marriott 7

Toward a Circular Economy: Analytical and Data Driven Models

General Session

Session Chair

Cerag Pince, [1]</sup

1 Using Computer Vision to Measure Commercial Food Waste

Yu Nu[1], Elena Belavina[2], Karan Girotra[3], [1]Cornell University, New York City, NY, [2]Cornell University, New York, NY, [3]Cornell Tech/Johnson Cornell University, New York, NY, Contact: yn292@cornell.edu

A key impediment to reducing food waste is the lack of transaction level measurement of food waste. In collaboration with a leading foodtech company, we developed a food-waste taxonomy, and a computer-vision and weight-sensors enabled waste bin to record food waste in commercial kitchens. We then tracked the staggered deployment of various versions of this system in 1000+ commercial kitchens. Using a staggered synthetic control estimator, we estimate that, on average, sites adopting the smart waste bin reduce their daily waste by 18.61% (± 7.51%) within the first 4 months of adoption. Sites that adopt the limited weight-only system experience a 13.53% (± 5.00%) reduction in their waste. Finally, the impact of the systems increases with user-engagement—managers that view reports (even once) achieve an additional 7-9 percentage point reductions.

2 Business Model Choice Under Right to Repair: Economic and Environmental Consequences

Ece Gulserliler[1], Atalay Atasu[2], Luk N. Van Wassenhove[3], [1]INSEAD, Fontainebleau, France; [2]INSEAD, Fontainebleau, France; [3]INSEAD, Fontainebleau Cedex, France. Contact: eceguliz.gulserliler@insead.edu

Right-to-Repair regulations require producers to design repairable products and supply information and parts for consumers to independently undertake repairs. While these regulations aim to prolong product lifetimes through repairs; the ease of access to proprietary information and spare parts can have unintended consequences, such as facilitating cloning by third parties. The increased risk of cloning under RTR may encourage producers to reconsider their business model choices. We analyze the effect of RTR on business model choice, and the implications for producers, consumers, and the environment. We find that, for a wide range of product types, these regulations may result in a lose-lose situation for producers and the environment, while also decreasing consumer surplus and potentially curtailing innovation.

3 Analysis of Farm Equipment Sharing in Emerging Economies

Olufunke Adebola[1], Priyank Arora[2], Can Zhang[3], [1]Deloitte, Atlanta, GA, [2]University of Massachusetts Amherst, Amherst, MA, [3]Duke University, Durham, NC, Contact: parora@isenberg.umass.edu

We study the farm equipment sharing platforms in emerging economies. In particular, we capture a new role within these platforms—booking agents, who exert a costly effort by collecting demand from individual farmers and submitting the aggregated demand on the platform. We aim to analyze how the presence of booking agents affects the platform's optimal pricing and wage decisions, and how the key supply and demand characteristics of such a platform affects the optimal platform decisions and the equilibrium outcomes. Our analysis reveals that although farm equipment sharing platforms are often labeled as "Uber for Tractors," they should be cautious about applying findings for Uber or other conventional sharing settings.

4 Labor, Skills, and Product Recovery

Cerag Pince[1], Atalay Atasu[2], Beril L. Toktay[3], [1]Quinlan School of Business, Loyola University Chicago, Chicago, IL, [2]INSEAD, Fontainebleau, France; [3]Georgia Institute of Technology, Atlanta, GA

Motivated by a third-party remanufacturer of consumer products, we study the workforce capacity investment problem in product recovery operations. We analyze how a remanufacturing firm should determine its workforce's quantity and type when both the number and complexity of units to be processed are random. We characterize the optimal solution and the conditions when using only one type of workforce dominates the other.

Tuesday, 11AM–12:15 PM

TB61

M - Marriott 8

Competing Objectives in the Energy Transition

General Session

Session Chair

Michael Craig, University of Michigan, Ann Arbor, MI

1 Replacing Coal Plant Jobs with Local Instead of Distant Wind and Solar Jobs is Cost-effective

Michael Craig, Max Vanatta, University of Michigan, Ann Arbor, MI, Contact: mtcraig@umich.edu

A just transition requires consideration of direct employment losses at coal plants; coal plant workers' community ties and place-based preferences; and environmental benefits of coal plant retirements. We quantify how replacing coal jobs with local versus relocation-required renewable energy jobs affects investment costs and decisions. We use a bottom-up model that optimizes coal plant retirements, then replaces their generation and employment with wind and solar investments. We find renewables can replace coal generation and employment even when limited to a 50 mile radius from retiring coal plants. Replacing coal plants with local instead of distant renewables increases costs by roughly 25%.

3 An Energy and ESG Case Study

Benjamin Nelson[1], Brian Petrus[2], Christie Nelson[3], [1]Rutgers Universitu, New Brunswick, NJ, [2]Westminster College, New Wilmington, PA, [3]Rutgers University, Princeton, NJ

We investigate global energy transition. We evaluate various sectors of the economy, including oil & gas, transportation, and power generation. We consider factors like decarbonization objectives, geopolitical tensions, development and commercialization of renewable energy technology, and access to capital.

Tuesday, 11AM–12:15 PM

TB62

M - Marriott 9

Strategic Behavior in Renewable-dominated Energy Systems

General Session

Session Chair

Yunhe Hou, University of Hong Kong, Hong Kong, Hong Kong.

Session Chair

Feng Liu, Tsinghua University, Beijing

1 A Reverse Stackelerg Game Model for Grid Usage Pricing

Luce Brotcorne[1], Helene Le Cadre[2], Juan Pablo Sepulveda[1], [1]INRIA, Lille, France; [2]INRIA Lille—Nord Europe, Lille, France.

Nowadays local energy communities are considered as a promising solution for prosumers empowerment. Including the distribution system operator and underlying network in the clearing of the local market arise as a challenge.In this talk, we define short-term incentive policies based on grid usage prices to drive the system towards an economically efficient market equilibrium, subject to operational security constraints. The incentive policies are defined as affine functions of the prosumers' active and reactive power outputs. A reverse Stackelberg is defined to determine optimal policies. Market related properties of the policies such as individual rationality, incentive compatibility, and fairness are rigorously discussed. Numerical results are presented and described.

2 A Mean Field Game Approach for Peer-to-peer Energy Trading with Energy Storage

Chen Feng[1], Andrew Liu[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, West Lafayette, IN, Contact: feng219@purdue.edu

Utilizing distributed renewable and energy storage resources via peer-to-peer (P2P) energy trading has been touted as a solution to improve energy system's resilience and sustainability. Consumers/prosumers, however, do not have expertise to engage in repeated P2P trading, and the zero-marginal costs of renewables present challenges in determining fair market prices. To address the issues, we propose a mean-field-game-based framework to help automate consumers' bidding and management of their solar PV and energy storage resources. We prove the uniqueness of the optimal strategy for each agent and show by numerical experiments that the market with a large number of agents can converge to a steady state if everyone implements the proposed.

3 Information-theoretic Method in Power System

Chenxi Hu[1], Yunhe Hou[2], [1]The University of Hong Kong, Hong Kong, China; [2]The University of Hong Kong, Hong Kong, Hong Kong.

The increasing penetration of renewable energy has introduced higher uncertainty in power system. This directly led to the explosion of the scenarios to be considered during power system operation. Under this circumstance, stochastic optimization and robust optimization models have been widely adopted in the decision-making process of scheduling and dispatching. Although these methods achieve good performance, their success is hindered by the lack of an explanatory theory. The information bottleneck theory is a possible information-theoretic paradigm for deriving

explainable models. In this study, an information-theoretic approach for power system planning will be introduced. The decision-making model is constructed in terms of information measures to quantify the value of the resulting strategy.

4 Submodular Optimization of DTR Sensor Placement for Risk Mitigation

Qinfei Long, The University of Hong Kong, Hong Kong, China.

Cascading failure poses a significant risk to society. One approach to mitigating failure risk is through dynamic thermal rating (DTR) sensor. Sensor placement, as the basis of DTR analysis, is a combinatorial optimization problem, while traditional solving methods cannot provide optimality guarantee and suffer easily from dimensionality curse. This study reports a submodular optimization-based DTR placement model for risk mitigation considering Braess paradox. First, the important sampling weight is utilized to quantify the failure risk before and after DTR placement, which is also applied to reveal the Braess paradox condition. Then, a novel submodular optimization approach is established to reformulate the risk mitigation model. Finally, an efficient solving algorithm is designed. The performance of the proposed model is verified by case results.

Tuesday, 11AM–12:15 PM

TB63

M - Marriott 10

Smart Critical Infrastructures Resilience Against Natural Hazards and Cyberattacks

General Session

Session Chair

Charalampos Avraam, 1</sup

Session Chair

Yury Dvorkin, New York University, Brooklyn, NY

1 Scalable Learning for Optimal Load Shedding Under Power Grid Emergency Operations

Yuqi Zhou, Hao Zhu, The University of Texas at Austin, Austin, TX

Effective and timely responses to natural disasters are crucial for enhancing the resilience of power grid infrastructures. However, the fast cascading propagation under severe contingencies can make corrective actions such as optimal load shedding (OLS) difficult to attain in real time. To deal with the computational complexity that arises from solving the centralized optimization problem, we put forth an innovative decentralized learning approach by constructing the optimal decision rules of load shedding under potential contingency scenarios through offline neural network training. This scalable design enables each individual load center to quickly react to system contingencies using locally available measurements.

2 Smart Energy Infrastructures Resilience and Response Against Compound Cyber-physical Threats

Charalampos Avraam[1], Luis Ceferino[2], Yury Dvorkin[3], [1]New York University, Brooklyn, NY, [2]New York University, Brooklyn, NY, [3]New York University, Brooklyn, NY, Contact: avraam@nyu.edu

The growing frequency of extreme weather events and cyberattacks creates conditions for the novel compound cyber-physical threats, i.e., a cyberattack on infrastructure components stressed by an extreme weather event. We develop a two-stage methodology to identify cyber and physical vulnerabilities of critical infrastructures under compound cyber-physical threats. In the first stage, a probabilistic model identifies failed power system components under a hurricane based on local environmental, infrastructure and sociodemographic predictors. In the second stage, a game-theoretic model assesses operational disruptions induced by components failures due to cyber stressors. Preliminary results show that a compound cyber-physical threat can aggravate short-term unserved energy by 60% compared to unserved energy under each individual hazard in New York City.

3 Data Analytics for Mitigating Fire Hazards in Electric Distribution Systems

Jhi-Young Joo[1], Indrasis Chakraborty[2], [1]Lawrence Livermore National Laboratory, Livermore, CA, [2]Lawrence Livermore National Laboratory, Livermore, CA

Wildfires caused by electric equipment have become a challenge for electric distribution operators and utilities in vulnerable regions, as witnessed by the recent catastrophic events. Part of the challenge in preventing such events is lack of effective ways for monitoring equipment condition that may produce arcing and sparks. In the meantime, high-resolution sensor measurements can be used to detect unique signatures of arcing that can potentially cause fires. However, even with high-resolution measurement data, low-current arcing events are difficult to detect due to their short durations and low amplitudes. This talk discuss a combination of unsupervised learning and supervised classification framework to detect anomalies including instantaneous low-current arcing events, using time-synchronous phasor measurements.

Tuesday, 11AM–12:15 PM

TB64

M - Indiana A
Emerging Trends in Mechanism Design
General Session

Session Chair
Carmine Ventre, 1</sup

1 Algorithms for Imperfect Rational Mechanisms

Diodato Ferraioli, Università degli Studi di Salerno, Fisciano (SA), Italy.

The realization that selfish interests need to be accounted for in the design of algorithms has produced many interesting and valuable contributions within the field of algorithmic mechanism design.
However, selfishness is different from rationality; agents will attempt to strategize whenever they perceive it to be convenient. Recent work in economics has focused on a particular notion of imperfect rationality, namely absence of contingent reasoning skills, and defined obvious strategyproofness (OSP) as a way to deal with the selfishness of these agents. However, it is not clear what algorithmic approaches ought to be used for OSP.
In this talk, we will discuss some recent results about the algorithmic structure of OSP mechanisms, and how these will help research to design these mechanisms, and to establish their performance for many practical problems.

2 Prior-free Deterministic, Bayesian, and Randomized Clock Auctions

Giorgos Christodoulou[1], Michal Feldman[2], Vasilis Gkatzelis[3], Nikolai Gravin[4], Daniel Schoepflin[3], [1]University of Liverpool, Liverpool, United Kingdom; [2]Tel Aviv University, Tel Aviv, Israel; [3]Drexel University, Philadelphia, PA, [4]Shanghai University of Finance and Economics, Shanghai, China. Contact: drs332@drexel.edu

In a single-parameter mechanism design problem, a provider is looking to sell a service to a group of potential buyers. Each buyer has a private value for the service, and a feasibility constraint restricts which subsets of buyers can be served. Recent work in economics proposed clock auctions as a superior solution for this problem due to their transparency, simplicity, and strong incentive guarantees. Unfortunately, early results studying clock auctions for welfare-maximization led to logarithmic inapproximability results even for very simple instances. In this work, we first propose an optimal prior-free deterministic clock auction achieving a logarithmic approximation for any downward-closed set system. We then achieve better bounds by leveraging prior information and randomization. These results originally appeared in papers accepted at ITCS 2022 and EC 2022.

3 Non-Obvious Manipulability for Single-parameter Agents and Bilateral Trade

Thomas Archbold, Bart de Keijzer, Carmine Ventre, King's College London, London, United Kingdom. Contact: thomas.archbold@kcl.ac.uk

A recent line of work in mechanism design focuses on incentive compatibility for agents without contingent reasoning skills: obviously strategyproof mechanisms guarantee it is "obvious" for these agents to behave honestly, whereas non-obviously manipulable (NOM) mechanisms ensure they only misbehave when it is "obvious" to do so. We present a technique for designing NOM mechanisms with money and use this to characterise their allocation and payment functions for one-parameter agents. We apply this to bilateral trade to study the subsidy needed to guarantee NOM, efficiency, and individual rationality and prove a stark dichotomy: no finite subsidy exists if agents consider only best-case outcomes while no subsidy is required if agents focus on worst-case outcomes. We conclude by characterising NOM mechanisms without subsidies that satisfy individual rationality.

4 Polynomial Time Approximately Optimal Correlated Mechanism Design

Michael Albert, University of Virginia - Darden School of Business, Charlottesville, VA

Mechanism design under settings of correlated valuations has been demonstrated to provide for much stronger revenue guarantees than independent valuations. However, the construction of the optimal mechanism has generally been thought to be exponential in the number of participants. This is due to the size of the correlated distribution increasingly exponentially with the number of bidders. In this work, we assume sample access to the underlying correlated distribution, and we use the samples from the distribution to construct a nearly optimal mechanism in polynomial time in the number of bidders.

Tuesday, 11AM–12:15 PM

TB65

M - Indiana B

Economics and Computation II

Award Session

1 [ec2022] Estimation of Standard Auction Models

Yeshwanth Cherapanamjeri[1], Konstantinos Daskalakis[2], Andrew Ilyas[3], Manolis Zampetakis[1], [1]Berkeley, Berkeley, CA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]MIT, Cambridge, MA

We provide efficient estimation methods for first- and second-price auctions under independent (asymmetric) private values and partial observability. Given a finite set of observations, each comprising the identity of the winner and the price they paid in a sequence of identical auctions, we provide algorithms for non-parametrically estimating the bid distribution of each bidder, as well as their value distributions under equilibrium assumptions. Our estimation guarantees advance a body of work in Econometrics wherein only identification results have been obtained, unless the setting is symmetric, parametric, or all bids are observable.

2 EC2022 Sequential Information Design: Markov Persuasion Process and Its Efficient Reinforcement Learning

Jibang Wu[1], Zixuan Zhang[2], Zhe Feng[3], Zhaoran Wang[4], Zhuoran Yang[5], Michael I. Jordan[6], Haifeng Xu[1], [1]University of Virginia, Charlottesville, VA, [2]University of Science and Technology of China, Hefei, China; [3]Google, Mountain View, CA, [4]Northwestern University, Evanston, IL, [5]Yale University, New Haven, CT, [6]UC Berkeley, Berkeley, CA, Contact: jw7jb@virginia.edu

In today's economy, it becomes important for Internet platforms to consider the sequential information design problem to align its long term interest with incentives of the gig service providers. This paper proposes a novel model of sequential information design, namely the Markov persuasion processes (MPPs), where a sender, with informational advantage, seeks to persuade a stream of myopic receivers to take actions that maximizes the sender's cumulative utilities in a finite horizon Markovian environment with varying prior and utility functions. We study MPPs under the online reinforcement learning setting, and design a provably efficient no-regret learning algorithm, OP4, which features a novel combination of both optimism and pessimism principles. Our algorithm enjoys sample efficiency by achieving a sublinear regret upper bound.

3 (EC 2022) Learning in Stackelberg Games with Non-myopic Agents

Nika Haghtalab[1], Thodoris Lykouris[2], Sloan Nietert[3], Alexander Wei[1], [1]UC Berkeley, Berkeley, CA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Cornell University, Ithaca, NY, Contact: sbn45@cornell.edu

We study Stackelberg games where a principal repeatedly interacts with a long-lived, non-myopic agent, without knowing the agent's utilities. Although learning in Stackelberg games is well-understood for myopic agents, non-myopic agents pose additional challenges since they may select inferior actions in the present to mislead the principal. We provide a general framework reducing learning in this setting to robust bandit optimization with myopic agents. To apply this, we design minimally reactive bandit algorithms for security games, demand learning, strategic classification, and finite Stackelberg games. Along the way, we improve the state-of-the-art query complexity of learning security games from $O(n^3)$ to a near-optimal $O(n \log n)$.

4 Ec2022 in This Apportionment Lottery, The House Always Wins

Paul Gölz, Carnegie Mellon University, Pittsburgh, PA

Apportionment is the problem of distributing *h* indivisible seats across states in proportion to the states' populations. Grimmett [2004] suggested to apportion seats in a *randomized* way such that each state receives exactly their proportional share q□ of seats in expectation (*ex ante proportionality*) and receives either q□ or q_i many seats ex post (*quota*). However, there is a vast space of randomized apportionment methods satisfying these two axioms, and so we additionally consider prominent axioms from the apportionment literature. Our main result is a randomized method satisfying quota, ex ante proportionality and *house monotonicity*—a property that prevents paradoxes when the number of seats changes and which we require to hold ex post. This result is based on a generalization of dependent rounding on bipartite graphs, which we call *cumulative rounding*.

Session Chair

Andrew Ilyas, Massachusetts Institute of Technology, Cambridge, MN

Tuesday, 11AM–12:15 PM

TB66

M - Indiana C

The Operations Management of Carbon Emissions

General Session

Session Chair
Andre Du Pin Calmon, Scheller College of Business, Georgia Institute of Technology, Atlanta, GA

Session Chair
Mike Gordon, 1</sup

1 Economics of Grid-scale Energy Storage in Wholesale Electricity Markets

Omer Karaduman, Stanford University, Cambridge, MA, Contact: omerkrdmn@gmail.com

I investigate whether private incentives for operating and investing in grid-scale energy storage are optimal. I build a new dynamic structural equilibrium framework and apply it to study the South Australian Electricity Market. My equilibrium framework adds key modeling features to the literature by allowing storage's price impact and incumbents to the best response to energy storage's production. We find that (1) ignoring the price impact of energy storage may lead to large biases, (2) although entering the electricity market is not profitable for privately operated storage, such entry would increase consumer surplus and reduce emissions, (3) load ownership for energy storage leads to double improvement in consumer surplus, and (4) entry of energy storage reduces renewable generators' revenue for moderate renewable levels; however, it increases for high levels.

2 Storing Carbon in Closed-loop Supply Chains Using Biogenic Material

Donghyun Choi, Andre Du Pin Calmon, Beril L. Toktay, Georgia Institute of Technology, Atlanta, GA, Contact: donghyun.choi@scheller.gatech.edu

A nascent carbon mitigation practice is the production of carbon-negative products by using bio-based materials in lieu of petroleum-based materials. Motivated by a carpet manufacturing company that uses bio-based materials to make carbon-negative products, we model a firm that optimizes a product's material composition mix and the amount of carbon offsets it must purchase to achieve carbon neutrality. Our model allows for different carbon accounting mechanisms and investigates how operating under these mechanisms can shape the firm's decisions. We find that the use of bio-based materials can conflict with the use of recycled content under a high carbon offset price. Our results suggest that accounting methods that credit delayed emissions can promote firms to choose internal mitigation options rather than carbon offsetting.

3 Environmental Strategies for Building Competitive Advantage: When Does It Pay to be "Green"?

Arda Yenipazarli, Georgia Southern University, Statesboro, GA, Contact: ayenipazarli@georgiasouthern.edu

In this paper, we focus on competing firms' incentives to pursue product-oriented differentiation-based environmental strategies associated with high technological risk, delayed payoffs (if successful) and substantial research and development (R&D) investments in lieu of lower-risk, short-term and low-cost process-oriented environmental strategies, and vice versa. Drawing on a two-period game-theoretic model, we characterize how the presence of strategic rivals who potentially pursue an environmental strategy in dynamic markets, competition intensity, product development capabilities, technology trajectories and customer concerns govern the environmental strategy priorities and choices of firms, and identify under what supply and market conditions these strategic choices provide competitive advantage and thereby result in win-win outcomes.

4 Sustainable Investment: Effects of Green Manufacturing and Social Responsibility in Competition

Mike M. Gordon, Virginia Tech, Christiansburg, VA

We examine how firms can use sustainability in competition. Using a three-period model, we examine two competitive supply chains, each of which consists of a retailer and an exclusive manufacturer. The model is used to identify equilibria for CSR investment (Stage 1), wholesale prices (Stage 2), and retail prices (Stage 3). We find the resulting equilibria and the conditions under which these equilibria lead to higher profits for the competitors.

Tuesday, 11AM–12:15 PM

TB67

M - Indiana D
New Models in Revenue Management
General Session

Session Chair
Murray Lei, Queen's University, Kingston, ON, Canada.

1 Online Learning and Pricing for Network Service Systems with Reusable Resources

Huiwen Jia, Cong Shi, Siqian Shen, University of Michigan, Ann Arbor, MI, Contact: hwjia@umich.edu

We consider a price-based network revenue management problem over a finite time horizon. Stochastically arrived customers request a product (service) that occupies a sequence of reusable resources (servers). The goal is to maximize the total expected revenue. We assume incomplete information where the firm does not know the mappings between customer demand across products and the offered prices. We propose two new multi-armed bandit-based learning algorithms for finding near-optimal pricing policies. The proposed algorithms can achieve a cumulative regret $\tilde{O}\left(\sqrt{JXT}\right)$, which matches the lower bound. In establishing the regret, we bound the transient system performance upon price changes via mapping to a Jackson Network.

2 The Impact of Automation on Workers when Workers are Strategic: The Case of Ride-hailing

Saif Benjaafar, Zicheng Wang, Xiaotang Yang, University of Minnesota, Minneapolis, MN, Contact: wang2569@umn.edu

Technological advances in robotics, machine learning, and artificial intelligence have raised concerns about the displacement of human workers by automation. We study the impact of automation on worker welfare when workers have discretion in how they carry out the work and may act strategically. We ground our analysis in the setting of a ride-hailing service that operates a mixed fleet with human drivers and autonomous vehicles (AVs). We show that the introduction of AVs, by inducing a more favorable equilibrium, can lead to outcomes that improve both efficiency and worker welfare.

3 Ordering and Ranking Products for An Online Retailer

Zijin Zhang, Hyun-Soo Ahn, Lennart Baardman, University of Michigan, Ann Arbor, MI, Contact: zijinz@umich.edu

In e-commerce, how products are displayed on a webpage or mobile app has a large effect on customer behavior and sales. Data has shown that highly ranked products receive more clicks and are purchased more often. We consider an online retailer who faces the challenge of ordering their inventory and ranking their products. Specifically, we study analytic models in three separate scenarios: order and rank only once, order and rank when rankings can be updated over time, and order and rank when pre-orders can be used to learn about demand. We develop an optimal polynomial-time algorithm when order quantities and ranking decisions are made simultaneously. We extend this algorithm to the dynamic settings where rankings are updated and demand is learned. Theoretically and computationally, we show that our algorithms quickly generate good ordering and ranking decisions.

4 Joint Monitoring and Learning of Threatened Species

Roozbeh Yousefi[1], Jue Wang[2], [1]Queen's University, Kingston, ON, Canada; [2]Smith School of Business, Queen's University, Kingston, ON, Canada. Contact: r.yousefi@queensu.ca

Most threatened species are cryptic; managers of conservation reserves are often unsure about their presence in a region. If the species remains unseen, should the managers stop the efforts and reallocate the resources? Such decisions depend on the detectability of the species and its risk of extinction. We develop a decision-theoretic framework for joint monitoring and learning. We formulate the problem as a POMDP in which both the transition and observation probabilities are initially unknown but can be learned from monitoring. While a standard formulation is computationally intractable, we exploit the problem structure to reformulate the dynamic program in a lower dimension. We fully characterize the structure of the optimal policy and prove that the optimal decision rule exhibits a quasi-Lipschitz structure despite being non-monotone and non-convex.

Tuesday, 11AM–12:15 PM

TB69

M - Indiana F

Learning Algorithms to Manage Service Systems

General Session

Session Chair

Pengyi Shi, Purdue University, West Lafayette

1 Learning The Scheduling Policy in a Multiclass Many Server Queue with Abandonment

Yueyang Zhong[1], John R. Birge[2], Amy R. Ward[1], [1]The University of Chicago Booth School of Business, Chicago, IL, [2]University of Chicago, Chicago, IL, Contact: amy.ward@chicagobooth.edu

We consider a learning variant of a canonical scheduling problem in a multiclass many server queue with abandonment (specifically, the multiclass M(t)/M/N+M and GI/GI/N+GI queues). The objective is to minimize the long-run average class-dependent expected linear holding and abandonment costs when the class-dependent model parameters or distributions are unknown. We propose a Learn-Then-Schedule algorithm, which is composed of a learning phase during which point estimates of the mean service and patience times are formed, and an exploitation phase during which a static priority scheduling rule is followed. We establish a logarithmic lower bound on regret, and show that the regret of our Learn-Then-Schedule algorithm has the same order as that lower bound.

2 Online Learning and Pricing for Service Systems with Reusable Resources

Huiwen Jia, Cong Shi, Siqian Shen, University of Michigan, Ann Arbor, MI, Contact: shicong@umich.edu

We consider a price-based revenue management problem with finite reusable resources over a finite time horizon \$T\$. Customers arrive following a price-dependent Poisson process and each customer requests one unit of \$c\$ homogeneous reusable resources. If there is an available unit, the customer gets served within a price-dependent exponentially distributed service time; otherwise, she waits in a queue until the next available unit. We assume that the firm does not know how the arrival and service rates depend on posted prices, and thus it makes adaptive pricing decisions in each period based only on past observations to maximize the cumulative revenue. Given a discrete price set with cardinality \$P\$, we propose two optimal online learning algorithms and prove that the cumulative regret upper bound is \$\tilde{O}(\sqrt{PT})\$, which matches the lower bound.

3 An Online Queueing Design for Service Systems with Impatient Customers

Lun Yu[1], Zeyu Zheng[2], Zuo-Jun Max Shen[3], [1]Tsinghua University, Beijing, China; [2]University of California, Berkeley, Berkeley, CA, [3]University of California Berkeley, Berkeley, CA

We consider an online system design problem for an M/G/1+G queue. The system manager aims to find the optimal capacity allocation and scheduling policy to serve an arriving stream of impatient customers. We consider that the system manager does not know how long customers are likely to wait but can periodically review and update the capacity allocation and scheduling policy based on observed customers' abandonment decisions. Combining fluid approximation with online learning, we propose an iterative policy update approach so that the system manager can quickly find a close-to-optimal solution. Based on a new moment bound of the transient M/G/1+G queue, we show that, as the size of the system increases, our approach finds an asymptotically optimal policy with square-root accuracy within logarithmic time.

4 A Prescriptive Machine Learning Method for Courier Scheduling on Crowdsourced Delivery Platforms

He Wang[1], Adam Behrendt[1], Martin W P Savelsbergh[2], [1]Georgia Tech, Atlanta, GA, [2]ISyE Georgia Tech, Darlington, Australia.

The delivery capacity of crowdsourced delivery platforms is uncertain. To reduce the uncertainty, platforms can offer a reward to couriers that agree to be available to make deliveries for a specified period of time. We consider a scheduling problem in which a mix of scheduled and ad-hoc couriers serves dynamically arriving pickup and delivery orders. The platform seeks a set of shifts for scheduled couriers so as to minimize total courier payments and penalty costs. We present an ML method that combines simulation optimization for offline training and a neural network for online solution prescription. In experiments using real-world data provided by a crowdsourced delivery platform, our ML method achieves solution quality that is within 0.2%-1.9% of a sample average approximation method, while being orders of magnitude faster in terms of online solution generation.

Tuesday, 11AM–12:15 PM

TB70

M - Indiana G

Conditional Gradients and Machine Learning

General Session

Session Chair

Elias Wirth, ZIB, Germany.

Session Chair

Sebastian Pokutta, Zuse Institute Berlin (ZIB), Berlin, Germany.

1 Acceleration of Frank-Wolfe Algorithms with Open Loop Step-sizes

Elias Wirth, TU Berlin, Berlin, Germany. Contact: wirth@zib.de

Frank-Wolfe (FW) algorithms are popular first-order methods to solve convex optimization problems. They are generally slower than proximal methods but many works have identified accelerated convergence rates under various structural assumptions on the optimization problem and for specific FW variants.

These accelerated regimes hold for FW with line search or short-step but little is known about accelerated convergence regimes utilizing open loop step-size rules, a.k.a. FW with pre-determined step-sizes, which are algorithmically extremely simple and stable. We study FW with open loop step-size rules, characterize a problem setting for which FW with open loop step-size rules converges faster than line search and short-step, prove new convergence rates, and propose a partial answer to an open problem in kernel herding.

2 Affine Invariant Convergence Rates of The Conditional Gradient Method

Javier F. Pena, Carnegie Mellon University, Pittsburgh, PA

We show that the conditional gradient method for the convex composite problem \[\min_x\{f(x) + \Psi(x)\}\] generates primal and dual iterates with a duality gap converging to zero provided a suitable growth property holds and the algorithm makes a judicious choice of stepsizes. The rate of convergence of the duality gap to zero ranges from sublinear to linear depending on the degree of the growth property. The growth property and convergence results depend exclusively on the pair (f,Ψ). They are both affine invariant and norm-independent.

3 Continuous Time Frank-Wolfe Does Not Zig-Zag, but Multistep Methods Do Not Accelerate

Zhaoyue Chen, Stony Brook University, Stony Brook, NY, Contact: zhaoyue.chen@stonybrook.edu

The Frank-Wolfe algorithm has regained much interest in its use in structurally constrained machine learning applications. However, one major limitation of the Frank-Wolfe algorithm is the slow local convergence property due to the zig-zagging behavior. We observe that this zig-zagging phenomenon can be viewed as an artifact of discretization, as when the method is viewed as an Euler discretization of a continuous time flow, that flow does not zig-zag. For this reason, we propose multistep Frank-Wolfe variants based on discretizations of the same flow whose truncation errors decay as $O(\Delta^p)$, where p is the method's order. This strategy "stabilizes" the method, and allows tools like line search and momentum to have more benefit.

4 Using Taylor Approximated Gradients to Improve The Frank-wolfe Method for Empirical Risk Minimization

Zikai Xiong[1], Robert Michael Freund[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: zikai@mit.edu

The Frank-Wolfe method has become increasingly useful in applications, especially in settings where linear minimization is more computationally efficient than projection. In the setting of Empirical Risk Minimization, the complexity of the Frank-Wolfe methods typically grows linearly in the number of data observations *n*. In order to reduce this dependence on *n*, we propose amending it with Taylor-approximated gradients, including variants for deterministic and stochastic settings. Compared with existing methods when the optimality tolerance is small, our methods are able to simultaneously eliminate the dependence on *n* and obtain optimal convergence rates in convex and non-convex settings. We also propose a novel adaptive step size and show its convergence. Our experiments demonstrate that our methods exhibit very significant speed-ups over existing methods.

Tuesday, 11AM–12:15 PM

TB71

M - Arizona

Hybrid Classical-quantum Methods for Optimization and Sampling

General Session

Session Chair

David Bernal Neira, NASA Ames Research Center, Pittsburgh, PA

1 Copositive Optimization Via Ising Solvers

Robin Brown[1], David Bernal Neira[2], Davide Venturelli[3], Marco Pavone[1], [1]Stanford University, Stanford, CA, [2]NASA Ames Research Center, Pittsburgh, PA, [3]Universities Space Research Association, Mountain View, CA, Contact: rabrown1@stanford.edu

Recent years have seen significant advances in quantum-inspired technologies capable of approximately searching for the ground state of Ising Hamiltonians. The promise of leveraging quantum technology to accelerate the solution of difficult optimization problems has spurred an increased interest in developing mappings from such problems to Ising Hamiltonians. However, many existing approaches inherit the heuristic nature of the underlying Ising solver, limiting their application to problems where heuristics are sufficient. In this talk, we show how mixed-binary quadratic programs can be mapped into convex copositive programs, which can then be solved using cutting-plane algorithms. The convex structure of the copositive program allows for rigorous optimality guarantees even if the Ising solver used is a black box and/or heuristic in nature.

2 Mixed-integer Programming Using a Bosonic Quantum Computer

Farhad Khosravi[1], Artur Scherer[1], Pooya Ronagh[2,1], [1]1QBit, Vancouver, BC, Canada; [2]University of Waterloo, Waterloo, ON, Canada.

We propose a scheme for solving mixed-integer programming problems in which the optimization problem is translated to a ground-state preparation problem on a set of bosonic quantum field modes (qumodes). We perform numerical demonstrations by simulating a circuit-based optical quantum computer with each individual qumode prepared in a Gaussian state. We simulate an adiabatic evolution from an initial mixing Hamiltonian, written in terms of the momentum operators of the qumodes, to a final Hamiltonian which is a polynomial of the position and boson number operators. In these demonstrations, we solve a variety of small non-convex optimization problems in integer programming, continuous non-convex optimization, and mixed-integer programming.

3 On The Emerging Potential of Quantum Annealing Hardware for Combinatorial Optimization

Byron Tasseff[1], Yuchen Pang[2], Andrey Lokhov[1], Marc Vuffray[1], Sidhant Misra[1], Carleton Coffrin[3], [1]Los Alamos National Laboratory, Los Alamos, NM, [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]Los Alamos National Laboratory, los Alamos, NM, Contact: lokhov@lanl.gov

The recent emergence of novel computational devices such as quantum annealers presents new opportunities for hardware-accelerated hybrid optimization algorithms. This work reports our experience in benchmarking D-Wave Systems' quantum annealing computers for conducting combinatorial optimization and present new results on the recently released *Advantage* platform, which supports combinatorial optimization problems with more than 5,000 binary decision variables. Through the careful design of contrived optimization tasks, our work provides new insights into the computation properties of quantum annealing and suggests that this model has the potential to provide notable performance gains over established optimization algorithms, calling for the development of hybrid quantum-classical algorithms.

4 Generating High-Quality Samples with Quantum Annealing Hardware

Jon Nelson[1], Marc Vuffray[1], Andrey Lokhov[1], Tameem Albash[2], Carleton Coffrin[1], [1]Los Alamos National Laboratory, Los Alamos, NM, [2]University of New Mexico, Albuquerque, NM

Quantum annealing was originally intended for accelerating the solution of combinatorial optimization tasks that have natural encodings as Ising models. However, we will show that Quantum annealing platforms have the potential to be used as noisy Gibbs distribution sampler if tuned adequately. The procedure proposed in this work provides an approach to using QA hardware for Ising-model sampling presenting potential opportunities for applications in machine learning and physics simulation

Tuesday, 11AM–12:15 PM

TB72

M - California
AI in Social Media
General Session

Session Chair
Jie Zhang, University of Texas Arlington

1 Judging a Book by Its Cover? Examining The Formation of Social Bias with AI Experiments

Kay-Yut Chen[1], Diana (Yan) Wu[2], Jennifer Zhang[3], Xianghua Wu[3], [1]University of Texas at Arlington, Mansfield, TX, [2]University of Kansas, Lawrence, KS, [3]The University of Texas at Arlington, Arlington, TX, Contact: XIANGHUA.WU@MAVS.UTA.EDU

In this study, we construct deep neural network-based artificial intelligence (AI) agents and train them to play the trust game in groups. We find that social bias may emerge purely from repeated interactions with small groups of AIs. Conditions that influence levels of social bias by AIs and mitigation strategies for the bias are further explored.

2 Algorithmic Bias and Polarization in Social Media

Kevin Liu[1], Jie Zhang[2], Jiang Hu[2], [1]University of North Texas, Denton, TX, [2]University of Texas at Arlington, Arlington, TX, Contact: jiezhang@uta.edu

Social media platforms such as Facebook, Twitter, and Youtube apply recommendation algorithms to recommend/feed contributed content to users. While these algorithms work to increase the likelihood of clicks or views, they may result in an echo chamber and confirmation bias and potentially increase the polarization and extremism of users' opinions. This study explores the existence and conditions of this phenomenon and further shows the subsequent social impact.

3 A Machine Learning Approach to Augmenting Investor Rationality and Bias in Social Trading

Zhe Shen[1], Alex Zheng[2], Wei Jiang[1], [1]Shanghai Jiao Tong University, Shanghai, China; [2]Plano West Senior High, Plano, TX

Social trading allows layman investors (followers) to evaluate and copy expert traders' trades. The key challenge in social treading is how should followers identify a portfolio of traders to follow. This paper proposes a machine learning (ML) approach to augment followers' decisions in following traders. We show how ML algorithms can help augment investor intelligence and mitigate the biases present in human decisions such as herding. By mitigating these human decision biases, ML is able to augment investor decisions by producing a portfolio of traders that is more rational and fairer.

4 The Effect of Governors' Resilience Tweeting on Community Compliance during COVID-19 Pandemic

Bin Gu, Boston University, Boston, MA

We examine whether resilience messaging in governors' social media posts increases community compliance to government guidelines during the COVID-19 epidemic. We first conducted a secondary data analysis using a panel data of US states with community mobility, governors' tweets, and other information for the period between February 2020 and August 2021. We use the time residents spent at home and the time they spent at retail places to measure community compliance. We show that governors' resilience messaging significantly increases community compliance. We also conducted a controlled experiment to complement our secondary data analysis to identify the underlying mechanism. We find that the effect of resilience messaging on community compliance is partially mediated through residents' perceptions about inspirational leadership.

Tuesday, 11AM–12:15 PM

TB73

M - Colorado

Frontiers in Healthcare Operations Management

General Session

Session Chair

Tinglong Dai, Johns Hopkins University, Baltimore, MD

Session Chair

Guihua Wang, The University of Texas at Dallas

1 Robust Combination Testing: Methods and Application to Covid-19 Detection

Sanjay Jain[1], Jonas Oddur Jonasson[2], Jean Pauphilet[3], Kamalini Ramdas[3], [1]Oxford University, Oxford, United Kingdom; [2]MIT Sloan School of Management, Somerville, MA, [3]London Business School, London, United Kingdom. Contact: jpauphilet@london.edu

Situations where simple and affordable tests are available but not accurate enough to be operationally relevant are ubiquitous. We propose an analytical methodology to optimally combine results from cheap tests for increased predictive accuracy at low cost. Our robust optimization method can be applied to noisy and partially missing input data directly. On COVID-19 rapid antibody (resp. antigen) test data, we find that combining only three rapid tests increases out-of-sample AUC by 4% (6%) compared with the best performing individual test, and can increase sensitivity by 14% (10%) relative to available combination testing heuristics. Our methodology offers policymakers a data-driven path to identify, approve, and deploy a curated combination of cheap point-of-care tests in settings where gold standard tests are too expensive or slow.

2 What Can Personal Statements Tell Us? Insights About Physicians' Personality Traits and Clinical Performance

Jianing Ding, Susan F. Lu, Karthik Kannan, Purdue University, West Lafayette, IN, Contact: lu428@purdue.edu

Leveraging personality traits provide a promising pathway toward understanding physicians' cognitive behavior and their clinical performance. However, substantial challenges have prevented the exploitation of the relationship between physician personality and healthcare operations. In this study, we follow the Big Five model of personality to construct the measures of personality traits and examine the impact of physicians' personality traits on their clinical performance.

3 The Spillover Effects of Capacity Pooling in Hospitals

Jong Myeong Lim[1], Hummy Song[2], Julius Yang[3], [1]Tuck School of Business, Dartmouth College, Hanover, NH, [2]University of Pennsylvania, Philadelphia, PA, [3]Beth Israel Deaconess Medical Center, Boston, MA

Off-service placement is a common capacity pooling strategy that hospitals utilize to address mismatches in supply and demand that arise from the day-to-day variation in patient demand. This strategy involves placing patients in a bed in a unit that is designated for another specialty service. Building on prior work that documents the negative first-order effects of off-service placement on patients who are placed off service themselves, we quantify the spillover effects of this practice on patients who are actually placed on service. Using a combination of the Heckman sample selection model and the heterogeneity-based instrumental variables approach, we find that there are substantial negative spillover effects on productivity of care for patients placed on service, manifesting as longer lengths of stay.

4 Unintended Consequences of Generic Drug Review Policy

In Joon Noh[1], Hessam Bavafa[2], Christian Blanco[3], [1]Penn State University, University Park, PA, [2]Wisconsin School of Business, Madison, WI, [3]The Ohio State University, Columbus, OH, Contact: ikn5003@psu.edu

In this research, we examine if and the extent to which the faster generic drug application review process, enabled by Generic Drug User Fee Amendments (GDUFA) implemented in October 2012, may have compromised generic drug quality, as measured by drug recalls.

Tuesday, 11AM–12:15 PM

TB74

M - Florida

Learning and Risk

General Session

Session Chair

Paul Glasserman, Columbia University, New York, NY

1 Adversarial Reinforcement Learning: A Duality-Based Approach

Nan Chen[1], Mengzhou Liu[1], Mete Soner[2], [1]Chinese University of Hong Kong, Shatin N T, Hong Kong; [2]Princeton University, Princeton, NJ, Contact: nchen@se.cuhk.edu.hk

When applied to stochastic control problems, deep neural networks can overlearn the data and construct non-adapted policies, and thus susceptible to generalization error. In this paper, we propose an adversarial learning approach to address this issue. It stems from the literature of information relaxation. By relaxing the adapted requirement on the control policies and incorporating a Lagrangian martingale penalty into the objective function, we reformulate the problem as a min-max game between the agent and an adversary. The algorithm aims to learn both value and policy iteratively. Numerical experiments show the effectiveness of the approach.

2 Dynamic Leveraging-Deleveraging Games

Andreea Minca, Cornell University, Ithaca, NY

We introduce a new mechanism for leverage dynamics, based on a multi-period game of lenders with differentiated beliefs about the firm's fundamental returns. The game features strategic substitutability for low existing leverage and one-sided strategic complementarity for high existing leverage. The resulting leverage process exhibits a mean-reverting regime around a long-run level, as long as it stays below an instability level. Above the instability level, leverage becomes explosive.

3 Should Bank Stress Tests be Fair?

Paul Glasserman, Mike Li, Columbia University, New York, NY

Regulatory stress tests have become the primary tool for setting capital requirements at the largest U.S. banks. As a matter of policy, the same models are used for all banks to ensure consistency, despite considerable heterogeneity across institutions; individual banks have contended that some models are not suited to their businesses. Motivated by this debate, we ask, what is a fair aggregation of individually tailored models into a common model? We compare various notions of regression fairness. We argue that simply pooling data across banks treats banks equally but is vulnerable to implicit misdirection of legitimate information to infer bank identity. In the setting of linear models, we argue for estimating and then discarding centered bank fixed effects as preferable to simply ignoring differences across banks. We also discuss extensions to nonlinear models.

Tuesday, 11AM–12:15 PM

TB75

M - Illinois

Empirical Research on Blockchain and Fintech

General Session

Session Chair

Keongtae Kim, Chinese University of Hong Kong, New Territories, Hong Kong.

1 Winner's Return in The Nft Market

Hao Ying[1], Miaozhe Han[2], Keongtae Kim[2], [1]Chinese University of Hong Kong, New Territories, Hong Kong; [2]Chinese University of Hong Kong, New Territories, Hong Kong. Contact: yinghao@link.cuhk.edu.hk

The Non-fungible tokens (NFTs), the novel and fast-growing digital assets whose uniqueness, ownership, and history are protocolized, reached tens of billion U.S. dollars volume in 2021. Using a data set of auctions on an Ethereum-based

NFT marketplace, we study how the number of bids for an NFT in the primary sale auction affects its performance in the secondary market auctions. We find that NFTs with higher numbers of bids in the primary sale auctions also have a significantly higher possibility to be resold in the secondary auctions, controlling for the bidding amount dispersion of each auction. However, the number of bids in the primary sale auctions significantly reduces the winner's return in the secondary auctions. Overall, this project is one of the first to study the novel NFT market behavior and our findings do provide implications for bidding strategies in this market.

2 Sociolink: Leveraging Relational Information in Knowledge Graphs for Startup Recommendations

Ruiyun Xu[1], Hailiang Chen[2], J. Leon Zhao[3], [1]Shenzhen Research Institute of Big Data, Chinese University of Hong Kong (Shenzhen), Shenzhen, China; [2]The University of Hong Kong, Hong Kong, Hong Kong; [3]Chinese University of Hong Kong (Shenzhen), Shenzhen, China. Contact: ruiyunxu@cuhk.edu.cn

Venture capitalists are increasingly relying on recommendation models to facilitate their investment decisions. Unfortunately, previous works in startup recommendations fall short because they do not consider the uniqueness of venture capital context, including two-sided matching between two firms and high information asymmetry due to a lack of information disclosure by startups. Guided by the proximity principle, we develop a novel startup recommendations framework called SocioLink by leveraging complex relational information. SocioLink depicts various social relations in a knowledge graph and integrates machine learning with heterogeneous graph analysis and graph visualization. Experimental results show that our proposed methods significantly outperform existing startup recommendations methods in recommendation accuracy and quality.

3 Self-donations and Charitable Contributions in Online Crowdfunding: Theory and Evidence

Raghunath S. Rao[1], Zhuping Liu[2], Qiang Gao[2], [1]University of Texas-Austin, Austin, TX, [2]Baruch College, City University of New York, New York, NY

We posit that a donation-based crowdfunding project can credibly signal its intent and quality via a strategy of "self-donation," whereby the project steward donates to her own project. Using data from an online education crowdfunding platform, we find that self-donations improve the pace of donations and the overall level of contributions. We also find that the self-donation strategy is especially effective for inexperienced project stewards that face more significant uncertainty and works only when a self-donation is visible to potential donors during the earlier periods of fundraising efforts. These findings are consistent with our theorizing,

Tuesday, 11AM–12:15 PM

TB76

M - Michigan

Food Banks, Food Waste, and Retail Operations

General Session

Session Chair

John Lowrey, MD

1 Determining Minimum Shelf Life Requirements

Arzum E. Akkas[1], Dorothee Honhon[2], [1]Boston University, Boston, MA, [2]University of Texas at Dallas, Richardson, TX, Contact: aakkas@bu.edu

Products approaching the end of their shelf lives are a major contributor to food waste at retailers. For this reason, manufacturers are challenged to establish remaining shelf life thresholds for products that leave their warehouses. We offer a framework for manufacturers to determine minimum remaining shelf life thresholds that cater to characteristics of different products, which offer 5-10% improvement in profits and 6-12% reduction in food waste compared to the one-size-fits-all approach practiced at our collaborator.

2 Enhancing Fundraising Performance Through Staffing Decisions

Yingru "Ruby" Han, Luv Sharma, Pelin Pekgun, University of South Carolina, Columbia, SC, Contact: yingru@email.sc.edu

While fundraising is labor-intensive, the literature on understanding the human capital factor in fundraising teams is limited. We intend to fill this gap by using panel data from 183 food banks affiliated with Feeding America and proposing a new metric for fundraising efficiency. To facilitate food banks' staffing decisions, we test for the relationship between staffing levels and fundraising efficiency as well as the moderating roles of social media and labor composition of the relationship.

3 The Value of Delivery Platforms on Cross-channel Grocery Retailing

Lina Wang[1], Elliot Rabinovich[2], [1]Pennsylvania State University, State College, PA, [2]Arizona State University, Tempe, AZ, Contact: lkw5428@psu.edu

This study empirically investigates how the adoption of delivery platforms as an additional channel affects brick-and-mortar retailers' store performance based on transaction data from regional retail chains. More importantly, we evaluate how this effect varies across categories depending on households' preferences for using the platforms to purchase niche products or mainstream products.

4 Food Donations, Retail Operations, and Retail Pricing

John Lowrey[1], Timothy Richards[2], Steve Hamilton[3], [1]Northeastern University, Cambridge, MA, [2]Arizona State University, Mesa, AZ, [3]California Polytechnic State University, San Luis Obispo, CA, Contact: j.lowrey@northeastern.edu

For grocery retailers, managing perishable food that is nearing expiry is a major challenge. Donating food to food banks is a "green image" strategy for retailers as it reduces waste-generation and diverts food to a secondary, quality-differentiated market. In this paper, we quantify the economic impacts of this secondary market for food by examining donations and pricing behavior for competing retailers. This study contributes a new type of reuse platform to the literature on closed loop supply chains.

Tuesday, 11AM–12:15 PM

TB77

M - Texas

Behavioral Operations with Social and Environmental Impact

General Session

Session Chair

Leon Valdes, University of Pittsburgh, Pittsburgh, PA

1 Encouraging Energy Efficiency Investments in a Supply Chain: A Behavioral Investigation

Jason Nguyen[1], Karen L. Donohue[2], Behrooz Pourghannad[3], [1]Ivey Business School, Western University, London, ON, Canada; [2]University of Minnesota, Minneapolis, MN, [3]Lazaridis School of Business & Economic, Rochester, MN, Contact: jnguyen@ivey.ca

Suppliers' propensity to accept external assistance from third-party organizations and buyers and undertake subsequent Energy Efficiency investments is still elusive. Through controlled behavioral experiments, this paper studies how the source of external assistance, and characteristics of the investment influence the supplier's propensity to undertake the assessments and subsequent investments

2 The Value of Long-term Relationships when Selling to Informal Retailers - Evidence from India

Andre Calmon[1], Olumurejiwa Fatunde[2], Joann de Zegher[3], Gonzalo Romero[4], [1]Georgia Institute of Technology, Atlanta, GA, [2]Massachusetts Institute of Technology, Grapevine, TX, [3]MIT Sloan, Cambridge, MA, [4]Rotman, University of Toronto, Toronto, ON, Canada.

Attempts to distribute durable, life-improving goods to customers at the Base of the Pyramid (BoP) through traditional supply chains or e-commerce have struggled to succeed at scale. One potential explanation is poor relationship management with informal retailers, which are often embedded within communities. By analyzing panel data from a distributor selling to 331 formal retailers and 493 informal retailers in India from April 2016 to December 2019, we demonstrate that after a sales agent reallocation, informal retailers take longer to recover than formal retailers. We rule out multiple alternative explanations for these results, thereby providing support for the hypothesis that disruptions to social/business relationships are particularly harmful when selling to retailers in informal markets.

3 Enterprise Social Media Platform Design and Knowledge Worker Productivity

Samer Charbaji, Roman Kapuscinski, Stephen Leider, University of Michigan, Ann Arbor, MI, Contact: charbaji@umich.edu

Enterprise social media platforms are used by companies to encourage helping behavior among knowledge workers, but have had mixed success due to low employee usage. We conduct a lab experiment that studies the effect of different platform design features on helping behavior and performance and elicit the behavioral mechanisms driving effective design features. In our first study, we show that rewarding participants with private badges for achieving helping goals yields the most help and the best participant performance, while treatments that provide participants with information on platform helping behavior result in minimal effects on help and no effect on performance. In our second study, we find that helping behavior in our badges treatment is driven primarily by both goal setting and symbolic rewards rather than early helpfulness nudging and intermediate feedback.

4 The Effects of Hiring and Paying on Social Audits: An Experiment

Gabriel Alfonso Pensamiento Calderon[1], Leon Valdes[2], [1]Katz Business School, University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, Contact: gap75@pitt.edu

Companies often rely on audits to assess the social and environmental practices of their suppliers. However, empirical evidence suggests that these audits can be too lenient and that poor practices can go undetected or unreported. In this study, we conduct an incentivized laboratory experiment to investigate some of the causes and mechanisms behind this behavior. Specifically, we examine and disentangle how the supplier hiring and/or paying the auditor affects the accuracy of audit reports. Moreover, we explore whether these effects are impacted by auditors' motivated beliefs.

Tuesday, 11AM–12:15 PM

TB78

M - Utah

Networks, Diffusion, and Media

General Session

Session Chair

Yuan Yuan, 1</sup

1 Heterogeneous Relationships Between Multiple Types of Uniqueness and Popularity in Music

Yulin Yu, University of Michigan, Ann Arbor, MI, Contact: yulinyu@umich.edu

In this paper, we first unpack the multiple facets of a song's novelty or uniqueness and, next, measure its impact on a song's popularity. We employ a series of statistical models to study the relationship between a song's popularity and novelty associated with its lyrics, chord progressions, or audio properties. Overall we found a song's lyrical uniqueness to have the most significant association with its popularity. However, audio uniqueness was the strongest predictor of a song's popularity, conditional on the song's genre. We further found the theme and repetitiveness of a song's lyrics to mediate the relationship between the song's popularity and novelty. Broadly, our results contradict the ``optimal distinctiveness theory'' and call for an investigation into the multiple dimensions along which a cultural product's uniqueness could manifest.

2 Habits in Consumer Purchases: Evidence from Store Closures

Amir Tohidi[1], Dean Eckles[2], Ali Jadbabaie[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: atohidi@mit.edu

In-store shopping is a recurring behavior often happening in a familiar environment, making it very likely for the formation of habits. Here, using panel data on households' purchases, we use store closures as a shock that partially disrupts households' shopping behavior to identify the role of formed shopping habits in repeated brand purchases. Closures force people to visit new stores where we posit they are more likely to engage in deliberative decision-making processes driving them to explore some options. We find that following a closure households are more likely to purchase something other than their favorite brand in that product category. Over time, households return to higher levels of purchasing their modal brand indicating formation of new habits. However, we find that the temporarily habit disruption results in a lasting impact on households' brand choices.

3 The Covid-19 Infodemic: Prevalence, Adverse Actors, and Real-world Implications

Kai-Cheng Yang, Indiana University Bloomington, Bloomington, IN, Contact: yangkc@iu.edu

During the COVID-19 pandemic, the spread of virus in communities coincided with surges of misinformation on social media, which were termed the "Infodemic." Many were concerned that misinformation could undermine public's trust towards intervention measures. To reveal the infodemic landscape, I analyzed large-scale data collected from major social media platforms. I estimated the prevalence and cascade sizes of infodemic content and found that although it had a smaller volume in total than mainstream news, individual pieces of misinformation tended to reach larger audiences on average. In the misinformation dissemination process, some verified accounts and social bots were found to play an outsize role. I also showed that online misinformation was associated with increased vaccination refusal levels and off-label prescriptions of unproven drugs for COVID-19.

Tuesday, 11AM–12:15 PM

TB79

JWM - Room 201

New Technologies in Service Operations

General Session

Session Chair

Nil Karacaoglu, The Ohio State University, Columbus, OH

Session Chair
Kejia Hu, Vanderbilt University, Nashville, TN

1 Don't Fake It if You Can't Make It: Driver Misconduct in Last Mile Delivery

Srishti Arora[1], Vivek Choudhary[2], Pavel Kireyev[3], [1]INSEAD, Singapore, Singapore; [2]NTU, Singapore, Singapore; [3]INSEAD, Paris, France. Contact: srishti.arora@insead.edu

To study and quantify the impact of FE misconduct on last mile delivery (LMD) performance we collaborated with one of the largest LMD firms in India. Using instrumental variable regression, we identify the effect of fake remarked deliveries on future productivity. Our results suggest that operational losses due to fake remarks on a given day spill over to the subsequent day, by reducing the next day overall success rate of deliveries by 1.5%. This decrease is mostly driven by the reduction in first-time-right deliveries, resulting in significant revenue losses for the LMD firms. We find evidence that opportunistic circumstances, such as familiarity with the delivery area and cash on delivery parcels, exacerbate the detrimental effect of fake remarks. We present some of the first results on the impact of aberrant behaviors on workers' productivity in last mile logistics.

2 The Operational Value of Cross-channel Advertising on E-commerce Marketplaces

Qiyuan Deng[1], Kejia Hu[2], Yun Fong Lim[3], [1]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [2]Vanderbilt University, Nashville, TN, [3]Singapore Management University, Singapore, Singapore. Contact: dengqiyuan@cuhk.edu.cn

E-commerce marketplaces provide various paid advertising services, which promise to increase seller's exposure to potential buyers in different channels. We study the effect of cross-channel advertising on a seller's revenue at an e-commerce marketplace, based on which we develop an optimization model to facilitate the seller's advertising budget allocation decision.

3 Joint Capacity Allocation and Job Assignment Under Uncertainty

Peng Wang[1], Yun Fong Lim[2], Gar Goei Loke[3], [1]National University of Singapore, Singapore, Singapore; [2]Singapore Management University, Singapore, Singapore; [3]Erasmus University, Rotterdam, Netherlands. Contact: peng.wang.2016@pbs.smu.edu.sg

We consider a multi-period joint capacity allocation and job assignment problem. The planner simultaneously decides on allocating resources across J different supply nodes, and assigning of jobs from I different demand origins to these J nodes, so as to maximize the reward for matching or minimize the cost of failure to match. The setting can be applied in many service management settings such as ride-sharing fleet re-positioning, and patient management in healthcare. We introduce a distributive decision rule, which decides on the proportion of jobs to be served by each of the supply nodes. Our model has a convex reformulation and can be solved by a sequence of linear programs. We test our model against state-of-the-art models that focus solely on the capacity allocation or job assignment decisions. The result records 1-15% reductions in costs, and shorter computation times.

4 Understanding The Value of Feature-information Sharing

Hojun Choi[1], Ahmet Colak[2], Sina Golara[3], Achal Bassamboo[4], [1]Northwestern University, Evanston, IL, [2]Clemson University, Pendleton, SC, [3]Kennesaw State University, Marietta, GA, [4]Northwestern University, Evanston, IL, Contact: hojun.choi@kellogg.northwestern.edu

Automobile sales platforms have proliferated with e-commerce. Interestingly, they vary widely in their information-sharing policies. In this paper, we study novel feature data from Cars.com. Existing research focused on the base attributes of cars, but Cars.com data allows us to explore 209,567 unique features using a national sample from 13,869 dealerships and 50 million daily listings. We develop a two-stage estimation framework that estimates the information value of features, pricing strategies of car dealers, and listing days. Our results reveal that (i) features account for 15% of the price, explaining 28% of price variation, and (ii) high-value features mitigate the overpricing effect. We contribute to an information-sharing literature and document novel managerial insights on pricing that act as omitted effects in the absence of features information.

Tuesday, 11AM–12:15 PM

TB80

JWM - Room 202
Methodological Advancements in Multiobjective Optimization
General Session

Session Chair
Margaret M. Wiecek, Clemson University, Clemson, SC

1 Approximation Algorithms for Unbounded Convex Vector Optimization Problems

Firdevs Ulus[1], Andrea Wagner[2], Birgit Rudloff[3], Gabriela Kovacova[4], Niklas Hey[5], [1]Bilkent University, Ankara, Turkey; [2]Vienna University of Economics and Business, vienna, Austria; [3]Wirtschaftsuniversitat Wien, Wien, Austria; [4]Vienna University of Economics and Business, Austria, Vienna, Austria; [5]Vienna University of Economics and Business, Vienna, Austria.

There are various approximation algorithms for solving bounded convex vector optimization problems in the literature. In this work, we relax the assumption of boundedness. We generalize the solution concept to be applicable for both bounded and unbounded problems and derive algorithms capable of handling both types of problems. The algorithms initiate with a phase that simultaneously finds recession directions as well as an initial outer approximation of the image of the feasible region. We illustrate the algorithm with examples.

2 On Solving Two-stage Robust Biobjective Linear Progams

Rakhi Goswami, Margaret M. Wiecek, Clemson University, Clemson, SC, Contact: rgoswam@g.clemson.edu

Two-stage biobjective linear programs (TSBOLPs) model decision situations under uncertainty having conflicting objectives at every stage. The first-stage Pareto set is computed under incomplete information, while the second-stage Pareto set can be computed only when additional information becomes available. The goal is to solve a two-stage robust BOLP (TSrBOLP) for both Pareto sets. The application of the weighted sum scalarization, and the assumptions that the uncertainty set and/or the feasible set of second-stage problem are polytopes lead to three single-objective parametric formulations of the TSrBOLP of an increasing level of difficulty. Two of the models assume the form of LPs whose optimal parametric solutions provide the exact Pareto sets in closed form. Solution approaches are discussed for the third formulation that lead to a program with bilinear terms.

3 Set-based Regret for Online Multiobjective Optimization

Kristen Savary, Clemson University, Clemson, SC, Contact: ksavary@g.clemson.edu

In online multiobjective optimization, the computed solutions are not Pareto for the associated offline multiobjective problem (MOP). To assess the regret of not computing the Pareto set of the offline MOP at each iteration, a concept of set-based regret is introduced and approaches to its computation are developed. It is shown that the set-based regret computed using hypervolume achieves similar upper bounds to those obtained by the regret for the online single objective case. Numerical examples are included.

Tuesday, 11AM–12:15 PM

TB81

JWM - Room 203

Analytics and Business Applications

Contributed Session

Session Chair

Yilun Xu, Harvard University, Cambridge, MA

1 Predict Whether Restaurants Stay Open Using Yelp Dataset

Walamy Kouadio, Koko Biney, John Scheuplein, Ho-Chang Chae, University of Central Oklahoma, Edmond, OK

The restaurant industry is one of the largest sectors in the economy with a large workforce, and most prior studies examined restaurant survival from financial, economic, and internal factors. Using online reviews and business attributes to predict the success of restaurants is an important area that has not been sufficiently evaluated. By using the Yelp dataset, we developed a binary predictive model to distinguish restaurants staying open so that we can provide meaningful insight to restaurant owners and anyone wanting to invest in this industry. Various predictive models were created with the highest accuracy of 0.82. We found that being a franchise, the number of reviews, being good for lunch or dinner are important factors in staying open. Our models outperformed those of the past studies as we created additional features from user reviews with text analytics.

2 The Art of Paper Making is Already Dead

Elliott L. Bell, Radix Engineering, Houston, TX, Contact: elliott.bell@radixeng.com

Manufacturers pursuit to become more Capable, Stable, Predictable and Efficient. The competitive requirement to achieve operational excellence or at a minimum improve OEE has demanded growth beyond our human centric past.

3 Feature Selection as a Nash-bargaining Solution: Applications in Online Advertising and Information Systems

Kimia Keshanian[1], Daniel Zantedeschi[2], Kaushik Dutta[2], [1]University of Tampa, Tampa, FL, [2]University of South Florida, Tampa, FL

Feature selection is a fundamental problem in online advertising, as features usually need to be purchased from third parties, and they are costly. Although many feature selection techniques can be used in online advertising and the general information systems (IS) domain, their performance is often context specific. Therefore, the literature of IS is suffering from a lack of adequate and generic methods. In this study, we address this issue by proposing a novel approach that employs ideas from the field of cooperative game theory. We derive a (continuous) second-order cone program that any convex programming solver can solve for determining the best subset of features. We show the efficacy of our proposed method on a real-life online advertising case study.

4 Making Hard Decisions: Which Stores to Close?

Mohsen Bahrami[1], Yilun Xu[2], Miles Tweed[3], Burcin Bozkaya[3], Alex Pentland[1], [1]Massachusetts Institute of Technology-Media Lab, Cambridge, MA, [2]Harvard BUsiness School, Cambridge, MA, [3]New College of Florida, Sarasota, FL

Many studies propose methods for finding the best location for new stores and facilities, but few studies addressthe store closing problem. As a result of the recent COVID-19 pandemic, many companies have been facingfinancial issues. In this situation, one of the most common solutions to prevent loss is to downsize by closing oneor more chain stores. Such decisions are usually made based on single-store performance; therefore, the underperformingstores are subject to closures. This study first proposes a multiplicative variation of the well-knownHuff gravity model and introduces a new attractiveness factor to the model. Then a forward-backward approachis used to train the model and predict customer response and revenue loss after the hypothetical closure of aparticular store from a chain. In this research the department stores in New York City are studied using largescalespatial, mobility, and spending datasets. The case study results suggest that the stores recommendedbeing closed under the proposed model may not always match the single store performance, and emphasizes thefact that the performance of a chain is a result of interaction among the stores rather than a simple sum of theirperformance considered as isolated and independent units. The proposed approach provides managers anddecision-makers with new insights into store closing decisions and will likely reduce revenue loss due to storeclosures.

Tuesday, 11AM–12:15 PM

TB82

JWM - Room 204

Disaster Response Logistics

General Session

Session Chair

Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY

1 Managing The Volatility of a Municipal Service System During a Slow-onset Disaster

Duygu Pamukcu[1], Christopher W. Zobel[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Blacksburg, VA, Contact: duygu@vt.edu

The difficulties in managing the recent global pandemic have revealed a need for adapted emergency plans for slow-onset disasters with variable impacts. Despite the volatility in citizen needs and government capabilities during such crises, governments are responsible for adjusting their operations to maintain necessary services. We propose a time series model to assess the volatility in daily service demand during a slow-onset disaster. We demonstrate the effects of the COVID-19 pandemic on the citizens' daily non-emergency service request behavior in the New York City 311 system. We perform the analysis separately for call groups considering if they experienced a significant increase or decrease in demand volumes during the pandemic. We also discuss the possibility of differential impacts of such disasters across locations to account for discrepancies.

2 Energecy Vehicle Routing in Post-disaster Zones

Ruben Yie-Pinedo, Universidad el Norte, barranquilla, Colombia. Contact: ryie@uninorte.edu.co

The routing of emergency vehicles and the transportation of any kind of relief and war commodities is highly exposed to different kinds of threats (Natural disasters, terrorist attacks, common delinquency etc.) that could endanger in-transit cargo. Our research focuses on creating safety routes in order to avoid danger zones and confrontations by increasing the overall safety of the network. We will force cargoes (trucks, ships, planes, etc.) to use escort vehicles (patrols, plows, bulldozers, etc.) to increase the safety of the trip while in unsafe zones.

3 Creating Personalized Recommendation Menus of Nonprofit Tasks to Increase Volunteer Engagement

Milan Preet Kaur, Rensselaer Polytechnic Institute, Troy, NY, Contact: milankaur22@gmail.com

Nonprofit organizations (NPOs) depend on volunteers to provide crucial support to communities. Successful volunteer-to-task assignments in NPOs must balance critical community needs while providing opportunities that motivate future volunteer participation. NPOs rarely know specific preferences and constraints of volunteers that impact their participation. Thus, a volunteer-to-task matching methodology using an integer linear programming framework is developed. It uses an estimate of volunteer preferences and community needs to create personalized task recommendation menus for volunteers while also creating ideal volunteer groups to provide a collaborative environment to encourage volunteer engagement and satisfaction. The menu creation method has the potential to reduce match friction and can systematically capture community and volunteer needs.

4 Driver Allocation Based on Health Pre-conditions and the Geospatial Prediction of the COVID-19 Spread of Infection

Carlos D. Paternina-Arboleda, San Diego State University, San Diego, CA, Contact: cpaternina@sdsu.edu

This study addresses the design of an intelligent allocation model that aims to decrease the probability of infection and illness of COVID-19 among drivers of a transport fleet, considering different factors such as route risk of infection based on the geospatial prediction of contagion rates, and the drivers' medical status based on pre-existing health conditions. The main purpose of this approach is to reduce the probability of deaths and severe cases of COVID-19, based on pre-existing conditions and the interaction between the geospatial spread of the infection and driver's allocation, while minimizing labor disruptions in the distribution chain, including factors such as absenteeism and potential loss of lives. The application of the methodology herein proposed, estimated a decrease of both the average expected number of deaths and days of absenteeism.

Tuesday, 11AM–12:15 PM

TB84

JWM - Room 206

Simulation Analytics and Input Uncertainty

General Session

Session Chair

Enlu Zhou, ISyE Georgia Tech, Atlanta, GA

1 Metric Learning on Simulation Sample Paths for Nearest Neighbor Prediction

Graham Laidler[1], Lucy Elizabeth Morgan[1], Barry L. Nelson[2], Nicos Pavlidis[1], [1]Lancaster University, Lancaster, United Kingdom; [2]Northwestern University, Evanston, IL, Contact: g.laidler1@lancaster.ac.uk

Portions of the current state of a simulation model that are also observable in the real world can provide useful information for predictions about the future state of the real world. For example, the size of each queue upon a customer's arrival can be the basis for prediction of their sojourn time. With this aim, nearest neighbor methods are a natural, non-parametric way to make predictions based on the observed system state over time. We consider what 'nearest neighbor' means for a high-dimensional system state, and present a metric learning method that takes into account the stochastic nature of sample path data to learn a suitable distance function for this context.

2 Input Uncertainty was Central in Cornell University's Covid-19 Planning

Shane Henderson, Cornell University, Ithaca, NY, Contact: sgh9@cornell.edu

Cornell University managed to remain open for in-person instruction during the Covid-19 pandemic from Fall 2020 to the present. This was made possible by a huge collective effort that relied on mathematical modeling for guidance on the highest-level decisions. The mathematical modeling included various simulation models, all of which had in common that a number of input parameters were unknown. I'll survey our modeling of those input parameters, emphasizing the commonalities and differences with standard simulation input-uncertainty modeling.

3 Distributional Input Uncertainty

Zhenyuan Liu, Motong Chen, Henry Lam, Columbia University, New York, NY, Contact: zl2817@columbia.edu

The vast majority of the simulation input uncertainty literature focuses on estimating target output quantities that are real-valued. However, outputs of simulation models are random and real-valued targets essentially serve only as summary statistics. In this paper, we study the input uncertainty problem from a distributional view, namely we construct simultaneous confidence bands for the entire output distribution function. Our approach utilizes a novel test statistic that consists of the supremum of the sum of a Brownian bridge and a mean-zero Gaussian process whose covariance function is characterized by the influence function of a suitable functional, which generalizes the Kolmogorov-Smirnov statistic to account for input uncertainty. We demonstrate how subsampling helps estimate the covariance function of the Gaussian process, thereby leading to an implementable estimation of the quantile of the test statistic and a statistically valid confidence band.

4 A/b Tests Under Safety Budget: A Simulation-optimization Point of View

Nian Si[1], Jose Blanchet[1], Ramesh Johari[1], Zeyu Zheng[2], [1]Stanford University, Stanford, CA, [2]University of California, Berkeley, Berkeley, CA, Contact: niansi@stanford.edu

A/B testing is massively employed in online platforms, through experiments with real customers, to timely identify the best from a pool that includes new features and the in-use feature. Experimenting new features can be unsafe because they may incur large costs that are a priori unknown. In this work, we provide optimal A/B testing experimental design that minimizes the probability of false selection under pre-specified safety budgets, where experiments need to stop immediately if the safety budgets are exhausted before the experiment horizon. We show structural insights by solving explicit optimal sampling allocation and analyzing the probability of false selection at the stopping time. Finally, we propose an adaptive algorithm that converges to the optimal sampling allocation proportions and we demonstrate the effectiveness of the algorithm in simulation studies.

Tuesday, 11AM–12:15 PM

TB85

JWM - Room 207

Behavioral Operations Management and Innovation

Contributed Session

Session Chair

Zezhen (Dawn) He, Simon Business School, University of Rochester, Rochester, NY

1 Promoting Safety in Shop Floor Environment: Public Relative Performance Feedback and Best Practice Sharing

Soh Hyun Chu[1], Elliot Bendoly[1], James Hill[2], [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH, Contact: chu.589@osu.edu

While studies suggest possibly complementary relationships between safety and operational efficiency, we know less about the role of the feedback given to both metrics. Implementing a controlled laboratory experiment, we aim to observe the independent and moderating effects of multiple treatments on mitigating the tradeoffs between, in other words, jointly promoting the two metrics. Our treatments include Public Relative Performance Feedback (RPF) and Individual Absolute Performance on safety, Conflicting feedback on efficiency, and Best Practice on efficiency.

2 The Impact of Prior Innovative Ideation on Investment and Information Acquisition Decisions

Soheil Hooshangi, University of North Carolina at Greensboro, Greensboro, NC, Contact: s_hoosha@uncg.edu

In a series of experiments, we provide evidence that between individuals who have, and don't have, prior innovative ideation experience, the former group is increasingly curious about knowing the details of other people's potentially similar business ideas when information about those ideas is lacking. The experienced innovators can rely on elaborating on the information they already have, or seeking information from external resources, to satisfy their curiosity. In using the former method, they use their knowledge of their own idea as a data point to fill the informational gap about the other person's idea, which results in overvaluing and overinvesting in the other person's idea. In using the latter method, they select to acquire information about the details, at the expense of ignoring valuable information about the likelihood of success, of the other person's idea.

3 Relative Knowledge Proportions in Research and Development Partnerships

Abigail Richard[1], Fred Ahrens[2], Benjamin T. George[2], [1]University of Indianapolis, Indianapolis, IN, [2]The University of Toledo, Toledo, OH, Contact: richarda@uindy.edu

It is well-accepted that innovation has the potential to be greatly beneficial to firms, though the innovation process can also be risky. To aid R&D supply chain partners, we examine the consequences of various relative proportions of knowledge on innovation, and the corresponding role of these knowledge proportions in partnerships.

4 A Behavioral Study of Self-other Adoption Discrepancies in XAI

Fernanda Bravo[1], Zezhen (Dawn) He[2], Yaron Shaposhnik[2], Leon Valdes[3], [1]UCLA Anderson School of Management, Los Angeles, CA, [2]University of Rochester, Rochester, NY, [3]University of Pittsburgh, Pittsburgh, PA

Despite major investments in development of ML-based predictive models that outperform humans in certain tasks, it has been observed that in practice, often users do not follow recommendations from systems that utilize such technologies. However, the question of whether the subject that is affected by the prediction impacts adherence is not well understood. This question is relevant as several applications in ML, from medicine to the judicial system to lending decisions, are made by a user but affect a third party. In this work, we conduct behavioral experiments to study whether the party that is affected by a user's decision (self vs. other) impacts the user's adoption of ML recommendations. In addition, we study whether the presence vs. absence of explanations—commonly touted to increase ML adoption—moderates our results.

Tuesday, 11AM–12:15 PM

TB86

JWM - Room 208

AAS Best PhD Dissertation and Best Paper Awards

Flash Session

Session Chair

Kai Wang, Carnegie Mellon University's Heinz College, Pittsburgh, PA

Session Chair

Andrew Churchill, Mosaic ATM, Inc., Leesburg, VA

Session Chair

Sebastian Birolini, University of Bergamo, Dalmine (BG), Italy.

Tuesday, 11AM–12:15 PM

TB87

JWM - Room 209

Learning in Transportation Science/ Emergency Response

Contributed Session

Session Chair

Alireza Rostami, Michigan State University, East Lansing, MI

1 Evacuating Yosemite National Park Using Discrete Event Simulation Software

Thomas Rios[1], Aaron Bradley Hoskins[2], [1]California State University, Fresno, Fresno, CA, [2]California State University, Fresno, Fresno, CA

The frequency of wildfires and the population density of National Parks both surge in summer months. Recent trends indicate both continue to increase simultaneously. A study of the evacuation of Yosemite National Park was performed using Flexsim, a discrete event simulation software. The study was purposed to determine a baseline time estimate for a complete evacuation of the valley floor when using public transportation to supplement the process.

2 Efficient Search for Rescuees After a Natural Disaster

Victor Gonzalez[1], Patrick Jaillet[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: victorgo@mit.edu

When a natural disaster occurs, being able to send out rescue teams to people in need of help is crucial. One challenge in sending them out efficiently is uncertainty in the location of people in need of rescue. New technologies, such as drones, can be sent out to find people in need of rescue to reduce uncertainty. We mathematically formulate a model to represent the search process of drones over a domain. Using this model, we develop algorithms that can be used to search the region efficiently. We develop divide and conquer methods which can be used to solve larger problems and speed up optimization in larger problems and allows for adaptive solutions as we learn new information.

3 Application Driven Dimensionality Reduction for Representation Learning and Anomaly Detection in Transportation Systems

Ran Sun[1], Yueyue Fan[2], [1]University of California, Davis, Davis, CA, [2]University of California, Davis, Davis, CA, Contact: ransun@ucdavis.edu

Modern transportation systems have benefited from rich spatiotemporal data. Accurate and efficient sensing and data representation would enable a deeper understanding of the underlying phenomenon of human mobility and interactions with infrastructures, allowing better planning and operations decisions. In this study, we propose an application driven dimensionality reduction framework for data representation learning. A novel perspective is that the representation of the data should be dependent on how the data is used in downstream applications. Therefore, we incorporate the information loss for downstream application into the data encoding-decoding process. The approach is formulated as a Stiefel manifold optimization and is demonstrated using network travel time, vehicular emission estimation and anomaly detection case studies.

4 **Estimating Path Travel Cost in Large-scale Networks Using Machine Learning Techniques**

Alireza Rostami[1], Ali Zockaie[1], Fatemeh Fakhrmoosavi[2], Ehsan Kamjoo[3], [1]Michigan State University, East Lansing, MI, [2]University of Connecticut, Storrs, CT, [3]Michigan State University, East Lansing, MI, Contact: darzianr@msu.edu

Origin-Destination (OD) travel time and cost estimation are critical tasks for transportation planners and rideshare services. Path-finding algorithms and data-driven techniques based on historical trip records are primarily used in previous studies to address these tasks. However, these methods are either time-consuming or fail to consider the toll-path option in a network. Therefore, this study proposes a heuristic algorithm utilizing machine learning methods to predict OD travel distance, time, and cost using historical vehicle trajectory data. This study utilizes an ellipse boundary around OD to truncate the network and extract the relevant vehicle sub-trajectories. Numerical results of applying the proposed method to the Greater Chicago network showed promising performance in the efficient estimation of travel cost measures.

Tuesday, 12:30 PM–1:45 PM

TC01

CC - Room 101

Analytics Flash Session

Flash Session

Session Chair

Hieu Trung Pham, University of Alabama in Huntsville, Huntsville, AL

1 **Category Theory for Optimal Decisions**

Kemal Gursoy, Rutgers University, Piscataway, NJ, Contact: kemalgursoy@netscape.net

An introduction of category theory, as a decision making instrument, is the intended goal of this work. A brief evolution of category theory will be presented here with possible applications in practical decision making problems.

2 **MODEL SELECTION UNCERTAINTy and STABILITy in BETA REGRESSION MODELS : A STUDy of BOOTSTRAP-BASED MODEL AVERAGINg with AN EMPIRICAL APPLICATIOn to CLICKSTREAM DATA**

Corban Allenbrand, Ben Sherwood, University of Kansas, Lawrence, KS, Contact: callenbrand@ku.edu

Uncertainty in the statistical model development process has received inadequate attention and is frequently resolved non-rigorously. This is problematic in settings of abundant data as model selection routinely admits multiple models and imposes a large source of uncertainty. Regression models based on the beta distribution are a class of non-linear models, attractive because of their great flexibility, that have not been investigated from the standpoint of model selection uncertainty. For this reason, a formalized tool that can combine model selection uncertainty and beta regression modeling is presented in this work. The tool combines bootstrap model averaging, model selection, and asymptotic theory to yield a procedure that can perform joint modeling of parameters, capture sources of variability, and achieve more accurate claims of estimate precision, variable importance, and model stability. The tool is demonstrated through a study clickstream data. This work introduces an accessible technique to handle model selection uncertainty in beta regression models.

3 **Insights for Designing Recommender Systems for Microlending**

Sanjog Ray, Indian Institute of Management Indore, Indore, India. Contact: sanjogr@iimidr.ac.in

Recommender systems play a crucial role in micro-lending platforms. Micro-lending institutions are non-profit philanthropic organizations that provide a technology platform through which financially weak entrepreneurs can borrow money from individual lenders and lending teams. The main recommender system problem in this domain is matching the borrower to a lender. But because of the complexity of the domain there exists various other problems that recommender systems can help resolve. This paper reviews the extant literature to provide a summary of different recommender systems problems tackled in literature and the various approaches used. In addition to the review, we visualize the dataset from the widely used social lending platform Kiva to provide insights for designing better recommender systems for micro-lending platforms.

4 **Field Guide to Compelling Analytics: How An Individual Analytics Professional Can Make An Impact**

Walt DeGrange, CANA, Chapel Hill, NC, Contact: wdegrange@canallc.com

The individual Analytics Professional (AP) is a new breed of superhero that has saved companies from financial ruin, exposed fraud in the organization and transformed business models. The work they do demands creativity to solve complex problems with data insights--sometimes their own creation! How does one AP convince others of their math superpower? We present a basic formula, Analysis+Trust+Communication+Experience, that must overcome the level of convincing different audiences. The audiences might everyone from fellow team members to senior decision makers. We break each element down and provide actions that APs can take to increase their probability of success.

5 Profits or Loss: Install Electric Vehicles' Chargers on Public Parking Spots

Emily Zhu, Elizabeth Mallet, Texas State University, San Marcos, TX, Contact: c_z88@txstate.edu

We perform a data-based analytical modeling study to examine the profitability of installing charging equipment for electric vehicles (EVs) on public parking spots. Besides being charged at home or workplace, commuters can pay to charge EVs at any public parking spots with charging piles. Those parking spots installed with charging equipment actually become an exclusive parking privilege for EV users. Typically, those parking spots installed with EV charging piles are more expensive and better located than normal parking spots. Based on historical parking lot counts in the City of Santa Monica, California, we optimize the number of EV parking spots for public parking lots to maximize investors' profitability. This interdisciplinary study features data analysis, queueing models, optimization and simulation.

6 Customer Segmentation and Product Prioritization Under Loyalty Brand Context

Jin Fang[1], Hanxi Sun[2], Junhee Kim[3], [1]Clark University, Worcester, MA, [2]Purdue University, West Lafayette, IN, [3]California State University, Stanislaus, Turlock, CA, Contact: jinfang@clarku.edu

This paper presents a network-based model for the customer segmentation problem using the private data set from one South Korean manufacturing and retailing company. Our model can capture significant temporal structures and bring meaningful clustering solutions for customers' sequential purchasing paths. We also prioritize products through a weighted hyperlink-induced topic search (HITS) algorithm to identify star products. Finally, learning the linking relationships among products provides illuminating advertising insights such as product bundling.

7 Order Qualifiers and Order Winners in Urban Development

Yasamin Salmani[1], Amin Ariannezhad[2], Golshan Madraki[3], [1]Bryant University, Smithfield, RI, [2]University of Arizona, Tucson, AZ, [3]Clarkson University, Potsdam, NY

Identifying important factors that are associated with the high desirability of cities for residents has been always important for urban governors. This paper uses a data mining approach called association rule mining (ARM) to investigate characteristics that contribute to cities' high desirability. For this purpose, data for the 99 largest cities in the United States are analyzed. This paper examines the operational concepts of order qualifiers and order winners in urban science. The findings of this study could help local government authorities and policymakers to develop proper strategies for urban development undertakings.

8 Cryptocurrency Fraud Detection

Hamidreza Ahady Dolatsara[1], Ramona Jaberian[1], Gelareh Ahadi Dolatsara[2], [1]Clark University, Worcester, MA, [2]Allameh Tabataba'i, Tehran, Iran, Islamic Republic of. Contact: hamid@clarku.edu

Cryptocurrency as an application of Blockchain technology in financial transactions. draws the attention of many investors to jump early and gain a sizable profit. Although proof mechanisms have provided robust community-based secure transaction mechanisms, fraud in cryptocurrency projects has affected many investors. Among them are Ponzi-like schemes that mesmerize people with their initial rewards. This research provides a data-driven AI tool to identify these frauds by investigating the project characteristics in the initial phase and their transactional behaviors.

9 Towards a Systematic Understanding of Blockchain Governance in Proposal Voting: A Dash Case Study

Hieu Pham, University of Alabama in Huntsville, Huntsville, AL, Contact: hieu.pham@uah.edu

The transparent and immutable nature of the blockchain provides incentives for organizations wishing to create and implement an open, decentralized governance structure. As members exercise their voting rights, a fault-tolerant record accumulates on the blockchain that can be analyzed to diagnose and intercept potential threats to the governing body. In this paper, we provide an analysis of blockchain governance through a case study of the first cryptocurrency to adopt on-chain voting, Dash. Our analysis introduces the key characteristics of blockchain governance, steps through a data-driven exploration of Dash's on-chain voting system, and highlights exploitable attack vectors and vulnerabilities for the subversion of Dash's on-chain voting system via a novel network analysis methodology.

Tuesday, 12:30 PM–1:45 PM

TC02

CC - Room 102

Reinforcement Learning Showcases

General Session

Session Chair

Emily Diaz Badilla, 1</sup

Session Chair

Mohammad Dehghani, Northeastern University, Boston, MA

1 MATLAB Deep Reinforcement Learning with Engineering Applications

Sahil Belsare[1], Mohammad Dehghani[2], Rifat Sipahi[2], [1]Northeastern University, Medford, MA, [2]Northeastern University, Boston, MA

Reinforcement Learning (RL) is a class of Machine Learning technique that enables an agent to learn in an interactive environment by trial-and-error using feedback (reward) from its own actions and experiences. This presentation will demonstrate how to utilize MATLAB Reinforcement Learning (RL) Toolbox in solving real-life engineering-based problems. It also provides a framework of a series of structured workshops for a gradual learning experience. This framework is made of four progressively developing stages: 1)Manual RL Development, 2) Reinforcement Learning Designer App, 3)RL with Simulink Environment, and 4) Advanced RL Modeling.

2 Fast and Efficient Reinforcement Learning Policies for Imperfectly Observed Contextual Bandits

Mohamad Kazem Shirani Faradonbeh, University of Georgia, Athens, GA

Contextual bandits are canonical models in sequential decision-making under uncertainty. Design and analysis of implementable reinforcement learning policies with efficient performance is of interest in many applications. While the literature of fully observed bandits is mature, policies for imperfectly observed contextual bandits remain unexplored. We present fast posterior sampling algorithms that can efficiently learn optimal actions, and study their performance. The roles of different quantities of interest are considered, including the time horizon, failure probability, number of arms, dimensions, observation matrices, posterior rescaling factors, and signal-to-noise ratios.

3 From Randomized Trials to Adaptive Experiments: Reinforcement Learning Applications in Clinical Trials and Marketing Analytics

Amir Nasrollahzadeh[1], Amin Khademi[2], Mohamad Afkhami[3], Pip Courbois[4], [1]Blend360, Raleigh, NC, [2]Clemson University, Clemson, SC, [3]Blend360, New York, NY, [4]Blend360, Seattle, WA

Clinical trials and marketing A/B tests are a world apart in terms of application but are theoretically quite similar. Both suffer from equal allocation of samples to test groups resulting in two inefficiencies: wasting samples on the less effective option while requiring more to guarantee significance of the better option. Reinforcement learning techniques are replacing classical experimental designs because they offer similar statistical guarantees while reducing these inefficiencies. In this talk, we showcase this ability of reinforcement learning in clinical trials and marketing analytics.

4 Reinforcement Learning in Industrial Simulation Environments with Simio

Emily Diaz Badilla, Mohammad Dehghanimohammadabadi, Ashwin Devanga, Northeastern University, Boston, MA, Contact: diazbadilla.e@northeastern.edu

In recent years, Artificial Intelligence has transformed the way the industrial sector operates. One example of this is how the combination between simulation and machine learning has been key to providing solutions to complex systems by training algorithms over virtual representations of them. An area that is working on this kind of task and has shown promise is Reinforcement Learning (RL). The main purpose of this work is to show how to implement simulation-based RL. The proposed framework integrates Simio, as a discrete-event simulation environment, and Python, to include the RL algorithm. To demonstrate the applicability of this framework, a job-shop scheduling problem under different scenarios is tested and its results are compared with benchmark heuristic dispatching rules.

Tuesday, 12:30 PM–1:45 PM

TC03

CC - Room 103

Statistical Machine Learning with Application

General Session

Session Chair

Jeongsub Choi, West Virginia University, Morgantown, WV

Session Chair

Jaeseung Baek, Rutgers University, Piscataway, NJ

1 Multi-Sensor Multivariate Virtual Metrology Using Convolutional Neural Networks in Semiconductor Manufacturing

Jeongsub Choi[1], Mengmeng Zhu[2], Jihoon Kang[3], Myong Kee Jeong[4], [1]West Virginia University, Morgantown, WV, [2]North Carolina State University, Raleigh, NC, [3]Korea Polytechnic University, Siheung-si, Korea, Republic of; [4]Rutgers University, Piscataway, NJ

In virtual metrology (VM) in semiconductor manufacturing, wafer quality is predicted based on the fabrication process information from various sensors on production equipment. Recently, recent studies considered VM modeling with convolutional neural networks (CNN) and demonstrated its successful performance for univariate-response prediction. However, in the existing deep learning-based VM modeling, multivariate process outputs are overlooked although the joint information among the process outputs can be used to improve the prediction performance. In this talk, we present a CNN-based multivariate VM model using multi-sensors process sensor data and a case study of VM modeling at an etching process in wafer fabrication.

2 Multimode Anomaly Detection with Three-dimensional Topographic Data

Jaeseung Baek[1], Elsayed A. Elsayed[2], Myong Kee Jeong[2], [1]Northern Michigan University, Marquette, MI, [2]Rutgers University, Piscataway, NJ, Contact: jbaek@nmu.edu

In complex industrial processes, surfaces of final products may have multiple modes, such that the surface consists of different topographic features from one in-control mode to another. Thus, Identifying the modes and accurately monitoring the surface finish present many challenges. In this study, we propose a novel anomaly detection approach for monitoring local topographic variations in the presence of multimode surface topography. We present a multimode surface binarization model to capture the generic behavior of the multimodal surfaces and enhance the representation of the surface. To systematically monitor the surface, we introduce a probabilistic distance measure that quantifies the similarity of spatial patterns between two binarized surfaces. The effectiveness of the proposed approach is demonstrated through numerical simulation and case study.

3 A Novel Graph Based Market Segmentation Approach Using Inter-firm Financial Transactions and Each Firm's Attribute

Byunghoon Kim, Aparajita Bose, Hanyang University, Sangnok-Gu, Ansan-Si, Korea, Republic of. Contact: bhkim825@gmail.com

Market Segmentation in a market analysis is a very crucial task before selecting a target market. Our goal is to detecting communities in a business to business (B2B) financial transaction network.To the best of our knowledge, there are only few studies of graph-based market segmentation in market analysis. However these studies have missed to capture the characteristics of the financial transactions between firms (e.g., multiple and directed transactions) and the attributes of each firm. In this article we have proposed a novel graph based community detection approach with principled probabilistic method for market segmentation by using both the directed and weighted edge and ***the attribute of each firm*** in a B2B network. Our proposed model is applied to the real-world business datasets that include the financial transactions among firms in Korea.

Tuesday, 12:30 PM–1:45 PM

TC04

CC - Room 104

High Dimensional Statistical Learning for System Analytics

General Session

Session Chair

Yuqi Su, 1</sup

1 A Federated System Prognostics Regression Model

Yuqi Su[1], Xiaolei Fang[2], [1]North Carolina State University, Raleigh, NC, [2]North carolina state university, Raleigh, NC, Contact: ysu25@ncsu.edu

Data privacy plays an essential role in modern technology including data transmission, update, and storage. We present a federated system prognostics regression model that is capable of predicting the remaining useful lifetime of engines with high-dimensional features while keeping the data private. The case study shows the model closely matches the performance of non-federated algorithms and achieves high prediction accuracy.

2 A Supervised Tensor Dimension Reduction-based Prognostic Model for Applications with Incomplete Imaging Data

Chengyu Zhou, NC State University, Raleigh, NC, Contact: czhou9@ncsu.edu

Most image-based prognostic models have two common limitations. First, they require degradation images to be complete. Second, they usually employ an unsupervised dimension reduction method. To address these challenges, this article develops a supervised tensor dimension reduction-based prognostic model. The model first proposes a supervised dimension reduction method for tensor data. It uses historical TTFs to guide the detection of a tensor subspace to extract low-dimensional features. Next, the extracted features are used to construct a prognostic model based on (log)-location-scale regression. An optimization algorithm is proposed for parameter estimation, and closed-form solutions are derived under certain distributions. Simulated data and a real-world data set are used to validate the performance of the proposed model.

3 A Federated Sensor Selection and Data Fusion-based Prognostics Model for Applications with Incomplete Signals

Madi Arabi, North Carolina State University, Raleigh, NC, Contact: sarabi@ncsu.edu

Two of the most significant analytical challenges when constructing prognostic models for real-world industrial applications include missing data and limited training samples. Missing data means degradation signals are incomplete (i.e., some observations are missing, or the data are irregularly sampled due to varying sampling intervals), and limited training samples implies there are not enough historical samples for modeling training. To address these challenges, this talk proposes a federated prognostic model, which allows multiple users to jointly construct a failure time prediction model using their incomplete data while keeping each user's data local and confidential. The effectiveness of the proposed method is evaluated using numerical studies.

4 Self Awareness of Robotic Systems

Ayush Mohanty, Georgia Institute of Technology, Atlanta, GA, Contact: ayush.mohanty@gatech.edu

Robots working autonomously in critical environments experience degradation that often impacts position accuracy. The degradation of components of a robot are unobserved and are often affected by task severity (e.g., payload). This talk is aimed towards improving the self-awareness of robots. Specifically, we develop a statistical learning approach that allows robots to continuously assess their State-of-Health (SoH) as a function of task severity. We demonstrate our results using a robotic simulation study. We also demonstrate how this framework can be used to inform the portfolio of future tasks that the robot is allowed to perform such that it maximum uses its operational lifetime.

Tuesday, 12:30 PM–1:45 PM

TC05

CC - Room 105

Sensor-based Modeling and Optimization of Complex Systems

General Session

Session Chair

Rui Zhu, The University of Oklahoma, Norman, OK

1 Physics-constrained Deep Active Learning for Spatiotemporal Modeling of Cardiac Electrodynamics

Jianxin Xie[1], Bing Yao[2], [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Stillwater, OK, Contact: jianxin.xie@okstate.edu

The development of computational modeling and simulation have immensely benefited the study of cardiac disease mechanisms and facilitated the optimal disease diagnosis. Electrical signals from the heart are commonly collected through cardiac catheterization, which acquires cardiac signals from limited spatial locations. Such sparse sensor measurements significantly challenge traditional machine learning methods. We present a physics-constrained deep active learning algorithm (P-DAL) that integrates the physical laws of the cardiac electrical wave propagation with deep learning to accurately model the heart electrical behavior from sparse sensor measurements. Furthermore, a novel active learning strategy is proposed to seek informative spatial locations on the heart surface for data collection to further increase the predictive power of the model.

2 A Seasonal Long Short Term Memory Deep Learning Network for Estimating Time-series of Animal Activity Signals

Zhicheng Huang[1], Besozzi Elizabeth[1], Meelyn Pandit[1], Eli Bridge[1], Yifu Li[2], Rui Zhu[1], [1]The University of Oklahoma, Norman, OK, [2]University of Oklahoma, Norman, OK, Contact: zc.huang21@ou.edu

Acoustic recording is a popular method in ecological studies to observe nature. Although a human listener can extract biological data from an audio recording, it is often impractical to employ this analysis method to extensive sets of recordings. Retrieving information from massive audio data requires novel learning techniques to address the challenge. In our study, we proposed a recurrent neural network-based model for bird vocal signal estimation. We adopted built-in seasonal cells to store the seasonal states in the proposed model, which enhances the ability to capture the seasonal pattern in bird vocal sequences. We conducted extensive experiments based on time-series audio data collected in Oregon and Texas. We obtained significant experiment results in comparison with the other state-of-the-art time-series data prediction models.

3 Bio-signal-based Functional Data Analysis for Health Telemonitoring

Bing Si, State University of New York at Binghamton, Binghamton, NY

Technology advancements have enabled a wealth of health information to be remotely collected, resulting in increasing use of telemonitoring for patients with chronic diseases. In particular, multi-channel bio-signals such as ECG and EEG, gold-standard diagnostic approaches for many diseases, are able to be collected at home. However, multi-level and multi-channel data pose major challenges for most statistical prediction methods. To address these challenges, this paper proposes a multi-level multi-channel framework to integrate multi-channel epoch-level bio-signals and other patient-level health covariates for precise prediction of disease severity in health telemonitoring. The proposed framework was applied in a real-world dataset and achieved the highest prediction accuracy in comparison with benchmark methods.

Tuesday, 12:30 PM–1:45 PM

TC08

CC - Room 108

Misinformation in Social Networks

General Session

Session Chair

Ankur Mani, University of Minnesota, Creve Coeur, MO

1 Presenter

George Charlson, University of Cambridge, Cambridge, United Kingdom.

We examine the effect of social trust on a network in which agents communicate with each other and information sources, changing their opinion with some probability. Agents whose peers are more likely to spread misinformation are consequently less trusting than agents whose neighbours are more informed, and therefore change their views with less probability. When echo chambers are strong, weakening them results in there being more interaction between high and low social trust agents, increasing the spread of misinformation. When echo chambers are weak, weakening them further reduces the differences in social trust, decreasing the asymmetries in communication. As a result of the non-linear relationship between the strength of echo chambers and the spread of misinformation, optimal interventions in network structure depend on why agents form links in the first place.

2 Presenter

Iyer Krishnamurthy, University of Minnesota, Saint Paul, MN

Tuesday, 12:30 PM–1:45 PM

TC09

CC - Room 109

PSOR Flash Session I

Flash Session

Session Chair

Jonas Oddur Jonasson, MIT Sloan School of Management, Somerville, MA

1 The Impact of Stock Sharing and Postponement Strategies on Prepositioned Relief Stocks

Lamia G. Kasap, Burcu Balcik, Ozyegin University, Istanbul, Turkey. Contact: lamia.kasap@ozu.edu.tr

We consider a collaborative strategy among humanitarian agencies that preposition supplies in a single depot. We evaluate the effects of postponement and stock-sharing practices by a Monte-Carlo simulation model that incorporates inventory allocation models. We test our approach by focusing on the Caribbean region, using historical hurricane scenarios and data from humanitarian agencies. Our results show that significant savings can be obtained in fill rate, response time, and inventory utilization.

2 Proactive Care Management

Dilara Sonmez, University of Chicago, Chicago, IL

Temporally regular primary care (PC) visits could allow the physicians to address a medical problem before it progresses, resulting in reduced emergency department visits and hospitalizations. A proactive approach in primary care could increase the efficiency of the healthcare system and potentially lower the costs. This study aims to build a machine learning model to predict the annual medicare expenditures as a function of visit frequency and the regularity of visits. This analysis will be extended to results of employing a proactive approach in healthcare and its implications on the shortage of PC doctors in the U.S. An outline for the next steps would be constructing a model to optimize the visits frequency of the patients depending on patient characteristics, planning the required provider capacity, and optimizing the growth of the provider capacity.

3 Donations for Disaster Response: Competition on Earmarking and Fundraising Effort Vs. Joint Fundraising

Arian Aflaki[1], Alfonso J. Pedraza-Martinez[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]Indiana University, Bloomington, IN, Contact: aaflaki@katz.pitt.edu

We study how nonprofit funding competition and joint fundraising impact earmarking decisions, fundraising costs, and the performance of humanitarian organizations.

4 Assessment of The Effect of Diet Change on Achieving More Environmentally Sustainable Food System Using Robust Optimization

Zeynab Oveysi[1], Ronald McGarvey[2], Christine Costello[3], [1]University of Missouri, Columbia, MO, [2]University of Missouri, IMSE and TSPA, Columbia, MO, [3]The Pennsylvania State University, University Park, PA

In this study, robust (varying yield) and nonrobust (average yield) optimization techniques were applied to find the minimum radius required from the center of a specific location in the United States (U.S.) and land area by type to meet the population's food needs given yield data for conventional products. Six different food diets including current American diet were considered, and land type availability was defined using satellite data. Diets were compared with respect to the environmental impacts.

5 Uncertainty-robust Model to Preposition Relief Supplies

Muer Yang[1], Sameer Kumar[2], Xinfang Wang[3], Michael Fry[4], [1]University of St. Thomas, Minneapolis, MN, [2]University of St Thomas, Minneapolis, MN, [3]Georgia Southern University, Statesboro, GA, [4]University of Cincinnati, Cincinnati, OH, Contact: yangmuer@stthomas.edu

We develop an uncertainty-robust optimization model for prepositioning relief supplies at strategic facility locations. Our model is a hybrid of stochastic programming and robust optimization that considers the inherent aleatory uncertainty and epistemic uncertainty in disaster relief problems. The solutions are less conservative than robust optimization but still resilient to the uncertainties, demonstrated using a realistic case of hurricane preparedness in the Southeastern United States. Our method applies to other applications where a full discrete probability distribution of uncertain parameters can only be imprecisely estimated from historical data.

6 Discovering Causal Models with Optimization

Nur Kaynar[1], Auyon Siddiq[2], Frederick Eberhardt[3], [1]University of California-Los Angeles, Los Angeles, CA, [2]University of California-Los Angrles, Los Angeles, CA, [3]California Institute of Technology, Pasadena, CA

We propose a new method for learning causal structures from observational data, a process known as causal discovery. Our method takes as input observational data over a set of variables and returns a graph in which causal relations are specified by directed edges. We formulate the discovery problem as an integer program, and propose a solution technique that leverages the conditional independence structure in the data to identify promising edges for inclusion in the output graph. We demonstrate our approach by showing how it can be used to examine the validity of instrumental variables, which are widely used for causal inference.

7 Interactions Between Mission-oriented State Agencies and Profit-oriented Service Providers Under Demand Uncertainty

Gulten Busra Karkili, Senay Solak, University of Massachusetts Amherst, Amherst, MA, Contact: gkarkili@umass.edu

Subsidy welfare programs typically involve interactions between mission-oriented state agencies and profit-oriented service providers. In this paper, we identify funding-based mechanisms for mission-oriented state agencies to incentivize program participation and capacity allocation by service providers. The mechanisms specifically consider risk minimization by service providers under demand uncertainty.

8 Optimal Selection of Pre-event Building- and Community-level Mitigation Strategies for Flood Risk

Himadri Sen Gupta[1], Omar Nofal[2], Andres David Gonzalez[3], Charles D. Nicholson[3], John van de Lindt[2], [1]University of Oklahoma, Norman, OK, [2]Colorado State University, Fort Collins, CO, [3]University of Oklahoma, Norman, OK

Flood threats are becoming more severe and frequent, causing substantial damage to structures and infrastructure. This study proposes an optimization model to reduce the predicted economic loss and population dislocation in a community due to flooding hazards. The suggested mathematical model's capabilities are demonstrated for Lumberton, North Carolina, which has been impacted by major flooding events, resulting in considerable economic losses over the past decade. The suggested model takes into

account the cost and type of each mitigation technique, as well as the projected economic losses associated with each building at each mitigation level.

9 Fairness in Contextual Resource Allocation Systems: Metrics and Incompatibility Results

Nathanael Jo, Bill Tang, Kathryn Dullerud, Sina Aghaei, Phebe Vayanos, University of Southern California, Los Angeles, CA

We study critical systems that allocate scarce resources to satisfy basic needs, such as homeless services that provide housing. We propose a framework for evaluating fairness in contextual resource allocation systems that can be applied to assess the fairness properties of a historical policy, as well as to impose constraints in the design of new (counterfactual) allocation policies. Our work culminates with a set of impossibility results that investigate the interplay between the different fairness metrics we propose. Our framework can help guide the discussion among stakeholders deciding which fairness metrics to impose in deciding how to allocate resources.

10 Flash Paper

Mohammad Delasay[1], Armann Ingolfsson[2], Amir Rastpour[3], [1]Stony Brook University, Stony Brook, NY, [2]University of Alberta, Edmonton, AB, Canada; [3]Ontario Tech University, Oshawa, ON, Canada. Contact: mohammad.delasay@stonybrook.edu

We compare the reliability of the stationary independent period-by-period (SIPP) and modified offered load (MOL) approaches to staff loss systems with non-stationary arrival rates.

Tuesday, 12:30 PM–1:45 PM

TC11

CC - Room 111

Deep Decision Making with Reinforcement Learning

General Session

Session Chair

Ronilo Ragodos, University of Iowa, IA

1 The Ai Economist: Multi-agent Reinforcement Learning for Economic Modeling and Decision-making

Stephan Zheng, Salesforce Research, Palo Alto, CA

Solving global socioeconomic and business challenges, e.g., economic inequality or sustainability, requires new tools and data to design effective economic policies. The AI Economist is a multi-agent reinforcement learning (RL) framework that outperforms and overcomes key limitations of traditional policy design methods. I will survey key results and systems in this area, including: 1) AI tax policies that significantly improve equality and productivity, 2) AI-driven macroeconomic simulations and human-like AI agents, 3) AI pricing and matching for platform businesses, and 4) WarpDrive, our open-source GPU framework for orders-of-magnitude faster multi-agent RL. Finally, I will survey future research directions towards real-world scale.

2 Reinforcement Learning in Business, Economics, and Finance

Ronilo Ragodos, 1</sup

Since the success of DeepMind's AlphaGo, deep reinforcement learning has continued to gain popularity among computer science researchers. Despite providing a general framework for decision-making, reinforcement learning is comparatively less popular among machine learning researchers in business. In this talk, we give an overview of deep reinforcement learning and its applications to business, economics, and finance.

□div>

3 Detection of Critical Time Intervals in Multivariate Funcional Data Using Optimal Trees

Cristina Molero-Río[1], Rafael Blanquero[1], Emilio Carrizosa[1], Dolores Romero Morales[2], [1]Universidad de Sevilla, Sevilla, Spain; [2]Copenhagen Business School, Frederiksberg, Denmark.

In this talk, we tailor optimal regression trees to deal with multivariate functional data. A compromise between prediction accuracy and sparsity, as a proxy for interpretability, is sought. In particular, whilst fitting the tree model, the detection of a reduced number of predictor variables and the proportion of the domain used by the model is performed. This is achieved through the inclusion of LASSO-type regularization terms. The resulting optimization problem can be formulated as a nonlinear continuous optimization problem with linear constraints. We illustrate the performance of our approach on real-world and synthetic datasets.

Tuesday, 12:30 PM–1:45 PM

TC12

CC - Room 113
OR and AI for Military and Security
General Session

Session Chair
Trevor Bihl, Air Force Research Laboratory, Wheelersburg, OH

1 **The Weapon Target Assignment Problem: Rational Inference of Adversary Target Utility Valuations from Observed Solutions**
Michael S. Hughes[1], Brian J. Lunday[2], [1]USAF, Alexandria, VA, [2]Air Force Institute of Technology, Beavercreek, OH, Contact: mike6hughes@gmail.com
Identifying an adversary's strategic goals and values requires deliberate and unbiased analysis. This research is motivated by the premise that, if one observes an adversary's actions or planned actions, it is possible to draw reasonable inferences about their values, thereby reducing misperceptions and informing better decisions. Within the context of the static weapon target assignment problem, this research develops and empirically compares alternative methods to rationalize an adversary's value hierarchy over targets that informs their observed decisions. Furthermore, this research characterizes the solution methods' practical tractability and generalizability.

2 **Integration of Computer Vision with Analogical Reasoning for Describing Unknowns**
Kara Combs, Applied Research Solutions, Englewood, OH
Artificial intelligence (AI) struggles with accurate interpretation of out-of-library (OOL) objects. One method proposed remedy is analogical reasoning, which is learning by analogy. The Image Recognition Through Analogical Reasoning Algorithm (IRTARA) approach presented in this talk shows how analogical reasoning can be leveraged to improve computer vision in OOL situations. IRTARA produces a word-based term frequency list that characterizes the OOL object of interest. Evaluation of IRTARA included two automated quantitative methods and a third qualitative human experiment establishes a baseline to compare the automated methods and human-generated results. Testing showed consistent results across all three evaluation methods on the objects that performed exceptionally well or poorly overall but had ambiguity for mid-tier objects.

3 **Sensitivity Analysis of Hybrid Microgrids**
Daniel Reich, Susan M. Sanchez, Naval Postgraduate School, Monterey, CA, Contact: daniel.reich@nps.edu
We propose a two-stage approach that applies sensitivity analysis to rightsized microgrid designs, using design of experiments. This allows us to introduce a flexible notion of robustness, where potential microgrid designs can be tested under different conditions. By doing so, we can identify which designs are less and more robust, and provide this information to a decision-maker. If needed, we can also modify designs with capacity adjustments to increase their robustness.

4 **Using GANs to Augment UAV Classification Model's Training Data**
Benjamin J. McCloskey[1], Bruce A. Cox[2], Lance E. Champagne[3], Trevor Bihl[4], [1]Air Force Institute of Technology, Dayton, OH, [2]Air Force Institute of Technology, Dayton, OH, [3]Air Force Institute of Technology, Wright Patterson Afb, OH, [4]Air Force Research Laboratory, Wheelersburg, OH, Contact: bruceacox1@gmail.com
Training CNNs requires large & diverse labeled datasets. Collecting such data is costly even when possible. Traditional augmentation techniques (e.g., flip, rotate) have been implemented with some success. GANs can learn the distribution of training samples & produce synthetic replications. This research explored how GAN augmented training sets could increase the generalizability of a detection model. Towards this end salient objects within the original video frames were synthesized using various GANS, placed back into the original frames, and the augmented frames appended to the original training set. GAN augmentation led to a best-case mAP increase of 15.8%, and a best-case IoU increase of 9.6% over models trained on original data only.

Session Chair
Bruce Cox, Air Force Institute of Technology, Oakwood, OH

Tuesday, 12:30 PM–1:45 PM

TC13

CC - Room 114
Network Optimization and Applications
General Session

Session Chair
Rui Zhang, Leeds School of Business University of Colorado Boulder, Boulder, CO

Session Chair

Amin Rahimian, University of Pittsburgh, Pittsburgh, PA

3 Policy Gradient Play with Networked Agents in Markov Potential Games

Sarper Aydin[1], Ceyhun Eksin[2], [1]Texas A&M University, COLLEGE STATION, TX, [2]Texas A&M University, College Station, TX, Contact: sarper.aydin@tamu.edu

In this study, we propose a multi-agent networked policy gradient-play where agents employ policy gradient ascent to maximize discounted sum of rewards over infinite horizons. Agents consider others' parameters to update their policies in Markov potential games. Agents share their policies only with their neighbors over a communication network, and keep estimates of other agents' policies. We show that using unbiased estimates of policy gradients obtained by random horizon sampling, the joint policy parameters converge to a first-order stationary point of potential function on expectation. Numerical results corroborate the convergence results such that agents' policies in a ring network converge to a first-order stationary point in the lake game.

1 Heuristics for the Budget-constrained Immobile Server Problem

Adam Colley[1], Eli Olinick[2], [12]Southern Methodist University, Dallas, TX

Given a set of Poisson traffic streams (customers) and a fixed budget for opening and provisioning M/M/1 service queues at a set of potential locations, the Budget-Constrained Immobile Server Problem (BCISP) is to determine the number, location, and service capacities of the queues, and an assignment of customers to the queues that minimizes a cost function comprising fixed queue-setup costs and variable costs for customer assignment and waiting time. We propose heuristics for the BCISP that are easy and inexpensive to implement, and compare their performance against exact methods implemented with commercial mathematical programming software.

2 Design of Compact and Connected Ecological Reserves

Douglas R. Shier[1], Lakmali Weeraseena[2], Mark McFeaters[2], Christopher Collins[2], [1]Clemson University, Clemson, SC, [2]University of Tennessee Chattanooga, Chattanooga, TN, Contact: shierd@clemson.edu

Biological conservation depends increasingly on the establishment of protected areas that include as many species as possible, and are extensive, compass, and connected. We first identify core areas that are extensive and compact by maximizing the density of the network associated with the reserve. This serves to minimize the number of boundary edges of the reserve and thus reduces the opportunities for species to leave the core areas and for external threats to enter. Then we identify corridors connecting these areas based on site costs and species conservation goals, using both exact and heuristic network optimization approaches.

Tuesday, 12:30 PM–1:45 PM

TC14

CC - Room 115

Travelling Salesman Problem

Contributed Session

Session Chair

YUE Yu, University of Southern California, Los Angeles, CA

1 A Local Search Heuristic for Bi-criterion Steiner Travelling Salesman Problem

Debojjal Bagchi[1], Prateek Agarwal[1], Tarun Rambha[1], Venktesh Pandey[2], [1]Indian Institute of Science, Bangalore, India; [2]North Carolina Agricultural and Technical State University, Greensboro, NC, Contact: debojjalb@iisc.ac.in

Bi-criterion tours which visit a set of terminals while minimizing distance and turns are ideal for logistics companies. These routes are fuel-efficient and safer since they avoid stopping at junctions. We propose a local search method that first estimates single criteria versions of the problem and enumerates other points on the efficiency frontier using multi-objective 3-opt moves. Efficient paths between terminals are computed using a multi-objective label correcting method on a dual graph, which makes counting the number of turns easier. For a fixed computational budget, our method outperforms CPLEX solutions to an integer program generated using scalarization technique for medium-sized problems (up to 30 terminals).

2 Parallel Drone Scheduling Traveling Salesman Problem Considering Winds and Rains

Lan Peng, Chase Murray, University at Buffalo, Amherst, NY, Contact: lanpeng@buffalo.edu

Delivery drones are sensitive to weather conditions, yet, little attention has been paid to this factor. In this study, we first quantitatively analyzed the danger if we do not take weather into account in a truck-drone delivery system. Then, the impacts from winds and rains are modeled as time-dependent drone travel time and multi-no-fly time windows. We further formulated a MILP model. A heuristic approach is proposed to solve instances (up to 150 customers) that are more realistic. Finally, our numerical study illustrated that our model could significantly reduce the delivery makespan impacted by the bad weather condition, compared to the original model in which weather impacts were not considered.

3 A New Upper Bound for The Euclidean-tsp Constant

YUE YU[1], John Gunnar Carlsson[2], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, Contact: yyu56253@usc.edu

Let X_1, X_2, , X_n be n independent uniformly distributed random points in the unit square $[0, 1]^2$. The classical Beardwood-Halton-Hammersley theorem (1959) proved the existence of a universal constant □ such that: $\lim_{n□\infty} n^{-1/2}$ TSP(X_1, , X_n) = □, where TSP(X_1, , X_n) is the length of the optimal traveling salesman tour that traverses all the n points. The current best bounds for □ are 0.6277 ≤ □ ≤ 0.92116. Building upon an approach proposed by Steinerberger (2015), we present a computer-aided proof that improves the upper bound to □ ≤ 0.91.

Tuesday, 12:30 PM–1:45 PM

TC16

CC - Room 121

Data-driven Analysis and Models in Healthcare Applications

General Session

Session Chair

Osman Ozaltin, North Carolina State University, Raleigh, NC

1 Septic Shock Prediction and Knowledge Discovery Through Temporal Pattern Mining

Joseph Kapena Agor[1], Ruoting Li[2], Osman Ozaltin[3], [1]Oregon State University, Corvallis, OR, [2]North Carolina State University, Raleigh, NC, [3]North Carolina State University, Raleigh, NC, Contact: rli25@ncsu.edu

Sepsis is the body's adverse response to infection which can lead to septic shock and eventually death. Analyzing sepsis patients' health status over time using temporal pattern mining (TPM) methods can help predict septic shock allowing healthcare providers to be more proactive. However, these methods can return too many patterns hindering knowledge discovery. We propose a framework to find a small number of patterns for the early prediction of septic shock. Our framework contains a TPM method and three pattern selection techniques based on non-contrasted support (PST1), contrasted support (PST2), and predictive power (PST3). PST3 has the best prediction performance. PST2 identifies more patterns with abnormal health states indicating patient deterioration. Hence, it may be worthwhile to sacrifice slight prediction power for actionable information through PST2.

2 How Should Payers Respond to Consolidation in Healthcare Markets?

Houyuan Jiang[1], Zhan Pang[2], Sergei Savin[3], [1]University of Cambridge, Cambridge, United Kingdom; [2]Purdue University, West Lafayette, IN, [3]Wharton School, Philadelphia, PA, Contact: h.jiang@jbs.cam.ac.uk

We study the role of the performance-based incentives in managing the effects of both vertical and horizontal consolidation between the payer and two healthcare providers in healthcare markets. We analyze Nash equilibria emerging in different market configurations in the presence of performance-based incentives. We derive the optimal bonus-type incentives that the payer can use to adapt to changes in market concentration and quantify the resulting impact on patient access to care and social welfare. We identify the market conditions where bonus-type incentives are effective in generating the socially-optimal levels of patient access to care, as well as settings where changes in the market concentration create welfare gaps.

3 Analyzing the Effects of COVID-19 on Diabetes Mellitus Patients

Farzaneh Mansourifard[1], Kylee Alons[2], Joseph Kapena Agor[3], Julie Simmons Ivy[2], Osman Ozaltin[2], [1]Oregon State University, Corvallis, WA, [2]North Carolina State University, Raleigh, NC, [3]Oregon State University, Corvallis, OR, Contact: mansourf@oregonstate.edu

The COVID-19 Pandemic introduced unprecedented complications for the health system. As hospitals cleared space and moved staff to accommodate multiple surges of COVID patients, general COVID patients were not the only ones affected. For example, the pandemic disrupted the best practices for diabetes preservation that so many patients were left without care. So, patients with diabetes were chosen for this analysis because they present a significant challenge for COVID-19 protocols. We used a version of the Adapted Diabetes Complications Severity Index to quantify the presence and severity of diabetes complications. The goal of this analysis is to examine if the severity of patients with diabetes increased during the pandemic and to, hopefully, motivate more research on the far-reaching effects of pandemic measures.

4 Diabetes Complications and Covid-19: A Retrospective Study Using Electronic Health Records

Ni Luh Putu Satyaning Pradnya Paramita[1], Joseph Kapena Agor[2], Maria Esther Mayorga[1], Julie Simmons Ivy[1], Kristen Miller[3], Osman Ozaltin[1], [1]North Carolina State University, Raleigh, NC, [2]Oregon State University, Corvallis, OR, [3]MedStar Health, Washington DC, DC

Despite established relationships between diabetic status and an increased risk for COVID-19 severe outcomes, there is a limited number of studies examining the relationships between different diabetes complications and COVID-19-related risks. We use the Adapted Diabetes Complications Severity Index translation to the ICD-10 codes to define seven diabetes complications. We perform a retrospective case-control study using Electronic Health Records to show that different diabetes complications lead to statistically significant differences in the risks for COVID-19 infection, hospitalization, and severe outcomes with respect to in-hospital mortality and longer hospital length of stay. In addition, we show the presence of health disparities in COVID-19 outcomes across demographic groups in our diabetes population.

Tuesday, 12:30 PM–1:45 PM

TC17

CC - Room 122

Health Care, Modeling and Optimization Flash Session

Flash Session

Session Chair

Ruben Proano, Rochester Institute of Technology, Rochester, NY

1 Does Patient Adherence Impact Medical Expenses?

Saeideh Mirghorbani, Binghamton University, Binghamton, NY, Contact: smirghorbani@binghamton.edu

This research aims to investigate the effect of patient adherence to antihypertensive medications on treatment and hospitalization costs in patients with diabetes. We propose a finite horizon discounted Markov decision process (MDP) model that considers cardiovascular risk factors and patient adherence levels to map out the progression of hypertension in patients with diabetes.

2 More Accurate, Unbiased Predictions of Operating Room Times Can Increase Productivity Only Minimally with Same Staff Scheduling Unless Allocated Hours are Increased

Franklin Dexter[1], Zhengli Wang[2], [1]University of Iowa, Iowa City, IA, [2]University of Hong Kong, Hong Kong, China. Contact: franklin-dexter@uiowa.edu

Over the past 10 years, >55 papers have described machine learning and other computational methods for predicting operating room times. We use a published detailed, realistic discrete event model for surgical suites to study benefits of greater accuracy of unbiased predictions of operating room times. Simulation results were similar qualitatively to that of a simple analytical model for one operating room. (a) Simulations matched all earlier empirical findings. At most small benefits to more accurate estimates were obtained because studies used current cases and allocated time. That matches what would be obtained from machine learning. (b) Larger benefits can be accrued with greater allocated time. Cases need to be scheduled for more hours, extending closer to the end of scheduled shifts. Hospital execution depends on behavioral operations, being a newsvendor problem.

3 Gantry Call-back Control Method for Proton Therapy Systems

Feifan Wang[1], Yu-Li Huang[2], Feng Ju[3], [1]Mayo Clinic, Rochester, MN, [2]Mayo Clinic, Rochester, MN, [3]Arizona State University, Tempe, AZ, Contact: wang.feifan@mayo.edu

Proton therapy is an advanced radiation treatment technology, and its workflow efficiency and patient experience have not yet received enough attention especially in multiple-gantry proton therapy facilities. Proton therapy practitioners are seeking a high beam utilization and low beam wait time, which are difficult to achieve due to the variability of time on each procedure. In this study, we improve the proton therapy delivery process by making use of real-time system state. We propose a gantry call-back control method to determine the optimal time to call a patient back to the gantry, and thus beam request conflicts can be improved without sacrificing beam utilization. Simulation is used to demonstrate how the variability of time on setup, beam treatment and transition can undermine the system performance and how the proposed method can improve the system.

4 Technician Scheduling in Hemodialysis Centers

Sina Ansari[1], Farbod Farhadi[2], Francisco Jara Moroni[3], [1]Driehaus College of Business, DePaul University, Chicago, IL, [2]Roger Williams University, Bristol, RI, [3]Universidad

Diego Portales, Santiago, Chile. Contact: sina.ansari@depaul.edu

We develop mathematical models to minimize the operating costs at large-scale hemodialysis centers. We then simulate challenging instances based on the data from our collaborating hemodialysis center to evaluate the performance of our proposed models in practice. We further conduct a post optimality analysis and develop a predictive model that can estimate the number of required technicians using the average dialysis time of patients, their time flexibility, the number of available beds, and the number of demanded appointments by patients. Our findings can help clinic managers at hemodialysis centers to better manage the operating costs by accurately estimating the staff requirements.

5 Improving Operating Room Planning and Scheduling with An Integration of Optimization and Machine Learning

Yooneun Lee, University of Dayton, DAYTON, OH, Contact: ylee03@udayton.edu

In this presentation, an integrated approach of machine learning algorithms and optimization techniques is presented to improve effectiveness of operating room management. Three different machine learning algorithms are used to predict surgery durations and their results are compared with the estimates made by surgeons. The prediction outcomes are then used to schedule surgeries by a mathematical optimization model. The results obtained by machine learning methods significantly improves prediction accuracy of surgery durations. Improvements in estimation of duration and variability enables us to build a surgery schedule for specific surgery specialties and hence leads to reduction in schedule disruption and overtime. These results indicate that the proposed approach can help hospitals significantly improve utilization of operating rooms and service levels.

6 Appointment Scheduling for Multiple Servers

Alex Kuiper, Robert Lee, University of Amsterdam, Amsterdam, Netherlands. Contact: a.kuiper@uva.nl

Appointment schedules are often employed in settings where resources are scarce and thus a high utilization is realized (e.g., healthcare). Whereas most of the existing literature focuses on the single-server case, a framework is developed to study appointment scheduling in multiserver settings. Optimizing schedules for multiple servers reveals that the start and end of a session deviate greatly from the dome-shaped pattern as established for the single-server case. Furthermore, when servers are pooled, significant performance gains can be achieved.

In addition, steady-state appointment schedules are obtained and shown to converge quickly to optimal solutions obtained in a heavy-traffic regime. In this regime, algebraic solutions are derived, which provide interesting managerial guidelines when the pooling of servers is considered in appointment scheduling.

7 Quasi-experimental Models for National Electronic Health Records: Studies on Public Health, Causality, and Open Science

Dominik Piehlmaier[1,2], [1]University of Sussex, Brighton, United Kingdom; [2]University of Oxford, Oxford, United Kingdom.

Electronic health records (EHR) present a unique opportunity to investigate the effect of the COVID-19 (C19) pandemic on public health. The presented studies use interrupted time series (ITS) analysis with heteroskedasticity-robust standard errors and autoregressive adjustments on EHR from around 22 million patients in England (~40% of the population) to assess the C19 related impact on mental health outcomes among at-risk groups, such as lone households and chronic pain patients. The studies were conducted within the OpenSAFELY environment with data from TPP SystmOne. The method and results have implications for patient safety, targeted government programs, and public health research.

8 Equitable Access to a Safety Stock: The Ebola Vaccine Case

Ruben Proano, Rochester Institute of Technology, Rochester, NY, Contact: rpmeie@rit.edu

We discuss the efforts to set a centralized Ebola vaccine safety stock for potential outbreaks in Africa and its challenges. We present the modeling approach used to determine how to mitigate the need for significant safety stock levels. We show that the potential value of a vaccine in the stockpile to mitigate outbreaks is enhanced if contact tracing effectiveness increases and replenishment lead times reduce, which has implications beyond Africa.

Tuesday, 12:30 PM–1:45 PM

TC18

CC - Room 123

ML for Healthcare Applications

General Session

Session Chair

Anil Aswani, UC Berkeley, Berkeley, CA

Session Chair

Ilgin Dogan, University of California, Berkeley, Berkeley, CA

1 S2SSL: Simultaneous Feature and Instance Selection in Semi-supervised Learning with Application to Smartphone-based Telemonitoring

Nathan B. Gaw[1], Jing Li[2], Hyunsoo Yoon[3], [1]Air Force Institute of Technology, Wright-Patterson AFB, OH, [2]Georgia Institute of Technology, Tempe, AZ, [3]Yonsei University, Seoul, Korea, Republic of. Contact: Nathan.Gaw@afit.edu

Telemonitoring is the use of electronic devices such as smartphones to remotely monitor patients. To facilitate the decision making for each patient, a model is needed to translate the data collected by the patient's smartphone into a predicted score for his/her disease severity. To train a robust predictive model, semi-supervised learning (SSL) provides a viable approach by integrating both labeled and unlabeled samples to leverage all the available data from each patient. There are two challenging issues that need to be simultaneously addressed in using SSL for this problem: (1) feature selection from high-dimensional noisy telemonitoring data; and (2) instance selection from many, possibly redundant unlabeled samples. We propose a novel SSL model allowing for simultaneous feature and instance selection, namely the S2SSL model.

2 Nonnegative Tensor Completion Via Integer Optimization

Caleb Bugg, Georgia Institute of Technology, Atlanta, GA, Contact: caleb_bugg@berkeley.edu

Unlike matrix completion, tensor completion does not have an algorithm that is known to achieve the information-theoretic sample complexity rate. This paper develops a new algorithm for the special case of completion for nonnegative tensors. We prove that our algorithm converges in a linear (in numerical tolerance) number of oracle steps, while achieving the information-theoretic rate. Our approach is to define a new norm for nonnegative tensors using the gauge of a particular 0-1 polytope; integer linear programming can, in turn, be used to solve linear separation problems over this polytope. We combine this insight with a variant of the Frank-Wolfe algorithm to construct our numerical algorithm, and we demonstrate its effectiveness and scalability through computational experiments using a laptop on tensors with up to one-hundred million entries.

3 Bias in Reinforcement Learning: A Case Study in Heparin Administration in The ICU

Benjamin Smith[1], Anahita Khojandi[2], Senne Van Steelandt[2], Rama Vasudevan[1], [1]The University of Tennessee, Knoxville, Knoxville, TN, [2]University of Tennessee, Knoxville, TN, Contact: JLN766@vols.utk.edu

Reinforcement learning (RL) can leverage electronic health record data (EHR) to develop personalized treatment policies to improve patient care. However, RL models are typically trained using retrospective data that may contain bias or may develop their own bias not exhibited in the data. As such, if care is not taken in training, a learned treatment policy can present bias and further propagate it. In this study, we formalize this fact using a case study on heparin administration in the ICU. Specifically, we demonstrate that RL policies may lack robustness if patient characteristics are not fully considered. That is, learned policies from certain subpopulations may present domain shift bias when applied to un- or underrepresented subpopulations, formalizing the need for a more careful approach to RL training.

4 To use or Not to Use: Developing Fair Algorithms when Social Data Biases Predictions for Healthcare Needs

Ozgur Aksoy[1], Mehmet U.S. Ayvaci[1], Asunur Cezar[2], Srinivasan Raghunathan[1], [1]The University of Texas at Dallas, Richardson, TX, [2]Bogazici Universitesi, Istanbul, Turkey. Contact: ozgur@utdallas.edu

Predictive algorithms often use data capturing both the clinical observations about a patient (i.e., medical data) and the data relating to non-medical aspects of care provision such as business processes or the way patients live their lives (i.e., social data). Social data can help improve predictive accuracy. Yet, their inclusion can inadvertently lead to algorithmic biases. When used for policy interventions, such algorithmic biases may exacerbate existing healthcare disparities. Our goal in this research is to construct "fair" optimal policies in the presence of algorithmic bias emanating from the use of social data during prediction. The resulting policies can conflict depending on the measure of fairness used. A weighted approach to using medical and social data for predictive tasks can help mitigate such conflict.

Tuesday, 12:30 PM–1:45 PM

TC19

CC - Room 124

The Impact of COVID-19

Contributed Session

Session Chair

Roya Aghaeifar, Binghamton University, Binghamton, NY

1 **Geographical Clustering of Cancer Mortality Rates and Their Relationship with The Covid-19 Pandemic: County-level Analysis in The United States**

Wenting (Kayla) Jiang[1], Connor Y.H. Wu[2], Ashish Gupta[3], [1]Auburn University, Auburn, AL, [2]Troy University, Troy, AL, [3]Auburn University, Auburn, AL, Contact: wzj0027@auburn.edu

COVID-19 poses a higher risk for cancer patients. There is a lack of understanding about COVID-19 spread from a geo-location perspective. This study first performs the geographical clustering of county-level cancer mortality rates for thirty-two cancer types. Second, using a spatially constrained multivariate clustering technique, we investigate the relationships between the co-occurrence of COVID-19 variants and cancer within the United States (US). We find three important clusters in the northern, south-central, and southeastern US. Our analysis also indicates the relationship between cancer with COVID-19 cases, death, and vaccination rates changed across Covid-19 variants in different geo-location clusters. These results suggest the policies and resources should be adjusted for cancer patients in different clusters when COVID-19 domain variants change.

2 **The Effect of Air Conditioning on Covid-19 Droplet Transmission and Aerosol Diffusion in Indoor Setting**

Md Tariqul Islam[1], Yijie Chen[1], Young-Jun Son[1], Dahae Seong[2], Marc Verhougstraete[2], [1]The University of Arizona, Tucson, AZ, [2]The University of Arizona, Tucson, AZ, Contact: mdislam@email.arizona.edu

The SARS-CoV-2 virus has primarily spread through infectious respiratory droplets which necessitates an evaluation of our current HVAC system to keep infection levels in the indoor environment under control. The objective of this research is to understand the dynamics of exhaled droplets and aerosols, including the proportion of particles inhaled, escaped, and recirculated in space, or trapped on different surfaces in diverse environmental settings. Toward this goal, we developed CFD models to investigate the influence of changing HVAC parameters. By analyzing the spatial and temporal distribution of droplets from multiple injections and viral loads, the models will allow us to evaluate the infectious risk in indoor space and improve pandemic resiliency.

3 **Prediction of Covid-19 Spread in The United States Using Machine Learning Algorithms**

Ehsan Ahmadi[1], Reza Maihami[2], [1]Mercer University, Atlanta, GA, [2]East Tennessee State University, Johnson City, TN, Contact: ahmadi_e@mercer.edu

The 2019 Coronavirus disease (COVID-19) pandemic created significant challenges for the operations of health care systems. This research aims to predict the spread of COVID-19 by using a cross-learning forecasting approach to train machine learning algorithms with different time series. A wide number of potential factors that could impact COVID-19 spread are investigated. These factors include community mobility data, census data, weather data, Google search data, social distancing data, socioeconomic data, vaccination status, and past cases of infections. The model helps with the early identification of highly susceptible regions to variants of COVID-19. This allows officials to make more efficient strategic decisions in allocating the limited medical recourses to the regions most in need during peaks.

4 **Factors Affecting Countries' Responses to Covid-19 Pandemic Before and After Vaccination**

Roya Aghaeifar, Anseh Danesharasteh, Binghamton University, Binghamton, NY, Contact: raghaei1@binghamton.edu

Since early 2020, the COVID-19 pandemic has had catastrophic impacts on people's lives and countries' economies. Countries have responded differently to the pandemic as factors affecting the spread of the disease and the rate of mortality are different across countries. The government policies play a crucial role, though they are not the only ones. People's underlying health conditions, being committed to the government implemented rules, economic parameters, population, and the proficiency of the healthcare system are important factors in spreading the disease and can explain the differences in COVID-19 related indicators across countries. Performing a difference in difference fixed-effect regression model, we investigate the behavior of countries in controlling the number of COVI-19 cases before and after vaccination.

Tuesday, 12:30 PM–1:45 PM

TC20

CC - Room 125

Ethics in Risk and Decision Analysis

General Session

Session Chair

Seth Guikema, University of Michigan, Ann, MI

1 **Setting Stretch Targets to Diversify Against Risk**

Robert F. Bordley, Ann Arbor, MI
A product manager must meet an external weight target. The manager assigns weight targets to workers designing different subsystems of the product. But some workers may miss their weight targets. To offset these possible shortfalls, the manager deliberately assigns overly aggressive weight targets to each worker. If a few achieve the stated targets, the rest only need to meet less aggressive targets. Because those meeting the stated target may feel cheated, this paper discusses an alternate strategy of sharing the manager's underlying uncertainty about what targets are achievable by different workers. We also discuss the strategy of giving workers both a threshold and an aspirational target.

3 A Novel Hybrid Interpretability Method for Sequential Decision Making

Lan Hoang[1], Alexander Zadorojniy[2], [1]IBM Research, Daresbury, United Kingdom; [2]IBM Research, Haifa, Israel. Contact: lan.hoang@ibm.com
We consider the problem of interpretability for sequential decision making, which is frequently addressed by the Markov Decision Processes (MDP) approach. We distinguish interpretability toward two types: (i) for machines and (ii) for human users. The key difference between the two is that interpretability for a machine helps simplify the model and for humans helps understand the recommendations. We propose a hybrid approach combining these two types of interpretability to achieve more efficient problem formulation and better user satisfaction. For this work we utilised i) the Logical Neural Network (LNN) and ii) the classical Decision Tree (DT) techniques.

2 Measuring Equity in Access to Services

Seth Guikema, University of Michigan, Ann Arbor, MI, Contact: sguikema@umich.edu
Equity is an important consideration in consider community risk and resilience in hazard-prone communities. This talk will give an overview of recent research developing methods to assess inequities in access to essential services in a community after a natural hazard.

4 Predictably Unethical

Ali Abbas, University of Southern California, Los Angeles, CA
This talk presents two predictive models that lead to the build-up of ethical concerns in decision and risk analyses on both individual and organizational levels. The first model uses empirical data from media articles to identify seven patterns of ethical concerns before a collapse. The patterns were classified by categorizing data from both "for-profit" and "not-for-profit" organizations. The Second model identifies the cognitive and motivational biases at individual and organizational levels that accelerate the collapse. Validation of the model parameters through extensive media articles is provided.

Tuesday, 12:30 PM–1:45 PM

TC21

CC - Room 126

Social Responsibility and Sustainability in Supply Chains

General Session

Session Chair

Han Zhang, Michigan State University, East Lansing, MI

1 Combating Excessive Overtime in Global Supply Chains

Chuanya Jiao[1], Anyan Qi[2], Jiayu Chen[3], [1]University of Science and Technology of China, Hefei, China; [2]The University of Texas at Dallas, Richardson, TX, [3]University of Calgary, Calgary, AB, Canada. Contact: jiayu.chen1@ucalgary.ca
Workers in developing economies may be forced to work excessive overtime, which causes mental and physical issues and results in brand damages to the buyers if exposed in public. We develop a game-theoretic model of a dyadic supply chain and analyze the buyer's strategies to combat excessive overtime, including auditing and cross-training. We derive equilibrium outcomes and study the interaction of the strategies and their impact on the degree of excessive overtime and social welfare.

2 Fixed Vs. Flexible Premiums for Sustainable Sourcing of Agricultural Products

Vishal Agrawal[1], Can Zhang[2], [1]Georgetown University, Washington, [2]Duke University, Durham, NC, Contact: c.zhang@duke.edu
Sustainability certification programs, such as Fairtrade and Rainforest Alliance, have gained increasing popularity for the sourcing of agricultural products. In order to help smallholder farmers achieve a living income and to promote sustainable agricultural practices, an important lever these certification programs use is a premium that manufacturing firms pay to certified farmers. This paper analyzes and compares the effectiveness of two different premium strategies that have been considered by different certifiers in practice: fixed premium, under which farmers receive a fixed premium

level that is independent of the market price; and flexible premium, under which farmers receive a higher premium level when the market price is lower.

3 Improving Drinking Water Access and Equity in Rural Sub-saharan Africa

Alfonso J. Pedraza-Martinez, Chengcheng Zhai, Kurt M. Bretthauer, Jorge Mejia, Indiana University, Bloomington, IN, Contact: alpedraz@indiana.edu

In 2020, 771 million people lacked basic drinking water access (UNICEF and WHO 2021). United Nations Sustainable Development Goal 6 aims to achieve universal and equitable access to drinking water by 2030. Building new water projects such as hand-pumps and small piped systems is the primary operational response by many non-governmental organizations (NGO) to bring people their first access to clean water. Our research studies where to optimally build the new water projects. To close the loop between practice and research, we collaborate with a local NGO and an international NGO working in rural Sub-Saharan Africa and conduct field research in Ethiopia.

4 Implications of Supply Chain Environmental Violations on The Financial Performance of Buying Firms

Minghe Zhang[1], Basak Kalkanci[1], Yao Xie[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: minghe_zhang@gatech.edu

Utilizing a dataset publicizing the environmental violations of facilities in China and proprietary supply network data, we evaluate how suppliers' environmental responsibility violations affect the financial performance of buying firms that source from them. We find evidence for a significant reduction in the market value of buying firms following the announcements of their suppliers' environmental problems.

Tuesday, 12:30 PM–1:45 PM

TC22

CC - Room 127

Causal Inference: Data Corruption, Debiasing, and Fairness

General Session

Session Chair

Nur Kaynar, University of California-Los Angeles, Los Angeles, CA

1 Automatic Debiased Machine Learning for Dynamic Treatment Effects

Victor Chernozhukov[1], Whitney Newey[1], Rahul Singh[1], Vasilis Syrgkanis[2], [1]MIT, Cambridge, MA, [2]Stanford University, Palo Alto, CA

We extend the idea of automated debiased machine learning to the dynamic treatment regime. We show that the multiply robust formula for the dynamic treatment regime with discrete treatments can be re-stated in terms of a recursive Riesz representer characterization of nested mean regressions. We then apply a recursive Riesz representer estimation learning algorithm that estimates de-biasing corrections without the need to characterize how the correction terms look like, such as products of inverse probability weighting terms, as is done in prior work on doubly robust estimation in the dynamic regime. Our approach defines a sequence of loss minimization problems, whose minimizers are the mulitpliers of the de-biasing correction, circumventing the need for auxiliary propensity models and directly optimizing the mean squared error of the target de-biasing correction.

2 Interference in Randomized Experiments: A Unifying Design-based Framework and Treatment Effect Estimation

Christopher Harshaw[1], Yitan Wang[2], Fredrik Sävje[3], [1]UC Berkeley, Berkeley, CA, [2]Yale University, New Haven, CT, [3]Yale University, New Haven, CT

We present a new framework for modeling interference in randomized experiments, where the experimenter seeks to analyze an aggregated causal treatment effect. The framework suggests new methodological possibilities in the design-based inference setting and unifies several existing frameworks. We present a new method for treatment effect estimation and derive conditions for consistency and asymptotic normality of the point estimator. Additionally, we construct (possibly conservative) variance estimators which facilitate the construction of asymptotically valid confidence intervals. We apply our framework in re-analyzing the causal effects of a cash transfer program.

3 Fairness Under Feature Exemptions

Sanghamitra Dutta, University of Maryland College Park, College Park, MD, Contact: sanghamitra2612@gmail.com

When it comes to resolving legal disputes or informing policies, only identifying disparity in an algorithm's decision is insufficient. We need to dig deeper into how it arose. Disparities in hiring that can be explained by an occupational necessity (code-writing for software engineering) may be exempt by law, but the disparity arising due to an aptitude test may not be (Griggs v. Duke Power). This leads to a question that bridges the fields of fairness, explainability, and law: Did the disparity arise purely due to the critical occupational necessities? In this talk, I propose a *systematic* measure of "non-exempt disparity," i.e., the disparity which cannot be explained by the occupational necessities. To arrive at this measure, I adopt a rigorous axiomatic approach that brings together information theory (Partial Information Decomposition) with causality.

4 Causal Inference with Corrupted Data: Measurement Error, Missing Values, Discretization, and Differential Privacy

Anish Agarwal[1], Rahul Singh[2], [1]Simons Institute, Berkeley, CA, [2]MIT, Cambridge, MA, Contact: rahul.singh@mit.edu

The standard workflow for empirical research involves data cleaning followed by data analysis that typically ignores the bias and variance consequences of data cleaning. We propose a new end-to-end procedure for data cleaning, estimation, and inference with data cleaning-adjusted confidence intervals. We prove consistency, Gaussian approximation, and semiparametric efficiency for our estimator of the causal parameter by finite sample arguments. Our key assumption is that the true covariates are approximately low rank. In our analysis, we provide nonasymptotic theoretical contributions to matrix completion, statistical learning, and semiparametric statistics. We verify the coverage of the data cleaning-adjusted confidence intervals in simulations. Finally, we conduct a semi-synthetic exercise calibrated to privacy levels mandated for the 2020 US Census.

Tuesday, 12:30 PM–1:45 PM

TC23

CC - Room 128

TSL-PSOR Joint session: Improving Public Health and Transportation Accessibility

Joint Session

Session Chair

Lavanya Marla, U of Illinois at Urbana-Champaign, Urbana, IL

1 Managing Resources for Shared Micromobility: Approximate Optimality in Large-Scale Systems

Deniz Akturk[1], Ozan Candogan[2], Varun Gupta[1], [1]University of Chicago Booth School of Business, Chicago, IL, [2]University of Chicago, Chicago, IL

We consider the problem of managing resources in shared micromobility systems (bike-sharing and scooter-sharing). An important task in managing such systems is periodic repositioning/recharging/sourcing of units to avoid stockouts or excess inventory at nodes with unbalanced flows. We consider a discrete-time model: each period begins with an initial inventory at each node in the network, and then customers (demand) materialize at the nodes. Each customer picks up a unit at the origin node and drops it off at a randomly sampled destination node given origin-specific probability distribution. We introduce a mean-field approximation and prove that the mean-field optimal policy is asymptotically optimal. We then provide an algorithm to compute a near-optimal policy for the mean-field system. Using micromobility data, we show the strong performance of our algorithm.

2 Next Generation Emergency Response Network Design Through Drone-bystander-ambulance Coordination

Jungeun Shin[1], Lavanya Marla[1], Justin J. Boutilier[2], [1]University of Illinois at Urbana-Champaign, Urbana, IL, [2]University of Wisconsin - Madison, Fitchburg, WI, Contact: jungeun4@illinois.edu

Drones, due to their quicker mobility, are emerging as a technology to support ambulance-based emergency medical services(EMS) for out-of-hospital cardiac arrests. To be effective, drones need participation from a bystander who administers first-response with drone-delivered equipment. This work is the first to explicitly capture the concept of bystander participation in a joint location-queuing model for drone-bystander-ambulance network optimization, to maximize calls served within a threshold. Our solutions improve EMS service by pooling ambulances and placing drones in areas with lower ambulance access but high bystander availability. We propose a fast heuristic using this insight and show results for EMS in Toronto. Our results show that not capturing bystander behavior in drone-assisted EMS results in significant overestimation of system performance.

3 A Supervised Learning Approach for Ambulance Dispatching

Juan Camilo Paz, Purdue University, West Lafayette, IN, Contact: paz3@purdue.edu

Supervised learning has been successfully used in online decision-making (e.g., manufacturing), but they have yet to be applied to EMS logistic operations. In this research, we propose a novel framework for learning condition-based dispatch rules based on optimized schedules of sampled scenarios. The optimized schedules are obtained from offline solving a multi-depot vehicle routing problem for minimizing the total service latency, which assumes full knowledge of occurrence time and location of emergencies. We evaluate the performance of the proposed algorithm approach with simulated computational experiments.

Tuesday, 12:30 PM–1:45 PM

TC26

CC - Wabash 3
Location Problems in Humanitarian Logistics
General Session

Session Chair
Xiaofeng Nie, [1</sup]

1 On The Analysis of Allocating Servers to Existing Spatially Distributed Queuing Systems
Rajan Batta[1], Monir Sabbaghtorkan[2], [1]University at Buffalo (SUNY), Buffalo, NY, [2]University at Buffalo, Buffalo, NY, Contact: batta@buffalo.edu
This talk investigates facility location problems that strategically add servers among a set of spatially distributed queueing systems to improve the overall outcome for customers. A variety of models are analyzed, properties developed, and solution methods proposed. Computational tests are performed. The main applications are related to hurricane evacuation where the spatially distributed servers are existing gas stations, and to adding capacity to a set of existing electric vehicle charging stations. A case study from the hurricane evacuation application is investigated.

2 Disaster Relief Distribution with Mobile Beneficiaries
Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY
This research seeks to enhance the analytical formulations in disaster response by incorporating frequently overlooked real-life features of disaster conditions. A behavior-based location-allocation problem for disaster response logistics is proposed. This formulation minimizes social costs and explicitly considers the mobility of beneficiaries in search of relief aid.

3 Logistics of Mobile Vaccination Centers for Coronavirus Disease
Ozlem Karsu[1], Bahar Kara[1], Oya Ekin Karasan[1], Cagla Dursunoglu[1], Manoj Dora[2], Yang Zhang[3], [1]Bilkent University, Ankara, Turkey; [2]Anglia Ruskin University, Cambridge, United Kingdom; [3]Brunel University London, Uxbridge, United Kingdom. Contact: ozlemkarsu@bilkent.edu.tr
The rapid development and administration of multiple vaccines has helped in mitigating the adverse effects of the ongoing pandemic. However, in many countries, there are still major challenges in ramping up the vaccination capabilities, especially in rural areas. In response to the challenges around provisioning of vaccination, the aim of this study is to develop a methodology that will prescribe, for a given population, a delivery plan that entails a fair and a cost-effective allocation of vaccination resources. To achieve this, we first discuss the current practices in Turkey and the UK and then propose a paradigmatic case study based on our observations. The case study aims to ensure increased accessibility through mobile vaccination by designing a logistics system that considers criteria such as convenience for the people, fairness and cost-effectiveness.

4 Proactive Staging of Border Resources in a Secure and Humane Manner Via Stochastic Programming
Fatemeh Farajzadeh, Andrew C. Trapp, Worcester Polytechnic Institute, Worcester, MA, Contact: ffarajzadeh@wpi.edu
Migration crises are complex emergencies that evolve over time and feature high levels of uncertainty concerning human needs. We use stochastic programming to position scarce border resources under demand uncertainty with redistribution recourse decisions. Our costs include the human suffering experienced as a consequence of accumulated time of not accessing critical aid.

Tuesday, 12:30 PM–1:45 PM

TC27

CC - Room 138
Data-driven Decision-making: Understanding and Improving Standard Policies
General Session

Session Chair
David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA

Session Chair
Feng Zhu, Massachusetts Institue of Technology, Cambridge, MA

1 **A Simple and Optimal Policy Design with Safety against Heavy-tailed Risk for Multi-armed Bandits**

Feng Zhu[1], Zeyu Zheng[2], David Simchi-Levi[3], [1]Massachusetts Institue of Technology, Cambridge, MA, [2]University of California, Berkeley, Berkeley, CA, [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: fengzhu@mit.edu

In this paper, we study the tail behavior of online learning algorithms in the stochastic multi-armed bandit problem. We first show that some widely used policies incur heavy-tailed risk: the probability of incurring a linear regret slowly decays at a polynomial rate of 1/T (T is the time horizon). Then starting from the two-armed bandit setting, we provide a simple policy design that simultaneously enjoys optimal worst-case expected regret and ensures optimal exponentially decaying regret tail. We further enhance the policy design and analysis to (i) the general K-armed bandit setting and (ii) the “any-time” setting where T is unknown, and provide explicit tail bound for any regret threshold. A brief account of numerical experiments is conducted to illustrate the theoretical findings.

2 **Online Pricing with Offline Data: Phase Transition and Inverse Square Law**

Jinzhi Bu[1], David Simchi-Levi[2], Yunzong Xu[2], [1]Hong Kong Polytechnic University, Kowloon, Hong Kong; [2]Massachusetts Institute of Technology, Cambridge, MA

This paper investigates the impact of pre-existing offline data on online learning, in the context of dynamic pricing. We characterize the joint effect of the size, location and dispersion of the offline data on the optimal regret of the online pricing process. Our results reveal surprising transformations of the optimal regret rate with respect to the size of the offline data, which we refer to as phase transitions. In addition, our results demonstrate that the location and dispersion of the offline data also have an intrinsic effect on the optimal regret, and we quantify this effect via the inverse-square law.

3 **Non-stationary A/B Tests: Optimal Variance Reduction, Bias Correction, and Valid Inference**

Yuhang Wu[1], Zeyu Zheng[1], Guangyu Zhang[2], Zuohua Zhang[2], Chu Wang[2], [1]University of California, Berkeley, Berkeley, CA, [2]Amazon, Seattle, WA

A/B tests have been used at scale by data-driven enterprises to test innovative ideas to improve core business metrics. Non-stationarities, such as the time-of-day effect and the day-of-week effect, can often arise nonparametrically in key business metrics involving purchases, revenue, conversions, customer experiences, etc. We show that ignoring or inadequately addressing non-stationarities can cause standard A/B tests estimators to have sub-optimal variance and non-vanishing bias, therefore leading to loss of statistical efficiency and accuracy. We provide new estimators, prove central limit theorems, and prove them achieving optimal variance and asymptotic zero bias. A new time-grouped randomization design is proposed, under which simple estimators can achieve asymptotically optimal variance.

Tuesday, 12:30 PM–1:45 PM

TC28

CC - Room 139

Telehealth Operations

General Session

Session Chair

Jing Dong, Columbia University, New York, NY

Session Chair

Carri Chan, Columbia Business School, New York, NY

1 **Does Telemedicine Reduce Emergency Room Congestion? Evidence from New York State**

Shujing Sun[1], Susan F. Lu[2], Huaxia Rui[3], [1]University of Texas at Dallas, Dallas, TX, [2]Purdue University, West Lafayette, IN, [3]University of Rochester, Rochester, NY, Contact: shujing.sun@utdallas.edu

Using visit-level ER data from New York State, we investigate whether telemedicine enhances ER care delivery. We show that telemedicine adoption in the ER significantly reduces average patients’ length of stay (LOS), which is partially driven by flexible resource allocation. Specifically, telemedicine adoption leads to a larger reduction in ER LOS when there is a demand surge or supply shortage. Furthermore, such improvement is not a by-product of other widely adopted health IT applications and does not come at the expense of care quality or patient cost. We replicate the analysis using Hospital Compare data of U.S. hospitals and find that ER telemedicine adoption significantly reduces average patients’ waiting time, which suggests that the LOS reduction partially comes from the reduction of waiting time.

2 **Modeling Patient No-show Behavior in Outpatient Clinics: In-person Vs. Telehealth**

Jimmy Qin[1], Carri Chan[1], Jing Dong[2], [1]Columbia Business School, New York, NY, [2]Columbia University, New York, NY

The Covid-19 pandemic has forced outpatient clinics to shift to telemedicine and the increased adoption of telemedicine is likely to persist. To effectively manage and integrate this new modality of visit with the traditional in-person visits, it is important to understand patient behavior under different visit modalities. We take an empirical approach to study the no-show behavior of in-person versus telemedicine visits. Our results show that in-person and telemedicine no-shows can be affected by very different factors and telemedicine patients are more sensitive to delays. We also study the implications of behavioral differences on the optimal sequencing rule in appointment scheduling.

3 Optimal Deployment of Resources for TB Treatment

Nareen Molugu[1], Sarang Deo[1], Vishwakant Malladi[2], Milind Sohoni[3], [1]Indian School of Business, Hyderabad, India; [2]Indian School of Business, Mohali, Punjab, India; [3]Indian School of Business, HYDERABAD, India.

Tuberculosis is a leading cause of death worldwide with 1.4 million deaths reported in 2019. Lack of medication adherence is a major reason for poor health outcomes. Health organizations address this by employing Healthcare workers (HCWs) who visit patients to enforce adherence. Of late, imprecise digital adherence technologies (DATs) are being used to monitor patient death. The idea is for the HCWs to use signals from DATs to improve the HCW's patient visits. Using a Restless Multi-Armed Bandit framework, we devise an optimal HCW intervention policy given the DAT signal accuracy.

4 Telehealth in Acute Care: Pay Parity and Patient Access

Ozden Engin Cakici[1], Alex Mills[2], [1]American University, Washington, DC, [2]Baruch College, City University of New York, New York, NY, Contact: cakici@american.edu

Many US states have adopted telehealth pay-parity policies requiring payers to reimburse healthcare providers equally for telehealth and office visits. But telehealth may require a duplicate visit for a physical exam. We analyze a three-stage game to study the impact of telehealth reimbursement on provider's operational decisions, where patients choose strategically between telehealth and office channels. We find that pay parity can decrease patient access and discuss its policy implications.

Tuesday, 12:30 PM–1:45 PM

TC29

CC - Room 140

New Business Models in Automotive Industry and Flexibility

General Session

Session Chair

Liling Lu, Singapore.

1 Opaque Product Under Limited Flexibility and Pricing

Hailun Zhang, School of Data Science, The Chinese University of Hong Kong, Shenzhen

Selling opaque products has become popular on e-commerce platforms where the hidden attribute is often color or style. We first consider a setting in which an online retailer sells N products that only differ in a certain secondary attribute, and in addition offers opaque options where customer selects a subset of all products from which the seller allocates one to the customer. We find that the cost savings from using just 2-opaque products is on the same order as the fully flexible case where the opaque product contains all N products, extending the results in Elmachtoub et al.(2019).

We next investigate the opaque design problem where the objective is to maximize the expected profit through opaque product design and pricing. Extensive numerical experiments are conducted to support our main results and insights.

2 The Role of Dealer Demonstration in The Adoption of Electric Vehicles

Vishal Agrawal[1], Ioannis Bellos[2], Hang Ren[3], [1]Georgetown University, Washington, [2]School of Business, George Mason University, Fairfax, VA, [3]George Mason University, Fairfax, VA

Drivers' uncertainty around the extent to which they will be able to meet their mobility needs with an electric vehicle (EV) is often cited as one of the barriers to EV adoption. It has been suggested that one way to alleviate this issue is by offering demonstration services such as extended test drives. However, it has been noted that not all dealers adopt such practices. Empirical evidence also suggest that some dealers exhibit a lackluster attitude toward familiarizing customers with the electric vehicle technology. In this work we consider a monopolist dealer offering conventional and/or electric vehicles to customers who differ in their mobility needs. In addition to vehicle prices, the dealer determines whether to offer demonstration services. We explore the economic and environmental implications of this decision.

3 **Online Fulfillment with Inventory Allocation: Certainty Equivalent Control and One-step Lookahead**

Alessandro Arlotto[1], Irem Keskin[2], Yehua Wei[2], [1]Duke University, Durham, NC, [2]Fuqua School of Business, Duke University, Durham, NC

We study an e-commerce fulfillment model with arbitrary fulfillment flexibility network configuration. In our model, the decision-maker needs to allocate inventories at the beginning of the horizon and then make online fulfillment decisions as the orders arrive. We consider two frameworks for online resource allocations, certainty equivalent control, and one-step lookahead. Through regret analysis, we provide insights into why one-step lookahead policies and their variants are the preferred option under the e-commerce fulfillment model.

4 **Stochastic Capacity Investment and Flexible Vs. Dedicated Technology Choice in The Presence of Subscription Programs**

Liling Lu, Onur Boyabatli, Yini Gao, Singapore Management University, Singapore, Singapore. Contact: liling.lu.2018@pbs.smu.edu.sg

This paper studies flexible versus dedicated technology choice and capacity investment decision of a two-product firm under demand uncertainty in the presence of subscription programs. The key feature of subscription programs is that some proportion of consumers that are allocated a particular product later switch to using the other product. We investigate how the proportion of switching customers and the correlation between the two subscription demands affect capacity investment level and profitability with flexible and dedicated technologies, and shape optimal technology choice decision. We make a comparison with the benchmark where there is no switching to the other product under the traditional model.

Tuesday, 12:30 PM–1:45 PM

TC30

CC - Room 141

Information and Behavior in Service Systems

General Session

Session Chair

Luyi Yang, University of California, Berkeley, Orinda, CA

Session Chair

Shiliang Cui, Georgetown University, McDonough School of Business, McLean, VA

1 **On Information Disclosure in An Observable Shared Waiting Room**

Yanting Li, Ricky Roet-Green, University of Rochester, Rochester, NY, Contact: yanting.li@simon.rochester.edu

We study a service system where two types of customers with different service demands arrive at a facility utilizing a shared waiting room. In our base system, service providers release the queue length information to customers, and customers make a join-or-balk decision accordingly. We call such a system: full-information system. Alternatively, we formulate a partial-information system where the queue length information is unavailable. In this case, customers cannot distinguish between the types and make their joining decision based on the number of customers in the shared waiting room. We perform an analytical comparison of these two systems in terms of throughput and social welfare. In addition, we consider the scenario where types differ in their arrival rates and perform the comparison numerically.

2 **Ownership Utility Estimation in Rent-to-own Businesses**

Milad Armaghan[1], Metin Cakanyildirim[2], Andrew E. Frazelle[3], [1]University of Texas at Dallas, Richardson, TX, [2]The University of Texas at Dallas, Richardson, TX, [3]The University of Texas at Dallas, Dallas, TX, Contact: miladarmaghan@gmail.com

Rent-to-own (RTO) firms rent products in exchange for a periodic fee and offer the already-rented products for purchase at buyout prices to their renters. To model renter decisions, we develop a utility framework that incorporates the unique features of the RTO business, namely the repeated signals about each renter’s ownership utility provided by his acceptance or rejection of different buyout prices. We build six related models by considering renter types based on strategic (and myopic) purchase surplus evaluations as well as possible neglection of purchase offers. Our methodology and results can be used by RTO firms to estimate renter willingness to pay when setting buyout prices. While one-step lookahead model explains our data best, all of the models should be of independent interest for estimating utility in different settings.

3 **On Customer (dis)honesty in Queues: The Role of Lying Aversion**

Arturo Estrada Rodriguez, Rouba Ibrahim, Dongyuan Zhan, University College London, London, United Kingdom. Contact: uceiaes@ucl.ac.uk

We investigate the prioritization decision of a manager who solicits customers' private information. Customers have the incentive to misreport to shorten their waiting but incur lying costs. We construct a queueing game and find that lying costs lead to an optimal scheduling policy different from the cμ rule. We also run controlled online queueing experiments where we validate our theoretical insights.

4 **Implications of Vaccine Shopping During Pandemic**

Leela Nageswaran, University of Washington, Seattle, WA, Contact: lnages@uw.edu

We study whether a policy maker should allow individuals to choose their vaccine during a pandemic. We develop a multi-server queueing model, where individuals obtain a reward from the vaccine administered at a server and decide whether to join a queue based on the wait time and the level of choice provided. We find that restricting server choice leads to more vaccinations when the vaccine supply is low, but fewer vaccines are wasted when patients who are moderately hesitant towards vaccinations are allowed to choose their vaccine.

Tuesday, 12:30 PM–1:45 PM

TC31

CC - Room 142

Emerging Topics in Operations Marketing Interface

General Session

Session Chair

Honggang Hu, University of Florida, Gainesville, FL

Session Chair

Zhechao Yang, Gainesville, FL

1 **Cross-brand Pass-through and Channel Pricing**

Quan Zheng[1], Honggang Hu[2], Xiajun Amy Pan[3], [1]University of Science and Technology of China, Hefei, China; [2]University of Florida, Gainesville, FL, [3]University of Florida, Gainesville, FL, Contact: hongganghu@ufl.edu

Prior works on channel pricing assume either linear demands or symmetric-at-symmetric prices for tractability. Through a common retailer setting, we demonstrate that such a simplification amounts to zero cross-brand pass-through and may yield misleading implications. As an important complement and advance, we provide a general analysis for any level of cross-brand pass-through and apply it to several well-known channel problems.

2 **Probabilistic Selling for Vertically Differentiated Products in a Supply Chain**

Zhechao Yang[1], Xiajun Amy Pan[2], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL

We study probabilistic selling for vertically differentiated products in a supply chain. The supplier or retailer can create a probabilistic product (PP). Capturing consumers' enjoyment of receiving the high-quality product when purchasing the PP, we discover that both the supplier and retailer may prefer the supplier to create the PP.

Tuesday, 12:30 PM–1:45 PM

TC32

CC - Room 143

Empirical Session on Food Waste and Supply Chain

General Session

Session Chair

Ashish Kabra, University of Maryland-College Park, College Park, MD

Session Chair

Nitish Jain, London Business School, London, United Kingdom.

1 **The Carbon Footprint of Cold Chain Food Flows in The United States**

Junren Wang, Deniz Berfin Karakoc, Megan Konar, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: denizberfinkarakoc@gmail.com

The refrigerated food supply chain is an energy intensive, nutritious, and high-value part of the food system, making it particularly important to consider for CO_2 emissions. In this study, we develop a novel model of cold chain food flows between counties in the United States where we estimate the 2017 truck transport of meat and prepared foodstuffs. We use the roadway travel distance in our model to calculate the truck fuel consumption and CO_2 emissions more accurately. We find that the cold chain transport of meat emitted 8.4×10^6 tons of CO_2 per year, and prepared foodstuffs emitted 14.5×10^6 tons of CO_2 per year. We also find that cold chain CO_2 emissions are not projected to significantly increase with climate change. These county-level cold chain food flows could be used to inform infrastructure investment, supply chain decision making, and environmental footprint studies.

2 Drivers of Food Waste at Retail Level: An Empirical Study

Nitish Jain[1], Ashish Kabra[2], Varun Karamshetty[3], [1]London Business School, London, United Kingdom; [2]University of Maryland-College Park, College Park, MD, [3]National University of Singapore, London, Singapore.

Food waste in the retail sector is an urgent economic and social problem. Recent reports suggest that supermarkets in the UK throw away enough food for 190 million meals each year. This number is comparable to the total number of people undernourished in sub-Saharan Africa (200 million; 2015). In order to propose solutions, it is essential to understand the underlying causes. We analyze proprietary data from a supermarket chain in the UK to understand key drivers of food wastage in retail supermarkets. We estimate the amount of "avoidable" waste, identify controllable factors and quantify their impact. We propose guidelines for store managers and forecasters to minimize waste while maintaining service levels and revenues.

3 Detecting Production Planning Problems in Commercial Kitchens

Yu Nu[1], Elena Belavina[2], Karan Girotra[2], [1]Cornell Tech/ Johnson, Cornell University, New York City, NY, [2]Cornell Tech/Johnson, Cornell University, New York, NY, Contact: girotra@cornell.edu

Sub-optimal inventory management decisions are the root cause of food waste. While laboratory experiments have identified several behavioral errors that drive this sub-optimality, detecting instances of such errors in real-time in a real-world food production environment remains a challenge. In this study, we develop several econometric-modeling based and deep-learning based classifiers to detect common production problems using real-world data streams. We assess the performance of different estimators in different data environments, ranging from full instrumentation—where ordering, production, consumption, and waste data are all recorded—to settings where only the food waste may be recorded. We also evaluate the importance of auxiliary data (such as cooking time, shelf life, batch size) in problem detection.

4 Analyzing Food Waste in Food Supply Chains: A Machine Learning Approach

Shahryar Gheibi, Siena College, Loudonville, NY, Contact: sgheibi@siena.edu

This study examines food supply chains focusing on food waste and its underlying factors. We employ machine learning (and other analytics) methods to analyze supply chain inefficiencies and provide insights into the factors that impact food waste. The literature suggests a gap in quantitative studies that explore food waste from a supply chain perspective, particularly in the US. This research is intended to help develop a more holistic understanding of food waste and to aid data-driven decisions regarding the sustainability of our food and environment.

5 Increasing Knowledge or Trust? The Effects of Supply Chain Transparency on a Consumer Marketplace

Jane Jiang[1], Wedad Elmaghraby[2], Ken Moon[3], [1]UMD, Hyattsville, MD, [2]University of Maryland, College Park, MD, [3]University of Pennsylvania, Philadelphia, PA

: For many fished and agricultural goods, consumers lack important visibility into the origins, handling, and quality of products, especially when purchasing online. We study how supply chain transparency affects consumer trust when such goods are sold in online marketplaces. By collaborating with a major online retail platform that let sellers use its proprietary blockchain-based tracing, we find that transparency has two distinct effects. First, transparency increases trust, hence market activity, in the absence of strong reputational or economic guarantees. Second, transparency educates relatively unsophisticated consumers about product quality. By causing better choices, the educational effect increases welfare but may, counterintuitively, increase complaints.

Tuesday, 12:30 PM–1:45 PM

TC33

CC - Room 144
Inventory Control
Contributed Session

Session Chair
Xiaolong Li, National University of Singapore, Singapore, Singapore.

1 Dual Sourcing Under Non-stationary Demand with a Partially Observable Demand Process

Hannah Yee[1], Heletjé Van Staden[2], Robert Boute[1], [1]Catholic University of Leuven, Leuven, Belgium; [2]University College Dublin, Dublin, Ireland. Contact: hannah.yee@kuleuven.be

We consider an inventory control problem with stochastic and non-stationary demand. Inventory can be replenished from a fast and a slow source, with the latter being less expensive. We model the non-stationarity in demand through changes in the underlying demand distribution. The underlying demand distribution is not observed directly, yet demand observations provide partial information on the current distribution. We propose a solution where a pre-committed base volume from the slow source is complemented with flexible short-term orders from both the fast and slow source. The pre-committed volume is available at a lower cost, while flexible orders are responsive to partial information on the stochastic and non-stationary demand. In a comparative analysis, we demonstrate the value of capturing partial demand information and using the slow source for flexible orders.

2 Unimodality of Multiperiod Risk-averse Inventory Models with Log-concave Distribution

YUEQIN ZHONG, Rutgers University, Piscataway, NJ

Risk-averse inventory control using mean-variance(MV) criteria has long received attentions. We show that, in the single-period MV model, objective function is always unimodal as long as demand distribution is log-concave(PF2). Then, we apply extended Bellman equation to form finite horizon MV objective function and show that, under certain conditions, objective function preserves quasi-concavity.

3 Portfolio Selection Under Cognitive Constraints with Principal Component Analysis and Regularization

Robert Hill[1,2], [1]Verition Fund Management, Pinecrest, FL, [2]George Washington University SEAS, Washington, DC, Contact: bhill42@gwu.edu

Both technical leaders managing portfolios of projects and quantitative traders managing algorithmically designed portfolios alike are subject to cognitive constraints limiting their ability to dynamically manage complex portfolios. This research develops an applied statistical framework for incorporating agents' bounded rationality into the construction of portfolios. In this framework, cognitive bandwidth is depleted not only by the explicit number of assets in a portfolio, but also the implicit dimensionality of those asset returns and their variance. Thus, a volatile, uncorrelated asset that consumes more of a portfolio manager's cognitive bandwidth may be less desirable than modern portfolio theory would suggest. Principal component, LASSO, and ridge regression approaches are reviewed as potential solutions and tested on US equities end of day data.

4 The Exploration-exploitation-robustness Tradeoff in a Multiperiod Inventory Control Problem with Learning

Michael Jong Kim[1], Xiaolong Li[2], Andrew E.B. Lim[2], [1]The University of British Columbia, Vancouver, BC, Canada; [2]National University of Singapore, Singapore, Singapore. Contact: oralxi@nus.edu.sg

We study the tradeoff between exploration, exploitation and robustness in a finite-horizon multi-period Bayesian inventory problem with both parameter and model uncertainty. Nominal demand belongs to a given parameterized family of distributions, but the decision maker is uncertain about the value of the parameters and also doubts that the family is correct. He/she collects data up to a stopping time of his/her choice ("learning"), following which an inventory decision in the form of an order-up-to policy that is fixed for the remaining periods is made ("earning"). We consider a robust version of this problem where the decision maker optimizes a worst-case expected reward over the duration of the learning phase and the inventory decision, focusing on the tradeoff between learning (exploration), exploitation (earning) and robustness.

Tuesday, 12:30 PM–1:45 PM

TC34

CC - Room 145

Sustainability and Energy

Contributed Session

Session Chair

Fariba Farajbakhsh Mamaghani, Tulane University, River Ridge, LA

1 Decision Support for Transition from a Conventional Roof to a Cool Roof Under Energy Price Uncertainties: A Real Options Approach

Zhuoyi Zhao[1], K Jo Min[2], [1]Iowa State University, Ames, IA, [2]Iowa State University, Ames, IA, Contact: zyzhao@iastate.edu

The transition from a conventional roof to cool roof results in lower energy consumption for cooling but higher energy consumption for heating. Such a decision is costly yet irreversible and made under the energy price uncertainties. In this research, we aim to provide decision support for the roof transition when the electricity price and natural gas price follow correlated geometric Brownian motion (GBM) processes. Specifically, we construct and analyze the roof transition decision using a real options approach to derive the optimal thresholds of energy prices and the expected transition time. We also demonstrate the key features of our model through numerical examples and provide managerial insights and economic implications.

2 Meteorological Drivers of Resource Adequacy Failures During The Transition to a Decarbonized Power System

Srihari Sundar[1], Michael Craig[2], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: sriharis@umich.edu

Increasing meteorological extremes and renewable penetrations could challenge resource adequacy (RA) in the electric power system, as demonstrated by recent blackouts in California and Texas. We quantify meteorological drivers of RA in the Western U.S. power system, and examine how these drivers change with increasing renewable penetrations. Our analysis integrates an optimization-based capacity expansion model, stochastic RA model, and neural-network-based self-organizing maps. We find that RA failures are driven by high pressure circulation patterns which produce positive surface temperature anomalies and negative solar radiation and wind speed anomalies. Further, with increasing renewable penetration we find that the probability of failure attributed to patterns associated with heat waves over the region increases.

3 Comprehensive and Comparative Analysis of GAM-based Solar Power Forecasting Models Versus Four Machine Learning Methods

Takuji Matsumoto[1], Yuji Yamada[2], [1]Kanazawa University, Kanazawa-shi, Japan; [2]University of Tsukuba, Bunkyo-Ku, Japan. Contact: mtakuji@staff.kanazawa-u.ac.jp

This study proposes a solar power generation forecasting model based on a generalized additive model (GAM) and compares its forecasting accuracy with four machine learning methods such as k-nearest neighbor, artificial neural networks, support vector regression, and random forest. The empirical analysis confirmed the validity of the proposed model structure, as the shape of the multidimensional smooth trends estimated by GAM was intuitively interpreted. The effectiveness of GAM is particularly evident in trend completion for missing data. It can flexibly describe the entangled trend structure characteristic of time series data, which is advantageous not only for interpretability but also for improving forecast accuracy.

4 Harvesting Solar Power Foments Prices in a Vicious Cycle:breaking The Cycle with Price Mechanisms

Fariba Farajbakhsh Mamaghani[1], Metin Cakanyildirim[2], [1]Tulane University, New Orleans, LA, [2]The University of Texas at Dallas, Richardson, TX, Contact: fariba@tulane.edu

Distributed solar power generation is growing but not necessarily benefiting the utility firms. Reducing the demand, it hinders the coverage of utility costs with reasonable retail electricity prices. Utilities raise prices, unintentionally reducing both demand and affordability of electricity, and are said to be caught in a utility (death) spiral. The reduced affordability adversely affects consumers that cannot invest into solar generation. We provide a profit maximization formulation for a regulated utility and reveal the interaction between optimal price increases and growing solar power adoption. Iterating with this interaction, we study the utility death spiral for myopic and forward-looking consumers. We consider new pricing mechanisms with a buyback price and a subscription fee paid only by solar power generating consumers.

Tuesday, 12:30 PM–1:45 PM

TC35

CC - Sagamore 1

Reinforcement Learning Theory

General Session

Session Chair

Sajad Khodadadian, Georgia Institute of Technology, Atlanta, GA

1 Reinforcement Learning with Linear Value Function Approximation and Lookahead

Anna Winnicki, R. Srikant, University of Illinois at Urbana-Champaign, Urbana, IL, Contact: annaw5@illinois.edu

When the sizes of the state and action spaces are large, solving MDPs can be computationally prohibitive even if the probability transition matrix is known. So, in practice, a number of techniques are used to approximately solve the dynamic programming problem, including lookahead, approximate policy evaluation using an m-step return, and function approximation. We consider several algorithms based on techniques used by Alpha Zero that allow us to characterize the role of lookahead, return, and function approximation in enhancing the efficiency

and accuracy of modern algorithms that employ these techniques. The bounds we obtain are both asymptotic and finite-time in nature.

2 Policy Gradient Finds The Global Optimum of The Nonlinear Control

Yinbin Han, University of Southern California

We explore reinforcement learning methods for finding the optimal policy in the nonlinear optimal control problem. In particular, we consider the convergence of policy gradient methods in the setting of control-affine systems with unknown parameters. We are able to produce a global sublinear convergence guarantee for this approach in the setting of infinite horizon problem with neural policy via state dependent Riccati equation. The convergence of a projected policy gradient method is also established in order to handle problems with constraints.

3 Stochastic First-order Methods for Average-reward Markov Decision Processes

Tianjiao Li[1], Feiyang Wu[1], Guanghui Lan[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: tli432@gatech.edu

We study the problem of average-reward Markov decision processes (AMDPs) and develop novel first-order methods with strong theoretical guarantees for both policy evaluation and optimization. Existing on-policy evaluation methods suffer from sub-optimal convergence rates and failure in handling insufficiently random policies for lack of exploration. To remedy these issues, we develop a variance-reduced temporal difference (VRTD) method with linear function approximation for randomized policies and an exploratory VRTD method for insufficiently random policies with comparable convergence guarantees. For policy optimization, we develop an average-reward variant of the stochastic policy mirror descent (SPMD) (Lan, 2022). We establish the sample complexity for solving AMDPs with SPMD under both the generative model and Markovian noise model.

Tuesday, 12:30 PM–1:45 PM

TC36

CC - Sagamore 2

Stochastic and Risk Averse Optimization

General Session

Session Chair

Anirudh Subramanyam, 1</sup

1 Risk-averse Optimization and Resilient Network Flows

Masoud Eshghali, Pavlo A. Krokhmal, The University of Arizona, tucson, AZ, Contact: masoudeshghali@email.ariozna.edu

In this talk we propose an approach to constructing metrics of network resilience, where resilience is understood as the network's amenability to restoring its optimal or near-optimal operations subsequent to unforeseen (stochastic) disruptions of its topology or operational parameters, and illustrate it on the examples of the resilient maximum network flow problem and the resilient minimum cost network problem. Efficient decomposition algorithms have been proposed for both problems.

2 Cardinality-constrained Distributionally Robust Portfolio Optimization

Ken Kobayashi[1], Yuichi Takano[2], Kazuhide Nakata[1], [1]Tokyo Institute of Technology, Meguro-ku, Japan; [2]University of Tsukuba, Tsukuba-shi, Japan. Contact: kobayashi.k.ar@m.titech.ac.jp

This talk is focused on a distributionally robust portfolio optimization model with a cardinality constraint for limiting the number of invested assets. We formulate this model as a mixed-integer semidefinite optimization (MISDO) problem by means of the moment-based uncertainty set of probability distributions of asset returns. To exactly solve large-scale problems, we propose a specialized cutting-plane algorithm that is based on bilevel optimization reformulation. We apply a matrix completion technique to lower-level SDO problems to make their problem sizes much smaller. Numerical experiments demonstrate that our cutting-plane algorithm is significantly faster than the state-of-the-art MISDO solver SCIP-SDP. We also show that our portfolio optimization model can achieve good investment performance compared with the conventional mean-variance model.

3 Asymptotically Optimal Multistage Tests with Non-iid Data

Yiming Xing, Georgios Fellouris, University of Illinois at Urbana and Champaign, Champaign, IL, Contact: yimingx4@illinois.edu

A 3-stage test, two 4-stage tests and a general multistage test are proposed in the problem of testing two simple hypotheses. If the error probabilities of the fixed-sample-size test decay exponentially, first-order approximations are obtained on their expected sample sizes under both hypotheses, as the error probabilities go to 0 at certain or arbitrary rates. When in particular the test statistic is the log-likelihood ratio, all these multistage tests achieve in the above asymptotic sense, the optimal expected sample sizes under both hypotheses in the class of sequential tests with the same error control. This general asymptotic theory is specialized in testing problems with non-iid data, e.g., AR(1) series and Markov chain. Finally, numerical studies are presented, where they are compared to FSST, SPRT, and an existing multistage test called sequential thresholding.

4 A Lagrangian Dual Method for Two-stage Robust Optimization

Anirudh Subramanyam, Argonne National Laboratory, Lemont, IL

We present a new exact Lagrangian dual method to calculate worst-case parameter realizations in two-stage robust optimization problems with categorical or binary-valued uncertain data. We specialize the method to problems where the binary parameters switch on or off constraints as these are commonly encountered in applications, and discuss extensions to problems that lack relatively complete recourse and to those with integer recourse. Numerical experiments provide evidence of significant computational improvements over existing methods.

Tuesday, 12:30 PM–1:45 PM

TC37

CC - Sagamore 6

Learning and Sequential Decision Making

General Session

Session Chair

Parshan Pakiman, University of Illinois-Chicago, Chicago, IL

Session Chair

Selvaprabu Nadarajah, Information and Decision Sciences, University of Illinois at Chicago, Chicago, IL

1 Learning from Clickstream Data in Online Retail

Bharadwaj Kadiyala[1], Dorothee Honhon[2], Canan Ulu[3], [1]University of Utah, Salt Lake City, UT, [2]University of Texas at Dallas, Richardson, TX, [3]Georgetown University, Washington, DC, Contact: cu50@georgetown.edu

Today, online retailers (e-tailers) have the resources to collect and analyze detailed consumer response data, such as the clickstream, in addition to sales data. Such detailed browsing and purchase information may reveal consumer preferences and can be used to improve product assortments over time. We study how an e-tailer can dynamically make assortment decisions by learning about consumer preferences using clickstream and sales data. We formulate the e-tailer's problem as a dynamic assortment optimization problem using a Bayesian framework. We model the consumer click and purchase process based on the random consideration set model. We study the informativeness of products using the Blackwell informativeness of experiments. When product informativeness is aligned with the product rankings and prices, we show that the optimal assortments are popular sets.

2 Preference Exploration and Bayesian Optimization

Zhiyuan Jerry Lin[1], Raul Astudillo[2], Peter Frazier[3], Eytan Bakshy[4], [1]Meta, San Francisco, CA, [2]Cornell University, Ithaca, NY, [3]Cornell University, Ithaca, NY, [4]Meta, New York, NY, Contact: pf98@cornell.edu

It is hard to optimize for someone who cannot mathematically describe the way they make trade offs. This is a challenge in public policy, materials design, drug discovery, and business operations. Tracing a Pareto frontier via multi-objective optimization can help, but may too slow when objective function evaluation are time-consuming. We describe a new approach to this challenge. This approach interacts with the decision maker to learn their preferences while simultaneously running targeted time-consuming function evaluations in a Bayesian optimization framework. It quickly identifies options that are likely to be attractive to the decision maker without exploring the full Pareto frontier. Numerical experiments and theory show this approach helps decision-makers to find good solutions even if they are unable to articulate their objective function.

3 Electricity Capacity Planning Models with Inverse Optimization-based Operational Cost Approximation

Michael Pavlin[1], Mehrdad Pirnia[2], Ali Rafiee[2], [1]Wilfrid Laurier University, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada. Contact: mpavlin@wlu.ca

This project focuses on the estimation of the cost functions of energy market participants using inverse optimization to determine predictive operational models which are tractable for use in long-term investment planning. These models are studied first in the context of a 24-bus test system and then extended to the analysis of the Ontario energy market.

4 Self-adapting Risk Management in Demand Learning

Parshan Pakiman[1], Selvaprabu Nadarajah[1], Boxiao (Beryl) Chen[1], Stefanus Jasin[2], [1]University of Illinois Chicago, Chicago, IL, [2]University of Michigan, Ann Arbor, MI

We study dynamic pricing over a finite horizon in the presence of demand-model ambiguity. Here, a retailer sets prices at pre-specified times such that each price level can apply to many customers. The retailer thus faces the risk of a significant loss in total revenue if many arrivals observe a suboptimal price based on an incorrect demand model. We develop a pricing policy that trades off managing risk and learning the true model. We develop regret bounds and numerically show the ability of our policy to efficiently tradeoff revenue and value-at-risk against existing benchmarks.

Tuesday, 12:30 PM–1:45 PM

TC38

CC - Sagamore 7

Optimization under Ambiguity and Applications to Finance and Insurance

General Session

Session Chair

Mario Ghossoub, 1</sup

Session Chair

David Saunnders, 1</sup

Session Chair

Shuangjian Zhang, 1</sup

1 The Reinforcement Learning Kelly Strategy

Ruihong Jiang, David Saunders, Chengguo Weng, University of Waterloo, Waterloo, ON, Canada. Contact: rhjiang@uwaterloo.ca

The full Kelly portfolio strategy's deficiency in the face of estimation errors in practice can be mitigated by fractional or shrinkage Kelly strategies. We provide an alternative, the RL Kelly strategy, based on a reinforcement learning (RL) framework. RL algorithms are developed for the practical implementation of the RL Kelly strategy. Extensive simulation studies are conducted, and the results confirm the superior performance of the RL Kelly strategies.

2 Transferable Utility Matching Under Capacities

Mario Ghossoub, David Saunders, Kelvin Shuangjian Zhang, University of Waterloo, Waterloo, ON, Canada. Contact: ks3zhang@uwaterloo.ca

In this paper, we investigate a capacity version of Shapley and Shubik (1971). Namely, we aim to show the existence of primal and dual problem, the core, and the equilibria, and the equivalence between them.

3 Data-driven Integration of Norm Penalized Mean-variance Optimization

Andrew Butler, Roy H. Kwon, University of Toronto, Toronto, ON, Canada. Contact: rkwon@mie.utoronto.ca

Mean-variance optimization (MVO) is known to be sensitive to estimation error in its inputs. Norm penalization of MVO programs is a regularization technique that can mitigate the adverse effects of estimation error. We augment the standard MVO program with a convex combination of parameterized L1 and L2 norm penalty functions. The resulting program is a parameterized quadratic program (QP) whose dual is a box-constrained QP. We make use of recent advances in neural network architecture for differentiable QPs and present a data-driven framework for optimizing parameterized norm-penalties to minimize the downstream MVO objective. Historical simulations using US stocks and global futures data demonstrate the benefit of the integrated data-driven approach.

4 Ambiguity Averse Distributionally Robust Second-order Stochastic Dominance: Decision Theoretic and Data-driven Perspectives

Erick Delage[1], Chun Peng[2], [1]HEC Montreal, Montreal, QC, Canada; [2]HEC Montreal, Montreal, QC, Canada. Contact: erick.delage@hec.ca

Optimization with second-order stochastic dominance constraints (SSDC) has recently received an increasing amount of attention in the quantitative risk management literature. This talk offers two perspectives on the use of SSDC in data-driven environment where the underlying distribution is ambiguous. It first axiomatically motivates the use of a distributionally robust SSDC for this setting. It then offers statistical and computational arguments to support the use of a type-1 Wasserstein ball centered at the empirical distribution as an ambiguity set. Our experiments with stock market data show that the size of the Wasserstein ball can be calibrated to reach an "acceptable" level of out-of-sample stochastic dominance while out-performing (on average) the reference uniform portfolio investment strategy.

Tuesday, 12:30 PM–1:45 PM

TC39

CC - Room 201

Theoretical Foundations of Reinforcement Learning
General Session

Session Chair
Zhengyuan Zhou, Stern School of Business, New York University, New York, NY

Session Chair
Yuting Wei, 1</sup

1 Fictitious Discount Recipes in Episodic Reinforcement Learning
Xin Guo[1], Anran Hu[2], Junzi Zhang[3], [1]University of California-Berkeley, Piedmont, CA, [2]UC Berkeley, IEOR, Albany, CA, [3]Amazon.com Services LLC, Palo Alto, CA, Contact: junziz@stanford.edu

When designing algorithms for finite-horizon episodic reinforcement learning problems, a common approach is to introduce a fictitious discount factor and use stationary policies for approximations. Empirically, it has been shown that the fictitious discount factor helps reduce variance, and stationary policies serve to save the per-iteration computational cost. Theoretically, however, there is no existing work on convergence analysis for algorithms with this fictitious discount recipe. This paper takes the first step towards analyzing these algorithms by establishing the first set of convergence guarantees on fictitious discount policy gradient methods, which also leads to the first global convergence result of policy gradient methods for finite-horizon episodic reinforcement learning.

2 Instance Dependent Reinforcement Learning
Koulik Khamaru, Rutgers University, Piscataway, NJ

In recent years, there has been tremendous progress in the field of reinforcement learning (RL), especially on the empirical side. But it is fair to say that there is a considerable gap between theory and practice: many RL methods behave far better than existing worst-case theory would suggest.
In this talk, we will discuss why worst-case guarantees can severely overestimate the difficulty of reinforcement learning problems in presence of favorable structure. This motivates us to consider an instance-dependent difficulty measure that is responsive to the problem structure. Next, we discuss how we can construct estimators that adapt to this instance-dependent difficulty. We show that for problems with favorable structures our proposed estimators and associated confidence regions are significantly better than those obtained from the worst-case theory.

3 Provable Regret Bounds for Deep Online Learning and Control
Xinyi Chen, Edgar Minasyan, Jason D. Lee, Elad Hazan, Princeton University, Princeton, NJ, Contact: xinyic@princeton.edu

The use of deep neural networks has been highly successful in reinforcement learning and control, although few theoretical guarantees for deep learning exist for these problems. There are two main challenges for deriving performance guarantees: a) control is inherently online, while deep learning theory focuses on supervised learning and b) deep networks are nonconvex predictors for which online learning cannot provide guarantees in general.
In this work, we resolve these issues and give the first regret bound in online control over a neural network-based policy class. We show sublinear episodic regret guarantees against a policy class parameterized by deep neural networks rather than previously achieved linear policies. The main component in the analysis is deriving regret bounds for online learning over deep neural networks, which may be of independent interest.

Tuesday, 12:30 PM–1:45 PM

TC40

CC - Room 202
First Order Methods for Linear Programming
General Session

Session Chair
Oliver Hinder, University of Pittsburgh, Pittsburgh, PA

1 Practical Large-scale Linear Programming Using Primal-dual Hybrid Gradient
Haihao Lu, University of Chicago Booth School of Business, Chicago, IL

We present PDLP, a practical first-order method for linear programming (LP) that can solve to the high levels of accuracy that are expected in traditional LP applications. In addition, it can scale to very large problems because its core operation is matrix-vector multiplications. PDLP is derived by applying the primaldual hybrid gradient (PDHG) method to a saddle-point formulation of LP. PDLP enhances PDHG for LP by combining several new techniques with older tricks from the literature; the enhancements include diagonal preconditioning, presolving, adaptive step sizes, and adaptive restarting. With a target of 10−8 relative accuracy

and 1 hour time limit, PDLP achieves a 6.3x reduction in the geometric mean of solve times and a 4.6x reduction in the number of instances unsolved (from 227 to 49).

2 Infeasibility Detection with Primal-dual Hybrid Gradient for Large-scale Linear Programming

Mateo Diaz[1], Miles Lubin[2], Haihao Lu[3], David Applegate[2], [1]Califronia Institute of Technology, Pasadena, CA, [2]Google, New York, NY, [3]University of Chicago Booth School of Business, Chicago, IL, Contact: mateodd@caltech.edu

We consider the problem of detecting infeasibility of large-scale linear programming problems using the primal-dual hybrid gradient method (PDHG). The literature on PDHG has mostly focused on settings where the problem is feasible. When the problem has no solution, the iterates of the algorithm do not converge. In this scenario, we show that the iterates diverge at a controlled rate towards a well-defined ray. The direction of this ray is known as the infimal displacement vector. We show that this vector recovers certificates of infeasibility whenever they exist and propose a simple way to extract certificates from sequences generated by the iterates of PDHG. Further, we establish tight convergence rates that apply to any fixed-point iteration of a nonexpansive operator.

3 Grand: A Gradient Related Ascent and Descent Algorithmic Framework for Minimax Problems with Distributed Applications

Xiaochun Niu[1], Ermin Wei[2], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: xiaochunniu2024@u.northwestern.edu

Many distributed and centralized optimization problems can be formulated as minimax problems. This work proposes GRAND as a gradient related ascent and descent algorithm for solving minimax problems, which covers gradient-type, Newton-type, and other general descent ascent methods as special cases. GRAND also motivates the design of hybrid methods to utilize the system heterogeneity for a distributed setting, such as consensus optimization and network flow problems. We present a theoretical analysis of GRAND. Specially, we show global sublinear and linear rates on strongly-convex-nonconcave and strongly-convex-PL problems, respectively. We also discuss Newton related methods and their local higher-order rate. Finally, we conduct numerical experiments on both synthetic and real-life data. GRAND is the first generalized framework with provable guarantees.

4 Faster First-order Primal-dual Methods for Linear Programming Using Restarts and Sharpness

Oliver Hinder, University of Pittsburgh, Pittsburgh, PA

First-order primal-dual methods are often slow at finding high accuracy solutions, which creates a barrier to their use for linear programming (LP). Our work exploits the sharpness of primal-dual formulations of LP instances to achieve linear convergence using restarts in a general setting that applies to ADMM (alternating direction method of multipliers), PDHG (primal-dual hybrid gradient method) and EGM (extragradient method). In the special case of PDHG, without restarts we show a lower bound of $\Omega(\square^2 \log(1/\square))$, while with restarts we show an upper bound of $O(\square \log(1/\square))$, where $\square$ is a condition number and $\square$ is the desired accuracy. We develop an adaptive restart scheme and verify that restarts significantly improve the ability of PDHG to find high accuracy solutions to LP problems.

Tuesday, 12:30 PM–1:45 PM

TC41

CC - Room 203

Learning and Optimization

Contributed Session

Session Chair

Khalid Y. Aram, Emporia State University, Emporia, KS

1 Careful Training Relevance is Real

Chenbo Shi[1], Mohsen Emadikhiav[2], Leonardo Lozano[3], David Bergman[1], [1]University of Connecticut, Storrs, CT, [2]Florida Atlantic University, Boca Raton, CT, [3]University of Cincinnati, Cincinnati, OH, Contact: stan@uconn.edu

There is a recent proliferation of research on the integration of machine learning and optimization. One area within this research stream is predictive-model embedded optimization, which uses pre-trained predictive models for the objective function so that features of the predictive models become decision variables in the optimization problem. Despite a recent surge in publications in this area, one aspect of this decision-making pipeline that has been largely overlooked is training relevance, i.e., ensuring that solutions to the optimization problem should be similar to the data used to train the predictive models. In this paper, we propose constraints designed to enforce training relevance, and show through a collection of experimental results that adding the suggested constraints significantly improves the quality of solutions obtained.

2 Hessian-vector Products Evaluation Using Second Order Adjoint Method in Neural Ode

Atsuhiro Hada, Satoru Iwasaki, Osaka university, Osaka, Japan. Contact: atsuhiro.hada@ist.osaka-u.ac.jp
Neural ODE is one of the neural net models and its intermediate layer is replaced by ordinary differential equations.The learning of Neural ODE can be formulated as a nonlinear optimization problem with ordinary differential equation constraints and this problem can be solved efficiently by using adjoint method, which is developed in the field of data assimilation and optimal control. In this study, we propose a procedure to efficiently compute the Hessian-Vector products in Neural ODEs by using the second order adjoint method, which is an extension of the adjoint method. The algorithm for obtaining the Hessian-Vector Products is expected to have applications such as second order optimization and uncertainty quantification of prediction by evaluating the posterior probability distribution.

3 Dynamic Bandits with Temporal Structure

Djallel Bouneffouf[1], Qinyi Chen[2], Negin Golrezaei[3], [1]IBM, New York, NY, [2]MIT, Cambridge, MA, [3]Massachusetts Institute of Technology, Lexington, MA, Contact: djallel.bouneffouf@ibm.com
Multi-armed bandit are mainly studied under two extreme settings known as stochastic and adversarial. The two aforementioned settings, however, does not capture realistic environments such as search engines and marketing and advertising, in which rewards stochastically change in time. Motivated by that, we introduce and study dynamic MAB with stochastic temporal structures. In this problem, the expected reward of each arm follows an auto-regressive (AR) model that governs the temporal structure of the rewards. Due to the dynamic nature of the rewards, simple "explore and commit" policies fail, as all arms have to get explored continuously over time. We formalize this by characterizing a per-round regret lower bound, where the regret is measured against a strong benchmark. We then present an algorithm whose per-round regret almost matches the regret lower bound.

4 Cost-sensitive Embedded Feature Selection Models for SVM

Khalid Y. Aram[1], Sarah S. Lam[2], Mohammad T. Khasawneh[2], [1]Emporia State University, Emporia, KS, [2]Binghamton University, Binghamton, NY
The models in this research were designed to select relevant, independent features for Support Vector Machines (SVM) in a cost-sensitive manner. Cost sensitivity of classification models is effective when the cost of error varies by error type. This research introduces Knapsack Max-Margin Feature Selection (KS-MMFS), an SVM-based filter method. KS-MMFS was then expanded resulting in two SVM embedded feature selection models: an efficient linear programming model and a mixed-integer linear programming model. The models offer two different ways of imposing cost sensitivity on SVM classifiers. Experimental analysis showed that different cost sensitivity requirements influence the features needed to perform SVM classification.

Tuesday, 12:30 PM–1:45 PM

TC42

CC - Room 204
Fairness in Sequential Decision Making
General Session

Session Chair
Siddhartha Banerjee, Cornell University, Ithaca, NY

Session Chair
Sean Sinclair, Cornell University, Ithaca, NY

1 Ranked Prioritization of Groups in Combinatorial Bandit Allocation

Lily Xu, Harvard University, Cambridge, MA
Preventing poaching through ranger patrols protects endangered wildlife, improving biodiversity outcomes globally. Combinatorial bandits have been used to allocate limited patrol resources, but existing approaches overlook that each location is home to multiple species in varying proportions, so a patrol benefits each species to differing degrees. When some species are more vulnerable, we ought to offer more protection to these animals. To bridge this gap, we propose a novel "ranked prioritization" objective that trades off reward maximization and species prioritization. We show this objective can be expressed as a weighted linear sum and provide RankedCUCB, an algorithm which we show achieves theoretical no-regret and empirical 38% improvement in outcomes for endangered species.

2 Proportionally Fair Online Allocation of Public Goods

Siddhartha Banerjee[1], Vasilis Gkatzelis[2], Safwan Hossain[3], Billy Jin[1], Evi Micha[3], Nisarg Shah[3], [1]Cornell University, Ithaca, NY, [2]Drexel University, Drexel, PA, [3]University of Toronto, Toronto, ON, Canada. Contact: emicha@cs.toronto.edu
We study the problem of designing online algorithms for the fair allocation of public goods to ; agents, over a sequence of ; rounds. In each round ; a new public good becomes available and each agent's value for this good is revealed to the algorithm, which needs to make an

irrevocable decision regarding how much to invest in this good, without knowing the agents' values for the public goods to arrive in future rounds. Each agent receives a fraction of each good that is proportional to that investment. The problem becomes interesting when the algorithm is bound to invest no more than a total budget of ;, across all rounds. We study proportional fairness as our notion of fairness, which informally demands that each group of agents receive treatment proportionate to its size and the cohesiveness of its preferences.

3 Fairness of Exposure in Stochastic Bandits

Luke Wang, Cornell University, Ithaca, NY, Contact: lw633@cornell.edu

Contextual bandit algorithms have become widely used for recommendation in online systems, where they now wield substantial influence on which items get exposed to the users. This raises questions of fairness to the items. We argue that the conventional bandit formulation can lead to an unfair winner-takes-all allocation of exposure. To remedy this problem, we propose a bandit objective that guarantees merit-based fairness of exposure to the items while optimizing utility to the users. We formulate fairness regret and reward regret in this setting, and present algorithms for both stochastic multi-armed bandits and stochastic linear bandits. We prove that the algorithms achieve sub-linear fairness and reward regret. Beyond the theoretical analysis, we also provide empirical evidence that these algorithms can fairly allocate exposure to different arms effectively.

4 The Algorithmic Landscape of Priority-respecting Allocations

Matthew Eichhorn[1], Siddhartha Banerjee[1], David Kempe[2], [1]Cornell University, Ithaca, NY, [2]University of Southern California, Los Angeles, CA, Contact: mae226@cornell.edu

In applications from rationing medical care to university admissions, the decision of who is allocated is justified by various normative criteria. Such settings motivate the following priority-respecting allocation problem: several categories wish to allocate their quota of interchangeable items to a set of agents. The goal is to find a Pareto efficient allocation that respects quotas and adheres to eligibility and priority requirements stipulated by the categories. We exhibit a bijection between such allocations and maximum-weight matchings under carefully chosen weights. This clean characterization recovers known results in this space and demonstrates that the problem straddles a fine line of computational efficiency. Some extensions of priority-respecting allocation are handled by specializations of our algorithm, while related extensions are NP-hard.

Tuesday, 12:30 PM–1:45 PM

TC44

CC - Room 206

Recent Algorithmic Advances in Integer Programming

General Session

Session Chair

Manish Bansal, Virginia Tech., Blacksburg, VA

1 Developments for Integrated Serial Supply Chain Systems with Multi-mode Transportation

Kartik Kulkarni[1], Manish Bansal[2], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech., Blacksburg, VA, Contact: kartikrf@vt.edu

In this talk, we present our recent advances on solving integrated multi-period supply chain systems where inbound transportation and inventory decisions are made at multiple levels of the supply chain. Moreover, the total transportation capacity in each time period is a summation of binary multiples of the capacities of the several available modes.

2 Approximation Algorithms for Some Capacitated Assignment Problems with Budget Constraints and Their Applications in Transportation Systems

Hongyi Jiang, Samitha Samaranayake, Cornell University, Ithaca, NY, Contact: hj348@cornell.edu

We study the following capacitated assignment problem under a budget constraint. Assume there are L bins and P items. Bin l has a utilization cost c_l and an n_l-dimensional capacity vector. Item p has an n_l-dimensional binary weight vector r_{lp} with consecutive 1s when assigned to bin l. Assigning item p to bin l yields a reward v_{lp} and a cost c_{lp}. The objective is to maximize the total rewards by designing an assignment such that (i) no bin's capacity is violated by the weights of assigned items; (ii) item p can be assigned to at most ?$_p$ utilized bins and at most once for each bin; (iii) the overall costs do not exceed the budget B.

We present two randomized rounding algorithms and a hardness result. We also extend our results to the cases with two-dimensional costs and budgets. Finally we show how to apply our framework onto three problems related to transportation.

3 Relay Logistics: A Multi-variable Generation Approach

Alexandre Jacquillat[1], Alexandria Schmid[2], Kai Wang[3], [1]MIT Sloan School of Management, Cambridge, MA, [2]MIT, Somerville, MA, [3]Carnegie Mellon University's Heinz College, Pittsburgh, PA, Contact: alexjacq@mit.edu

Motivated by relay-based logistics (in which each shipment is decomposed into short segments traveled by separate drivers), this paper formulates a Relay Pickup-and-Delivery Problem (RPDP) as an integer program across coupled time-space networks. It develops a multi-variable generation algorithm that iterates between a sparse master problem (which fixes some variables to zero) and a multi-variable generation subproblem (which seeks a deviation of negative reduced cost within a relaxed and projected polyhedron). Embedded into branch-and-price framework, the algorithm converges finitely to an optimal solution. Using real-world data, results show that it significantly outperforms benchmarks and can provide win-win outcomes in relay logistics: better driver lifestyles, better customer service, lower operating costs, and a smaller environmental footprint.

4 Combinatorial Optimization Under Uncertainty

Rudy Zhou, Carnegie Mellon University, Pittsburgh, PA, Contact: rbz@andrew.cmu.edu

In this talk, we present new directions for handling uncertainty in combinatorial optimization problems. This includes models where the input arrives online or we only have stochastic information about the input. We develop new data-driven techniques leading to improved approximation algorithms for fundamental problems in these settings.

Tuesday, 12:30 PM–1:45 PM

TC45

CC - Room 207

Recent Advances of First-order Methods with Data Science Applications

General Session

Session Chair

Renbo Zhao, Massachusetts Institute of Technology, Cambridge, MA

1 Efficient and Optimal Online Portfolio Selection

Dmitrii Ostrovskii[1], Rémi Jézéquel[2], Pierre Gaillard[3], [1]University of Southern California, Los Angeles, CA, [2]INRIA Paris, Paris, France; [3]INRIA Grenoble, Grenoble, France. Contact: dostrovs@usc.edu

In the problem of online portfolio selection as formulated by Cover (1991), a trader repeatedly allocates her capital over d assets in each of T rounds, with the goal of maximizing the total earnings. Cover proposed an algorithm, termed Universal Portfolios that achieves an O(d\log(t)) regret for the logarithmic loss; this guarantee is known to be worst-case optimal, and no other algorithm attaining it has ever been discovered. Unfortunately, Cover's algorithm crucially relies on computing some d-dimensional integrals; this results in a prohibitive O(d^4 (T+d)^{14}) per-round runtime for the fastest known implementation due to Kalai and Vempala (2002). We propose an algorithm for online portfolio selection that matches the regret guarantee for Universal Portfolios, yet has a dramatically reduced runtime of O(d^2 T + d^3) per round.

2 Analysis of The Frank-wolfe Method for Convex Composite Optimization Involving a Logarithmically-homogeneous Barrier

Renbo Zhao, Robert Michael Freund, Massachusetts Institute of Technology, Cambridge, MA

We present and analyze a new generalized Frank-Wolfe method for the composite optimization problem min_x f(Ax)+h(x), where f is a ⍰-log-homogeneous self-concordant barrier, A is a linear operator and h has a bounded domain but is possibly non-smooth. We show that our generalized Frank-Wolfe method requires O((⍰_0+⍰+R_h) ln(⍰_0)+(⍰+R_h)^2/⍰) iterations to produce an ⍰-approximate solution, where ⍰_0 denotes the initial optimality gap and R_h is the variation of h on its domain. This result establishes certain intrinsic connections between ⍰-log-homogeneous barriers and the Frank-Wolfe method. When specialized to the D-optimal design problem, we essentially recover the complexity obtained by Khachiyan. We present computational experiments that point to the potential usefulness of our method on Poisson image de-blurring problems with TV regularization.

3 AN Õ(1/⍰) FIRST-ORDER METHOd for MARGIN MAXIMIZATIOn of THE INTERSECTIOn of CONVEX CONES

Song Zhou, Cornell University, Ithaca, NY

We revisit the notion of maximal-margin classifiers, from around 2000, but now from a general perspective - the intersections of general closed convex cones, not just half-spaces (i.e., the perceptron). This requires extending concepts and establishing more general theories, but even more interesting, we lead to the first Õ(1/⍰) first-order method for approximating, with relative error ⍰, the margin-maximizer of the intersection cone. Previous results, only in the case of the perceptron, were O(1/⍰^{2}), making our result a notable improvement even in the most basic of cases.

4 Federated Learning on Adaptively Weighted Nodes by Bilevel Optimization

Yankun Huang[1], Qihang Lin[1], Nick Street[1], Stephen Baek[2], [1]University of Iowa, Iowa City, IA, [2]University of Virginia, Charlottesville, VA, Contact: yankun-huang@uiowa.edu

We propose a federated learning method with weighted nodes in which the weights can be modified to optimize the model's performance on a separate validation set. The problem is formulated as a bilevel optimization where the inner problem is a federated learning problem with weighted nodes and the outer problem focuses on optimizing the weights based on the validation performance of the model returned from the inner problem. A communication-efficient federated optimization algorithm is designed to solve this bilevel optimization problem. Under an error-bound assumption, we analyze the generalization performance of the output model and identify scenarios when our method is superior to training a model only locally and to federated learning with static and evenly distributed weights.

Session Chair

Lijun Ding, University of Washington, Seattle, WA

Tuesday, 12:30 PM–1:45 PM

TC46

CC - Room 208

Transportation Network Modeling and Optimization in a Smart and Connected Environment

General Session

Session Chair

Abdul Aziz Husain, 1</sup

1 Analytical Characterization of Multi-state Effective Discharge Rates for Bus-only Lane Conversion Scheduling Problem

XianBiao Hu, Penn State University, University Park, PA, Contact: xbhu@psu.edu

An accurate quantification of traffic flow characteristics with and without bus-only lane is important for determining transit priority strategies. Examinations of real-world vehicle trajectory data, like those from the NGSIM dataset, found that an effective discharge rate may be discounted when merging or lane-changing behaviors are observed. To deal with this, we analytically derives the effective discharge rate of a roadway segment by considering multi-stage merging behavior and vehicular traffic kinematics near a side entrance, for optimal bus-only lane conversion. The classic fluid-based approximation model by Newell that characterizes the queuing and dissipation process is extended to a multi-state queuing analysis framework. The derived effective discharge rates are represented by mathematically-simple expressions in a closed-form

2 AI APPROACHEs for CONGESTION CONTROl in ROAD TRANSPORTATION NETWORK

Arif Khan[1], Arun Sathanur[2], Ashutosh Dutta[1], Milan Jain[1], [1]Pacific Northwest National Laboratory, RICHLAND, WA, [2]Pacific Northwest National Laboratory, Seattle, WA

We investigate the efficacy of various Deep Reinforcement Learning (DRL) based AI algorithms in reducing traffic congestion on multi-lane freeways. We focus on adaptive detouring strategies so that a portion of the freeway lanes along with the arterials in proximity are utilized in an optimal manner to reduce the resulting congestion and improve the speeds in the event of an accident. The test network is a 2.6-mile-long 4-lane freeway stretch in Shoreline, Washington, USA with two exits and associated arterial roads. We demonstrate the usefulness of the DRL-based controllers in reducing the congestion by showing a 21% improvement in the average speed compared to no action. We then explain how the learning accomplished by the DRL agent and the trade-offs discovered automatically, are consistent with the first principles of traffic theory.

3 Optimal Location and Sizing of Layover Charging Stations for Electric Buses

Dan McCabe, Xuegang Ban, University of Washington, Seattle, WA, Contact: dmccabe@uw.edu

Many transit agencies transitioning from conventionally fueled vehicles to battery-electric buses (BEBs) plan to charge buses between trips during the service day, a strategy known as layover charging. In this work, we develop a mixed-integer linear programming model called BEB-OCL (BEB Optimal Charging Location) to optimize the locations of layover charging stations, the number of charging ports at each station, and the scheduling of charger visits for each bus in the system. We demonstrate the model's effectiveness with a case study of the South King County, WA transit network as well as a sensitivity analysis on a simple notional transit network.

4 Cooperative Traffic Signal and Ramp Metering Control in a Fully Connected Corridor Network

Ali Hajbabaie, Abdullah Farabi, Rasool Mohebifard, Ramin Niroumand, North Carolina State University, Raleigh, NC

This study develops a mixed-integer non-linear program to jointly optimize the intersection signal timing plans and ramp metering decisions over a signalized corridor within a fully connected environment. The Cell Transmission Model network loading concept is used to model the dynamics of vehicles. The objective function of this model is designed to maximize the network throughput with decision variables of intersection signal states and ramp metering rates. Four scenarios are designed to test the performance of each component of the proposed methodology, namely no optimization (existing condition), metering rate optimization, signal timing optimization, and integrated signal timing and metering rate optimization.

Tuesday, 12:30 PM–1:45 PM

TC47

CC - Room 209

TSL Best Dissertation Award Session

Award Session

Session Chair

Chrysanthos E. Gounaris, Carnegie Mellon University, Pittsburgh, PA

Session Chair

Jan Fabian Ehmke, University of Vienna, Wien, Austria.

TSL Dissertation Award Presentation

Award Presenter, IN

The winner of the TSL Dissertation Award will present their thesis. The winner will be announced at the TSL Business Meeting. More details on the award can be found here: https://connect.informs.org/tsl/awards/dissertation-appilcation

TSL Dissertation Award Presentation

Award Presenter, IN

The winner of the TSL Dissertation Award will present their thesis. The winner will be announced at the TSL Business Meeting. More details on the award can be found here: https://connect.informs.org/tsl/awards/dissertation-appilcation

Tuesday, 12:30 PM–1:45 PM

TC48

CC - Room 210

Autonomous Vehicles and Driving

Contributed Session

Session Chair

Ehsan Kamjoo, Michigan State University, East Lansing, MI

1 Incentive-based Decentralized Routing for Mixed Traffic Flow

Chaojie Wang[1], Srinivas Peeta[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: chaojie.wang@gatech.edu

Human drivers and autonomous vehicles react differently towards behavioral interventions, and there is a lack of effective and efficient incentive mechanisms for collaborative routing in a mixed-traffic environment. To address the gap, this study proposes an incentive-based routing strategy, which leverages the heterogeneity in individual preferences to enhance system performance. The problem is formulated as a consensus optimization model, and a decentralized algorithm is developed to mitigate the computational burden and protect user privacy, thereby enabling the proposed routing strategy to be deployable in real-time.

2 Modeling and Simulation of Vehicle Dynamics and Information Propagation in a Connected Autonomous Vehicle Environment

Yangjiao Chen, Srinivas Peeta, Georgia Institute of Technology, Atlanta, GA, Contact: ychen3254@gatech.edu

Wireless communication technologies enable connected and autonomous vehicles to provide new paradigms for traffic efficiency improvement. While traffic flow dynmaics and V2V communication constraints influence the multi-hop information propagation, the propagation of information would also generate new traffic flow dynamics. This study explores information propagation characteristics in space and time as a result of this interactive process. The effects of optimal cooperative driving strategies on traffic capacity and stability performance are explored under different traffic conditions.

3 Impact of String Stability on Human Drivers' Car-following Behavior: A Driving Simulator Study

Anye Zhou, Srinivas Peeta, Georgia Institute of Technology, Atlanta, GA

String stability is an important feature of adaptive cruise control (ACC) as it alleviates traffic congestion. However, human drivers' car-following (CF) behavior in response to string stable/unstable (SS/SU) ACCs in mixed-flow traffic is not well-understood. This study uses a driving simulator environment to explore the characteristics of human drivers' CF behavior and its evolution when following SS/SU ACCs in traffic congestion. Results suggest that SS ACC may induce more speed fluctuations and distractive driving from human drivers in traffic congestion. In addition, human drivers prefer to follow vehicles with similar CF behavior as themselves.

4 Optimizing The Placement of Dedicated Lanes for Autonomous Vehicles at Large-scale Transportation Networks

Ehsan Kamjoo[1], Fatemeh Fakhrmoosavi[2], Alireza Rostami[3], Ali Zockaie[1], [1]Michigan State University, East Lansing, MI, [2]University of Connecticut, Mansfield, CT, [3]Michigan State University, East Lansing, MI, Contact: kamjooeh@msu.edu

Autonomous Vehicle (AV) dedicated lanes are introduced as an effective strategy to improve mobility in mixed traffic of AVs and heterogeneous drivers. Previous studies focused on optimal deployment of these lanes over small hypothetical networks which are not applicable to realistic networks due to computational complexity and not being able to realize traffic dynamics of mixed traffic. Thus, this study aims to introduce an efficient framework for finding optimal locations for implementing AV dedicated lanes to maximize their benefits at large-scale networks under different demand and AV Market Penetration Rate scenarios while considering their infrastructure cost. This framework is applied to network of Chicago and impacts of these factors on optimal locations of AV dedicated lanes and system benefit are explored, providing practical insights for policymakers.

Tuesday, 12:30 PM–1:45 PM

TC50

CC - Room 212

eBusiness Flash Session

Flash Session

Session Chair

Bryon Balint, Belmont University, Nashville, TN

1 Investigating The Coordination of Functionality Richness, First-party Content Quality, and Revenue-sharing on Digital Platforms

Zenan Chen[1], Soumya Sen[2], [1]University of Minnesota-Twin Cities, Minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, Contact: chen6029@umn.edu

On many digital platforms, first-party and third-party content providers co-create content for a bundle, where the total bundle revenue is shared between the two parties. As platform functionality-richness influences the content production costs of content providers, it also affects the platform's strategies such as revenue-sharing, first-party content quality, and bundle price. We introduce a holistic model that jointly accounts for platform functionality level, cost asymmetries, and revenue-sharing between first- and third-party content providers. Doing so allows us to uncover new insights.

2 Promote Data Products Selling: A Field Experiment with Different User Proactive Education Strategies

Feiteng Huang, University of Houston, Houston, TX, Contact: fhuang4@cougarnet.uh.edu

Many companies emerge to collect and offer diverse kinds of data products to users. To effectively improve users' motivation to use data product, we conduct a randomized field experiment with three different treatment strategies. Compared with the control group, the data product usage in the three treatment groups is significantly higher.

3 Ai Patents, Firm Growth, and Employment Changes

Jinsoo Yeo, Emory University, Atlanta, GA

Based on United States Patent and Trademark Office Artificial Intelligence Patent Dataset, we propose a new firm level AI Exposure index across 8 distinctive separate patent applications. We connect the firm level AI Exposure index to job postings data to assess the relationship between investment in AI (e.g., patent invention or patent acquisition) and growth in sales and employment.

4 An Empirical Investigation of Sales Cheating Effect in E-Commerce

Le Wang[1], Jiahui Mo[2], Beibei Li[3], [1]City University of Hongkong, Hongkong, China; [2]Clemson University, Clemson, SC, [3]Carnegie Mellon University, Pittsburgh, PA, Contact: jiahuim@clemson.edu

Sales volume is one of the major information sources for decision-making in online purchasing. Yet the credibility of this information is fundamentally undermined when businesses commit sales cheating by creating fake sales volume using fictitious transactions. We empirically investigate the effect of sales cheating on products using a dataset from a popular e-commerce website in China. Our empirical findings provide important contributions to the literature on e-commerce and offer critical managerial implications to online retailers, e-commerce platforms, and consumers.

5 How Social Information Intensity Shapes Preventive Behavior in The Context of Covid-19?

Jingbo Hou[1], Chen Liang[2], Pei-yu Chen[1], [1]Arizona State University, Tempe, AZ, [2]University of Connecticut, Storrs, CT, Contact: jhou27@asu.edu

By connecting people across the globe, social technologies enable people to share information instantaneously and experience "in the moment" events virtually. In the context of COVID-19, sharing localized disaster information allows socially connected friends in other non/low affected areas to learn and virtually feel the "disaster", which in turn can increase their awareness and enhance their preventive behavior, even when they do not face immediate risk. The goal of this paper is to investigate if and to what extent social connectedness influences people's preventive behavior, while controlling for physical connectivity.

6 Learning The Ranking of Causal Effects with Confounded Data

Carlos Fernandez-Loria[1], Jorge Loria[2], [1]Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong; [2]Purdue University, West Lafayette, IN, Contact: loria@purdue.edu

Decision-makers often want to identify the individuals for whom some treatment will be most effective, such as when deciding whom to target with advertising. Therefore, the decision-maker would like to rank potential targets by their individual treatment effects. Unfortunately, historical data used to estimate causal effects often consists of observations that have been treated non-randomly, so treatment effects cannot be unbiasedly estimated (UE) from the historical data. We propose a framework for this type of settings that defines a set of conditions in which the ranking of the individual effects can be estimated from the historical data, even if the effects themselves cannot be UE. We provide some conditions where the selection bias in the treatment assignment improves the ranking estimation, in comparison to a smaller data set where effects can be UE.

7 Optimal Strategies and Product Attributes in Online Pay-per-bid Auctions

Bryon Balint, Belmont University, Nashville, TN, Contact: bryon.balint@belmont.edu

Pay-per-bid auction sites combine elements of electronic retail, online auctions, and gaming. As such, they have served as a fertile ground for research in decision making and behavioral economics In this study, we focus specifically on the characteristics of the products being sold on these sites. By analyzing data collected from four pay-per-bid auction sites, we show that price and other experience attributes affect bidding strategies and engagement. In addition, we find that features of the auction site such as statistics and product reviews moderate these effects. Our results indicate that auction designers should account for experience attributes when designing auctions in order to maximize revenue and engagement.

Tuesday, 12:30 PM–1:45 PM

TC51

M - Santa Fe

Assessing Technologies and Strategies for Transitioning to Climate-benign Energy Systems

General Session

Session Chair

Jeffrey Bielicki, Ohio State University, Columbus, OH

Session Chair

Daniel Gingerich, The Ohio State University

1 Pathways to Net-Zero Emissions and Carbon Removal at a State Scale

Andres Clarens, University of Virginia, Charlottesville, VA

Net-zero emissions targets are an increasingly popular instrument for organizing decarbonization efforts for subnational governments. Using GCAM-USA, we model how states might reach net-zero emissions by 2050 balancing decarbonization of positive emissions and the need for negative emissions technologies (NETs). Reliance on NETs is significant in these scenarios and deployed unevenly across the country. A number of US states have the potential to be net exporters of negative emissions while others will need to import this capacity. Many states either lack the resources to deploy NETs at suitable scales or have positive emissions that overwhelm the capacity to offset them.

2 Pricing Carbon Emissions Reduces Health Inequities from Air Pollution Exposure

Wei Peng, Xinyuan Huang, Penn State University, PA

Climate mitigation can bring health co-benefits by improving air quality. Yet, whether mitigation will widen or narrow current health disparities remains unclear. Here we use a coupled climate-energy-health model to assess the effects of a global carbon price on the distribution of ambient $PM_{2.5}$ exposure and associated health risks. Across a large ensemble of future scenarios, we find that pricing carbon consistently lowers the $PM_{2.5}$-attributable death rates in lower-income countries by reducing fossil fuel burning. However, the health effects in higher-income countries are more complex because pricing carbon could also increase the pollution from bioenergy use and land-use changes.

3 Pathways of Methane Control to Address Climate Change

Qingrun Yang, The Ohio State University, Columbus, OH, Contact: yang.5684@osu.edu

Methane (CH_4) is at present the second highest contributor to the radiative forcing that is driving climate change; it has a higher radiative efficiency, faster rate of increase in the atmosphere, and more prominent temperature-driven positive feedback than carbon dioxide (CO_2). Despite early actions to mitigate CH_4 emissions, a portfolio ofapproaches is urgently needed for CH_4 control. This talk presents a climate model on relationship among CO_2 and CH_4 emissions, concentrations, radiative forcing, and temperature, where a positive feedback uniquely exists between temperature and natural CH_4 emissions. With different scenarios to simulate future uncertainties, this model can help determine when and how we need to implement CH_4 control.

4 Life cycle assessment of the hydrogen supply chain for energy and agriculture in the Appalachian region

Diego Hincapie-Ossa, The Ohio State University

Hydrogen is an energy carrier that can be sourced from many raw materials, converted into many products, and used in many applications. In this work, we assess the environmental performance of two possible emerging hydrogen products: hydrogen fuel and ammonia fertilizer precursor. We studied the impacts of their production in the Appalachian region of the United States and we identified trade-offs and synergies in the development paths for the two selected products.

Tuesday, 12:30 PM–1:45 PM

TC52

M - Lincoln

Scheduling III

General Session

Session Chair

Marc E. E. Posner, The Ohio State University, Columbus, OH

1 A Combinatorial Auction Mechanism for Large Scale Scheduling Problems

Omar Abbaas[1], Jose Antonio Ventura[2], Sara Abu Aridah[1], Marta Ventura[3], [1]The Pennsylvania State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, [3]The Pennsylvania State University, University Park, PA, Contact: oxa95@psu.edu

Auctions are efficient in communicating valuations of items between different entities. Combinatorial auctions allow bidders to create packages and assign them values considering the complementarities between the items within a package. Therefore, combinatorial auctions allow bidders to share useful information about their items' valuations and allow for efficient items allocation. In this study we use an iterative combinatorial auction mechanism to coordinate the scheduling process of a set of available jobs on a set of machines in a manufacturing plant. Jobs are considered as bidders competing for available resources. Machines share their available capacities. The objective is to maximize the total manufacturer's profit.

2 Decomposition Algorithm for Parallel Machine Scheduling Problem Under Uncertain Sequence Dependent Setups

Zhengyang Fan[1], Ran Ji[2], [1]George Mason University, Fairfax, VA, [2]George Mason University, Fairfax, VA, Contact: rji2@gmu.edu

We study the parallel machine scheduling problem under uncertainties in job processing and sequence-dependent setup time. We propose a modified integer L-shaped method with optimality cuts strengthened via sequential lifting procedure. We then extend the decomposition solution framework to the distributionally robust setting under Wasserstein ambiguity. We carry out a series of numerical experiments to illustrate the effectiveness of the proposed decomposition method.

3 The Median Routing Problem for Simultaneous Planning of Emergency Response and Non-emergency Jobs

Robert van der Mei[1], Dylan Huizing[2], Sandjai Bhulai[3], Guido Schaefer[2], [1]CWI, Amsterdam, Netherlands; [2]CWI, Amsterdam, Netherlands; [3]Vrije Universiteit Amsterdam, Amsterdam, Netherlands. Contact: mei@cwi.nl

We study a setting where emergency responders must also perform a set of known, non-emergency jobs in the network when there are no active emergencies going on. These jobs are typically preventive, and allow the responders to use their idle time. When an emergency occurs, the nearest responder must abandon whatever job he is doing and go to the emergency. This leads to the optimization problem of timetabling jobs and moving responders over a discrete network such that the expected emergency response time remains minimal. Our model, the Median Routing Problem, addresses this complex problem by minimizing the expected response time to the next emergency and allowing for re-solving after this. We describe an MILP and several fast heuristics. Our results show great performance for real-life use cases, and are currently being deployed operationally in the Netherlands.

4 Job Scheduling for Maximum Revenue on Uniform, Parallel Machines with Major and Minor Setups and Job Splitting

Geoffrey Bryan Ang Chua[1,2], Ashwin Ravindran[3,2], Juan Ramon L. Senga[2], S. Viswanathan[1,2], [1]Nanyang Technological University, Singapore, Singapore; [2]HP-NTU Digital Manufacturing Corporate Laboratory, Singapore, Singapore; [3]Hewlett-Packard, Singapore, Singapore. Contact: juanramon.senga@ntu.edu.sg

We consider a revenue maximization scheduling problem where jobs can be split on parallel, uniform machines. By assuming that only major and minor setups exist between jobs and that these can be grouped together, we reformulate the scheduling problem as a continuous knapsack problem with setup time. We then create a semi-greedy algorithm called the *Revenue Rate Algorithm* that solves the maximum revenue scheduling problem. This makes use of a *revenue rate* - the ratio between total revenue that can be obtained from a job and the time required to achieve the revenue. The Revenue Rate Algorithm schedules the job with the highest revenue rate first and updates all the revenue rates based on existing scheduled families and remaining capacity. Numerical studies show that the Revenue Rate Algorithm performs well with an average optimality gap of 3.47% across a large set of parameters.

Tuesday, 12:30 PM–1:45 PM

TC53

M - Denver
FinTech and Finance
Contributed Session

Session Chair
Shubhi Asthana, IBM Research - Almaden, SAN JOSE, CA

1 Momentum Information Propagation Through Global Supply Chain Networks

Rei Yamamoto[1], Naoya KAWADAI[2], Hiroki Miyahara[3], [1]Keio University, Yokohama, Japan; [2]Sumitomo Mistui DS Asset Management, Tokyo, Japan; [3]FactSet Pacific Inc., Tokyo, Japan.

Customer momentum has been demonstrated to be effective in the US and Japanese stock markets but has not been examined using a large global supply chain network. In this presentation, we propose a new customer momentum strategy based on global supply chain network data combined with prior research. They apply (1) network theory, (2) medium-term momentum propagation, and (3) higher-layer customer information based on the characteristics of global supply chain network data. Empirical analysis in global stock markets confirms that the proposed strategy has a 4.5% annual return based on a long-short analysis. This strategy is more effective than standard momentum and customer momentum in previous studies.

2 College Tuition, Gas Price, Inflation, and Stock Return

Cynthia Shao, William Mason High School, Mason, OH, Contact: cynyu.shao@gmail.com

Inflation rate, the percentage change in a general consumer price index (CPI), is an important macroeconomic variable to predict stock return premium. Recently in the U.S., the inflation rate increases sharply. Unsurprisingly, the gas prices and college tuitions, as part of CPI, also increase rapidly. I first investigate the relationship between inflation and stock return. I then dissect CPI into energy index, education index, food index, and others and investigate their impact on stock return prediction, respectively. Besides inflation, I include some important predictors such as Stock Variance as in Goyal and Welch (2008). I first use conventional linear regression models and model averaging. Furthermore, I adopt state-of-the-art machine learning methods such as random forests, boosting trees, and deep learning neural networks to monthly S&P 500 index return data.

3 Finite Maturity Caps and Floors on Continuous Flows Under The Cev Process

Jose Carlos Dias[1], Joao Pedro Nunes[1], Fernando Silva[2], [1]ISCTE-IUL, Lisboa, Portugal; [2]ISCTE-IUL, Lisbon, Portugal. Contact: jose.carlos.dias@iscte.pt

This paper offers novel analytical solutions for evaluating perpetual caps and floors on continuous flows under the constant elasticity of variance (CEV) model. We demonstrate that the inclusion of a perpetual bubble value is required to avoid arbitrage opportunities in the case of the CEV process with upward-sloping volatility skews. We then extend the previous literature on caps and floors arrangements by providing new analytical formulae for valuing finite maturity caps and floors that are contingent on continuous flows. We discuss the impact of the finite-lived solutions on the optimal behavior of a firm relative to the perpetual case and compare the CEV results with the ones obtained when assuming a lognormal diffusion. Practical applications of these contractual agreements arising within the context of executive management decisions are also discussed.

4 Transformation of Order Management Service

Shubhi Asthana[1], bing zhang[2], Pawan Chowdhary[3], Taiga Nakamura[2], [1]IBM Research - Almaden, SAN JOSE, CA, [2]IBM, San Jose, CA, [3]IBM Research, San Jose, CA, Contact: sasthan@us.ibm.com

The transactions of goods and services between enterprise service providers are often driven by contracts and purchase orders. It requires considerable manual effort by the service provider to process and manage them. Moreover, the invoice's billed data may not be maintained in the same cloud system as the purchase orders. Sometimes the invoices may get into a dispute due to over exhaustion of allocated funds or billed to an expired purchase order. Hence managing the billing service is a huge undertaking along with increased cost.
To address these challenges, we developed a financial services-based order management framework that transforms the monitoring of financial purchase orders in order to increase their renewals as well as decreases disputes. We illustrate our approach with some promising results on data of one of the world's largest IT service providers.

Tuesday, 12:30 PM–1:45 PM

TC54

M - Marriott 1

Theoretical Foundations of Reinforcement Learning

General Session

Session Chair

Zaiwei Chen, Georgia Institute of Technology, Atlanta, GA

1 Target Network and Truncation Overcome The Deadly Triad in Q-learning

Zaiwei Chen, California Institute of Technology, Pasadena, CA, Contact: zchen458@gatech.edu

Q-learning with function approximation is one of the most empirically successful while theoretically mysterious reinforcement learning (RL) algorithms, and was identified in (Sutton, 1999) as one of the most important theoretical open problems in the RL community. Even in the basic linear function approximation setting, there are well-known divergent examples. In this work, we propose a stable design for Q-learning with linear function approximation using target network and truncation, and establish its finite-sample guarantees. Our result implies an $\Tilde{\mathcal{O}}(\epsilon^{-2})$ sample complexity up to a function approximation error. This is the first variant of Q-learning with linear function approximation that is provably stable without requiring strong assumptions or modifying the problem parameters, and achieves the optimal sample complexity.

2 On The Sample Complexity of Stabilizing Lti Systems on a Single Trajectory

Guannan Qu, Carnegie Mellon University, Pittsburgh, PA, Contact: gqu@andrew.cmu.edu

Stabilizing an unknown dynamical system is one of the central problems in control theory. In this paper, we study the sample complexity of the learn-to-stabilize problem in Linear Time-Invariant (LTI) systems on a single trajectory. Current state-of-the-art approaches require a sample complexity linear in n, the state dimension, which incurs a state norm that blows up exponentially in n. We propose a novel algorithm based on spectral decomposition that only needs to learn ``a small part'' of the dynamical matrix acting on its unstable subspace. We show that, under proper assumptions, our algorithm stabilizes an LTI system on a single trajectory with $\tilde{O}(k)$ samples, where k is the instability index of the system. This represents the first sub-linear sample complexity result for the stabilization of LTI systems under the regime when $k = o(n)$.

3 Settlingthe Sample Complexity of Model-based Offline Reinforcement Learning

Yuxin Chen, University of Pennsylvania, Princeton, NJ

This work is concerned with offline reinforcement learning (RL), which learns using pre-collected data without further exploration. Effective offline RL would be able to accommodate distribution shift and insufficient data coverage. However, prior algorithms either suffer from suboptimal sample complexities or incur high burn-in cost, thus posing an impediment to efficient RL in sample-starved applications. In this work, we demonstrate that the model-based (or ``plug-in'') approach achieves minimax-optimal sample optimality with minimal burn-in cost. Our algorithms are pessimistic variants of value iteration with Bernstein-style penalties, which do not rely on sophisticated schemes like variance reduction.

4 **Benign Overparameterization for Q-learning**

Anmol Kagrecha, Benjamin Van Roy, Stanford University, Stanford, CA, Contact: akagrecha@stanford.edu

Standard tabular Q-learning algorithm stores and updates one value per state-action pair. Recent work by Wan, Naik, and Sutton as well as recent work by Devraj, and Meyn, demonstrates that an overparameterized representation with a single additional parameter added to every state-action value can dramatically improve the rate of convergence. Given a suitable partition of state-action pairs, we demonstrate that adding additional parameters, each associated with a cell of the partition, further accelerates convergence.

Tuesday, 12:30 PM–1:45 PM

TC55

M - Marriott 2

Queueing Theory and Applications

General Session

Session Chair

Vahid Sarhangian, University of Toronto, Toronto, ON, Canada.

1 **Split Liver Transplantation: An Analytical Decision Support Model**

Yanhan (Savannah) Tang[1], Alan Scheller-Wolf[1], Sridhar R. Tayur[1], Emily R. Perito[2], John P. Roberts[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of California, San Francisco, San Francisco, CA, [3]University of California, San Francisco, San Francisco, CA, Contact: awolf@andrew.cmu.edu

Split liver transplantation (SLT) can potentially save two lives using one liver. To facilitate increased SLT usage, we formulate a multi-queue fluid model, incorporating size matching specifics, dynamic health conditions, transplant type, and fairness. We find the optimal organ allocation policy, and evaluate its performance versus other common allocations.

2 **Customer Scheduling in Large Service Systems Under Model Uncertainty**

Xu Sun[1], Hossein Abouee Mehrizi[2], [1]University of Florida, Gainesville, FL, [2]University of Waterloo, waterloo, ON, Canada.

When there are many servers and multiple customer classes, it is common practice to make simplifying assumptions, resulting in a "low-fidelity" model, hence potential model misspecification. We set forth a new approach for the decision maker to generate high-quality scheduling policies for large service systems such as call centers by relying on a simple and tractable low-fidelity model as opposed to its otherwise complex and intractable high-fidelity counterpart. At the core of this approach is a robust formulation in which the decision maker optimizes against an imaginary adversary. The adversary optimally exploits potential weaknesses in a scheduling rule by perturbing the low-fidelity model in a dynamic yet time-consistent fashion, assisting the decision maker in exploring the robustness of a candidate policy against possible model misspecification.

3 **Optimal Scheduling with Unknown Cost Parameters**

Xiaoshan Peng[1], Buyun Li[2], Owen Wu[1], [1]Indiana University, Bloomington, IN, [2]Kelley School of Business; Indiana University, Bloomington, IN, Contact: xp1@iu.edu

We consider a multi-class queueing system with no abandonments. The system manager decides which queue to service dynamically in order to maximize the expected total holding cost. With known cost parameters, the optimal schedule rule follows a cmu rule. We explore the case when the cost parameters are unknown and solve for the optimal schedule policy that balances the exploration and exploitation.

4 **Stochastic Approximation of Symmetric Nash Equilibria in Queueing Games**

Ran I. Snitkovsky[1], Liron Ravner[2], [1]Tel Aviv University, Tel Aviv - Jaffa, Israel; [2]University of Haifa, Haifa, Israel. Contact: ransnit@gmail.com

We suggest a novel stochastic approximation algorithm to compute a Symmetric Nash Equilibrium strategy in a general queueing game with a finite action space. The algorithm involves a single simulation of the queueing process with dynamic updating of the strategy at regeneration times. Under mild assumptions on utility function and on the regenerative structure of the queueing process, the algorithm converges to a symmetric equilibrium strategy almost surely. This yields a powerful tool that can be used to approximate equilibrium strategies in a broad range of strategic queueing models in which direct analysis is impracticable.

Tuesday, 12:30 PM–1:45 PM

TC56

M - Marriott 3

AI/OR: Research and Funding Opportunities

Panel Session

Session Chair
Cathy Honghui Xia, Ohio State University, Columbus, OH

Moderator

Theodore T. Allen, Ohio State University, Columbus, OH

Artificial intelligence (AI) has advanced tremendously in recent years due to breakthroughs in game playing, computer vision and natural language processing. AI is now at the stage to broaden its applications, with the potential to transform all sectors of the economy, including energy, health-care, manufacturing, security, supply chains, and transportation. This panel will discuss AI research and funding opportunities that are relevant to INFORMS communities, with particular emphasis on possible NSF programs that may embrace INFORMS research. The panelists will share recent success stories at NSF integrating OR with AI. Question-and-answer session will follow the presentation.

1 **Panelist**

Pascal Van Hentenryck, ISyE Georgia Tech, Atlanta, GA, Contact: pascal.vanhentenryck@isye.gatech.edu

2 **Panelist**

Ramayya Krishnan, Carnegie Mellon University, Pittsburgh, PA

3 **Panelist**

Dimitris Bertsimas, Massachusetts Institute of Technology, Cambridge, MA

4 **Panelist**

Sven Koenig, University of Southern California, Los Angeles, CA

UNREGISTERED **Panelist**

Guanghui Lan, ISyE Ga Tech, Atlanta, GA

Tuesday, 12:30 PM–1:45 PM

TC57

M - Marriott 4

Efficient Algorithms in Big Data Monitoring.

General Session

Session Chair
Ziqian Zheng, University of Wisconsin-Madison, Madison, WI

Session Chair
Kaibo Liu, University of Wisconsin-Madison, Madison, WI

1 **Detecting Objects in Vidoes by Tensor Decomposition**

Yinwei Zhang[1], Jian Liu[2], [1]university of arizona, Tucson, AZ, [2]University of Arizona, Tucson, AZ

Videos captured by the camera sensors often consist of a smooth, temporally varying background and a sparsely distributed object of interest. Existing methods analyze the video without considering the temporal patterns of the spatially distributed objects. The proposed method considers a video as a three-dimensional tensor and decomposes it into three layers, i.e., a background layer, an object layer, and a noise layer, each of which is regularized mathematically by considering the corresponding physical characteristics. An optimization algorithm is proposed to solve the regularization problem by considering the computational complexity. A case study is conducted to validate the proposed method.

2 **Aviation Event Hierarchical Embedding for Event Prediction and Risk Quantification**

Xinyu Zhao[1], Hao Yan[1], Yongming Liu[2], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Phoenix, AZ, Contact: xzhao119@asu.edu

Safety issue is always the primary concern of the aviation system. Typically, a final flight accident event is often caused by a sequence of failure events. This paper aims to study the relationship of the failure event sequence and evaluate the risk of the final accident according to these failure events. In this paper, the complex temporal correlation of the failure event sequence brings significant challenges in modeling the risk of the aircraft. Furthermore, the failure event taxonomy enables us to combine the different granular levels of information for event embedding learning, failure event prediction, and risk quantification. In this article, we proposed a hierarchical tree-based event embedding to reduce the dimensionality of the accident event. The learned embedding is then used for aviation failure event prediction and risk uncertainty quantification.

3 **Transfer Learning-based Independent Component Analysis**

Ziqian Zheng[1], Kaibo Liu[2], [1]University of Wisconsin-Madison, Madison, WI, [2]UW-Madison, Madison, WI, Contact: zzheng92@wisc.edu

Understanding the underlying component structure is crucial for multivariate signal analysis. Among all the techniques that try to learn the latent structure, independent component analysis (ICA) is one of the most important and popular methods, which aims to extract independent components from multivariate signals and enables further analysis. One critical challenge in existing ICA approaches is that the component extraction accuracy may degrade when the available data of a unit are limited. To address this issue, this paper proposes a transfer learning-based ICA method by innovatively transferring component distribution from a source domain, so that accurate component extraction results can be achieved even when only limited data are available in the target domain.

4 A Low Rank and Sparse Penalized Signal Decomposition Model with Constraints: Anomaly Detection in PV Systems

Yang Wei, Georgia Institute of Technology, Atlanta, GA

Recently, robust PCA has seen its wide application in various industries for its ability to perform the task of anomaly detection. The essence of robust PCA approach is to break down of the signal into a low rank component and a sparse component. However, such simple breakdown of the signal in many applications without considering the signs of low rank component and sparse component would violate the physical constraints of the decomposed signals. In addition, often times, the signals in real world collected are cyclostationary with evolving period and amplitude. The mean signals have smooth changes within a period and between periods. Neglecting these smoothness would result in miss detection of anomalous signals which are smooth within a period but non-smooth between periods and vice versa. In this paper, we developed a signal decomposition for the purpose of anomaly detection based on the idea of low rank and sparse decomposition taking into account the signs of the decomposed low rank and sparse components and the within-period and between-periods smooth changes in the mean signals. Using Monte Carlo simulations, we demonstrate the ability of our proposed approach for detecting anomalies with different duration and severities in photovoltaic (PV) system.

Tuesday, 12:30 PM–1:45 PM

TC58

M - Marriott 5

Looking for a Needle in a Haystack: Fine-grained Anomaly Detection in High Dimensional Data

General Session

Session Chair
Jianjun Shi, ISyE Georgia Tech, Atlanta, GA

Session Chair
Meng Cao, 1</sup

Session Chair
Shancong Mou, 1</sup

1 Change Detection for Dynamic High-dimensional Data with Incomplete Components and Uncommon Events

Meng Zhao, Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL

Statistical process control (SPC) techniques have been widely applied for process monitoring and anomaly detection in different applications, including transportation systems, healthcare, and manufacturing. The classical SPC methods for monitoring dynamic high-dimensional data usually ignore situations where the data is partially observed and contain uncommon observations. For example, when monitoring a sequence of dynamic networks with communities, the connection of two nodes from different communities is uncommon but natural. In another example, while the traffic data may follow its normal dynamic on a road, some perturbations may appear that are natural to the traffic system. This article develops a novel methodology for monitoring dynamic high-dimensional data that may have missing values and uncommon events for detecting temporal changes.

2 Multivariate Time Series Anomaly Detection from The Perspective of Graph Relational Learning

Weiqi Zhang, Hong Kong University of Science and Technology, Kowloon, Hong Kong. Contact: wzhangcd@connect.ust.hk

With the rapid development of cyber-physical systems, multiple sensors get involved to represent the system from different perspectives, which inspires us to detect anomalies considering feature dependence relationship among sensors instead of focusing on individual sensor's behavior. Thus, we propose a novel Graph Relational Learning Network (GReLeN) to detect multivariate time series anomaly from the perspective of between-sensor dependence relationship learning. Variational AutoEncoder (VAE) serves as the framework for feature extraction and representation. Graph Neural Networks (GNNs) are also imposed to capture the between-sensor dependence. Then a composite anomaly metric is established with the learned dependence structure explicitly. The experiments show our superiority in detection accuracy, anomaly diagnosis, and model interpretation.

3 Fusing High Dimensional Data from Sparse Channels for Better Anomaly Detection

Parham Shahidi, Apple Inc., Cupertino, CA, Contact: pshahidi@apple.com

High dimensional data is ubiquitous in manufacturing. In this talk we present an approach how sparse information from many channels can be leveraged to achieve improved anomaly detection results from low information content sources.

4 Unsupervised Anomaly Localization for Industrial Inspection

Shiyu Li, Xi Li, Apple, Cupertino, CA

In recent years, machine learning is playing an increasingly important role in industrial inspection. However, with extremely high yield rate on the production lines, large scale defective data collection is very hard and expensive. Therefore, one of the most important challenges for machine learning models is data imbalance. Unsupervised anomaly localization, an approach which only requires good samples in training stage, can get rid of the dependency on defective data and shows promising results in industrial inspection. In this presentation, we shall introduce several state-of-the-art works in unsupervised anomaly localization and the future opportunities in this field.

Tuesday, 12:30 PM–1:45 PM

TC59

M - Marriott 6

Explainable AI for Knowledge Discovery in Industrial Applications

General Session

Session Chair

Yuhao Zhong, College Station, TX

Session Chair

Satish Bukkapatnam, Texas A&M University, College Station, TX

1 Microstructure Classification for Materials Discovery Using Reproducing Kernel Hilbert Space

Ashif Iquebal[1], Shirish Pandagare[2], Satish Bukkapatnam[3], [1]Arizona State University, Tempe, AZ, [2]Capital One, Richmond, VA, [3]Texas A&M University, College Station, TX, Contact: aiquebal@asu.edu

In this work, we present a soft (and hard) classification method based on reproducing kernel Hilbert space to characterize the new microstructure types (standard to diffused) in an additively manufactured Ti-6Al-4V workpiece by using the acoustics of a nanolithography process. We model the odds ratio (and consequently the probability) of the observed microstructure to belong to standard or diffused state as a function of the frequency spectrum of the acoustic signal that can be obtained as an output to a penalized loglikelihood function.

2 An Explainable Graphical Regressor for Unraveling Fundamental Mechanism Behind The Deep Learning Model: A Study on Machining Sustainable Heterogeneous Composites

Qiyang Ma[1], Yuhao Zhong[2], Zimo Wang[1], [1]SUNY Binghamton, Binghamton, NY, [2]Texas A&M University, College Station, TX, Contact: zimowang@binghamton.edu

The neural network approach is a black box model which only has observable inputs and outputs without any knowledge built on its internal workings, albeit with the high accuracy for modeling fittings and prediction. We report a model-agnostic graphical regressor approach for unraveling fundamental mechanisms behind a convolutional neural network (CNN) schema with applications in process characterizations of machining fiber-reinforced composites. The investigations suggest that the presented approach can discover the relationships between certain patterns of material microstructures and the resultant micro-dynamics. Therefore, the presented approach opens up an avenue toward understanding the mechanisms of the microstructures on the achieved material machinability across multi-scales.

3 Explainable-AI-Empowered Travel Behavior Modeling

Xilei Zhao, University of Florida, Gainesville, FL, Contact: xilei.zhao@essie.ufl.edu

AI approaches, especially machine learning (ML), have become increasingly popular in travel behavior modeling. Compared to statistical methods, ML-based travel behavior models are found to have higher predictive power but lack transparency and interpretability. This raises doubt on the trustworthiness of ML models and hence undermines their applicability to inform high-stakes decision-making. In this talk, I will discuss how I leverage the state-of-the-art explainable AI techniques to develop ML-based travel behavior models that can achieve both high prediction accuracy and high interpretability (i.e., can be explained for useful behavioral insights). The results of this work will inform the development of the next-generation travel behavior models for transportation planning and management.

5 Improved Bayesian Local Interpretable Model-agnostic Explanations

Yuhao Zhong[1], Anirban Bhattacharya[2], Satish Bukkapatnam[1], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: hirobin_zhong@tamu.edu

Existing methods for explaining black-box machine learning models mostly generate point estimations of the explanation, e.g., feature importance. We propose a Bayesian hierarchical approach which provides insights into the distribution and uncertainty of the generated explanation. Mathematical expressions and theoretical outcomes of the framework are presented. Compared to the state-of-the-art methods, ours can produce superior results, on several benchmark datasets and in a novel case study of ultrasonic internal defect localization.

Tuesday, 12:30 PM–1:45 PM

TC60

M - Marriott 7

Energy Infrastructure Network Optimization

General Session

Session Chair

Benjamin D. Leibowicz, University of Texas-Austin, Austin, TX

1 Tax-credit Uncertainty and Carbon Capture Infrastructuredevelopment

Connor Colombe[1], Benjamin D. Leibowicz[2], Benjamin Mendoza[1], [1]The University of Texas at Austin, Austin, TX, [2]University of Texas-Austin, Austin, TX, Contact: ccolombe@utexas.edu

Carbon capture, utilization and storage (CCUS) plays a key role in long-run decarbonization strategies. Recent research suggests that it may be ready for large-scale deployment, and policy initiatives have increased U.S. federal CCUS incentives. Despite this, deployment of CCUS infrastructure in the U.S. remains low. Our goal is to quantify what effect uncertainty in future CCUS incentives has on expanding CCUS deployment. To achieve this, we construct a two-stage stochastic mixed-integer linear program that models CCUS infrastructure development from the perspective of a risk-averse profit maximizing investor. Using our model, we then conduct a case-study on CCUS infrastructure deployment in Southeast Texas under various levels of incentive uncertainty.

2 Restoration and Recovery of Interdependent Infrastructure After a Nuclear Detonation

Rachel Moglen[1], Benjamin D. Leibowicz[1], Alexis Kwasinski[2], Grant Cruse[2], [1]University of Texas-Austin, Austin, TX, [2]University of Pittsburgh, Pittsburgh, PA, Contact: rmoglen@utexas.edu

The restoration of infrastructure following a disaster, natural or man-made, is essential for the recovery of the critical services that infrastructure provides. The rarity of historical nuclear detonations limits observation-based mitigation strategies of their impacts on infrastructure. Characteristics of the destructive effects of nuclear detonations, such as lingering radioactive contamination, therefore present unique challenges in the restoration process that are not well studied. We address this gap by expanding the restoration modeling capabilities of the Toolbox for Interdependent Network Analysis (TINA), an existing framework for modelling nuclear detonation impacts on interdependent infrastructure.

3 Smart Curbspace -- Estimating The Potential for Optimized Delivery Vehicle Parking Assignment to Reduce Double Parking, Congestion and Energy Consumption

Aaron J. Burns[1], Jeremy J. Michalek[2], Constantine Samaras[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Carnegie Mellon University, Pittsburgh, PA, Contact: aaronbur@andrew.cmu.edu

When loading zones reach capacity, delivery vehicles may double park and increase road congestion and energy consumption. We develop a hybrid approach to optimizing smart parking spaces to minimize double parking through an integer and mixed-integer linear programming parking slot assignment formulation. We find that a smart curbspace can remove 7 minutes of double parking per hour when drivers have +/-5 minutes of arrival time flexibility. Additionally, we apply a queuing model to estimate congestion and energy effects of lane obstruction and find that a smart space can save ~45 minutes of congestion-induced travel time per hour (~$50,000 in externality costs per year) and ~700 gallons of fuel per year for one space. However, when arrival times are uncertain, smart spaces can, in some cases, generate more double parking than traditional first-come-first-serve parking.

4 **Deep-decarbonization of Indian Electricity System: Optimizing The Opportunities and Challenges**

Balachandra Patil[1], Varun Jyothiprakash[1], Abhishek Das[1], Samridh Sharma[2], [1]Indian Institute of Science, Bengaluru, India; [2]Indian Institute of Science, Bengaluru, India. Contact: patilb@iisc.ac.in

In line with global commitments to GHG mitigation, India is envisaged to have a Renewable Energy (RE) dominated electricity system by 2050. Such a transition will introduce several challenges (e.g., balancing variable supply with variable demand, temporal and permanent stranding of thermal value-chains) as well as present many opportunities (e.g., GHG mitigation, temporal and geographical complementarity of solar and wind energy resources). For sustainable and just transition, the optimal solution must ensure maximization of opportunities and minimization of impacts of challenges. To better plan the transition and manage a RE-dominated system, a large-scale mathematical model-based approach that integrates the above opportunities and challenges is proposed and validated.

Tuesday, 12:30 PM–1:45 PM

TC61

M - Marriott 8

Planning Next-day Electricity Generation

General Session

Session Chair

Feng Pan, Pacific Northwest National Laboratory, Richland, WA

1 **Feature-driven Economic Improvement for Network-constrained Unit Commitment: A Closed-loop Predict-and-optimize Framework**

Lei Wu, Stevens Institute of Technology, Hoboken, NJ, Contact: lei.wu@stevens.edu

As an important application in the power system operation and electricity market clearing, NCUC is usually executed by Independent System Operators (ISO) in an open-looped predict-then-optimize (O-PO) process, in which an upstream prediction and a downstream NCUC are executed in a queue. However, in the O-PO framework, a statistically more accurate prediction may not necessarily lead to a higher NCUC economics against actual RES and load realizations. This talk presents a closed-loop predict-and-optimize (C-PO) framework for improving the NCUC economics. Specifically, the C-PO leverages structures (i.e., constraints and objective) of the NCUC model and relevant feature data to train a cost-oriented RES prediction model, in which the prediction quality is evaluated via the induced NCUC cost instead of the statistical forecast errors.

2 **Scheduling Day-ahead Electricity Generation with Detailed Hydro Conditions**

Feng Pan, Pacific Northwest National Laboratory, Richland, WA

Efficiently integrating hydropower scheduling into system-level generation planning is important for reaching the 100% clean energy goal. We introduce hydro-related constraints to unit commitment problem to enhance hydropower representation in day-ahead generation scheduling. The constraints are intended to capture hydro related conditions such as flow rate, hydro-power conversion, limits on flow fluctuation, reservoir operation, and balance of streams among different river sites. The resulting hydro enhanced unit commitment problem can be solved as a mixed-integer programming model. We will discuss the importance of adding these hydro-related constraints by illustrating the impact of these constraints on generation scheduling in regional day-ahead electricity planning.

3 **Convex Hull Pricing Considering Practical Generator Features**

Yongpei Guan, University of Florida, Gainesville, FL

In this talk, we present the convex hull price for the wholesale markets considering practical generator features. We discuss how to refine the pricing schemes so as to achieve an exact or an approximated convex hull pricing, which could lead to an uplift payment reduction.

Tuesday, 12:30 PM–1:45 PM

TC62

M - Marriott 9

Optimization for Improving Power System Resilience

General Session

Session Chair

Feng Qiu, Argonne National Laboratory, Lemont, IL

1 **Switching Device-Cognizant Optimal Sequential Distribution System Restoration with DERs**

Zhaoyu Wang, Iowa State University, Ames, IA
We will present an optimization framework for sequential reconfiguration using an assortment of switching devices and repair process in distribution system restoration. Compared to existing studies, this paper considers types, capabilities and operational limits of different switching devices, making it applicable in practice. We develop a novel multiphase method to find the optimal sequential operation of various switching devices and repair faulted areas. We consider circuit breakers, reclosers, sectionalizers, load breaker switches, and fuses. The switching operation problem is decomposed into two mixed-integer linear programming (MILP) subproblems. The first subproblem determines the optimal network topology and estimates the number of steps to reach that topology, while the second subproblem generates a sequence of switching operations to coordinate the switches. For repairing the faults, we design a MILP model that dispatches repair crews to clear faults and replace melted fuses. After clearing a fault, we update the topology of the network by generating a new sequence of switching operations, and the process continues until all faults are cleared. To improve the computational efficiency, a network reduction algorithm is developed to group line sections, such that only switchable sections are present in the reduced network. The proposed method is validated on the IEEE 123-bus and 8500-bus systems.

2 A Distributionally Robust Resilience Enhancement Strategy for Distribution Grids Considering Decision-Dependent Contingencies

Yujia Li, 1</sup
When performing resilience enhancement for distribution grids, there are two obstacles for modeling uncertain contingencies: 1) decision-dependent uncertainty (DDU) resulting from line hardening decisions, and 2) distributional ambiguity due to limited outage information under extreme weather events (EWEs). To address these, scenario-wise decision-dependent ambiguity sets (SWDD-ASs) is proposed, where these two concerns are simultaneously captured. Then, based on the SWDD-ASs, a two-stage trilevel decision-dependent distributionally robust resilient enhancement (DD-DRRE) model is formulated. Subsequently, by recasting the DD-DRRE model, a customized column-and-constraint generation (C&CG) algorithm is adopted. Finally, numerical tests demonstrate a remarkable improvement in the out-of-sample performance of our model.

Tuesday, 12:30 PM–1:45 PM

TC63

M - Marriott 10

Recent Advancements of Data-driven Decision Making in Energy Systems

General Session

Session Chair

Chen Yize, 1</sup

Session Chair

Hao Wang, 1</sup

1 Data-driven Improvements for Stochastic Ac Opf

Deepjyoti Deka, Los Alamos National Lab, Los Alamos, NM
Stochastic AC-OPF considers the problem of solving optimal power flow under the regime of uncertainties in loads and renewables with feedback policies for generators while ensuring that the necessary constraints are satisfied with high probability. Current methods for stochastic AC-OPF include approximate analytical chance constrained optimization or computationally expensive scenario-based policies. This talk will feature recent work on two different ways to improve the solution of Stochastic AC-OPF. One part will focus on efficient scenario generation (importance sampling) to improve the computational performance of scenario methods. The other part will include use of deep neural network (DNN)-based generator policies while ensuring constraint feasibility. The advantages of either approach over simpler policies are demonstrated on a number of test cases.

2 Stability Constrained Reinforcement Learning for Real-time Voltage Control

Yuanyuan Shi[1], Guannan Qu[2], Steven Low[3], Anima Anandkumar[4], Adam Wierman[4], [1]University of California San Diego, San Diego, CA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Caltech, Pasadena, CA, [4]Caltech, Pasadena, CA
Deep reinforcement learning (RL) has been recognized as a promising tool to address the challenges in real-time control of power systems. However, its deployment in real-world power systems has been hindered by a lack of formal stability and safety guarantees. In this paper, we propose a stability-constrained reinforcement learning method for real-time voltage control in distribution grids and we prove that the proposed approach provides a formal voltage stability guarantee. The key idea underlying our approach is an explicitly constructed Lyapunov function that certifies stability. We demonstrate the effectiveness of the approach

in case studies, where the proposed method can reduce the transient control cost by more than 30% and shorten the response time by a third compared to a widely used linear policy, while always achieving voltage stability.

3 Where are all the Solar Panels: Applying Ai to Satellite Imagery to Identify and Forecast Solar Power Generation Across Large Regions

Julian de Hoog, The University of Melbourne, Melbourne, Australia.

Solar photovoltaic (PV) power is one of the fastest growing forms of electricity generation today. In Australia, more than one in four homes now have solar panels, and many other parts of the world are anticipating similar levels of uptake. However, too much solar can introduce challenges into the management of distribution networks and energy markets. These challenges can be alleviated with improved forecasting of the total output of all solar panels across extended regions. In this talk I will describe how we use latest AI techniques to (i) identify all solar panels in satellite imagery, (ii) forecast cloud movement, and (iii) use the forecasts to drive business outcomes that will ultimately enable greater uptake of distributed solar energy generation.

4 Constructing Dynamic Residential Energy Lifestyles Using Latentdirichlet Allocation

Xiao Chen[1], Chad Zanocco[2], June Flora[2], Ram Rajagopal[1], [1]Stanford University, Stanford, CA, [2]Stanford University, Stanford, CA, Contact: markcx@stanford.edu

We propose and test a new framework for understanding residential electricity demand by using a dynamic energy lifestyles approach. To obtain energy lifestyles, we develop a novel approach that applies Latent Dirichlet Allocation (LDA) to extract latent household energy attributes. By doing so, we provide a new perspective on household electricity consumption where each household is characterized by a mixture of energy attributes. We examine this approach by running experiments on smart meter data from 60,000 households and extract six energy attributes that describe daily use patterns. We then cluster six distinct energy lifestyle profiles from energy attribute proportions. We test our lifestyle approach seasonally to track energy lifestyle dynamics within and across households and find around 73% of households manifest multiple lifestyles across a year.

Tuesday, 12:30 PM–1:45 PM

TC64

M - Indiana A

Robust Mechanism Design
General Session

1 Screening with Limited Information: A Dual Perspective and a Geometric Approach

Zhi Chen[1], Zhenyu Hu[2], Ruiqin Wang[2], [1]College of Business, City University of Hong Kong, Kowloon, Hong Kong; [2]National University of Singapore, Singapore, Singapore.

Consider a seller seeking a selling mechanism to maximize the worst-case revenue obtained from a buyer whose valuation distribution lies in a certain ambiguity set. For a generic convex ambiguity set, we show via the minimax theorem that strong duality holds between the problem of finding the optimal robust mechanism and a minimax pricing problem where the adversary first chooses a worst-case distribution and then the seller decides the best posted price mechanism. This implies that the extra value of optimizing over more sophisticated mechanisms exactly amounts to the value of eliminating distributional ambiguity under a posted price mechanism. We further provide a geometric approach to analytically solving the minimax pricing problem. The solutions are then used to construct the optimal robust mechanism.

2 Minimax Regret Mechanism Design with Moments Information

Shixin Wang[1], Shaoxuan Liu[2], Jiawei Zhang[3], [1]The Chinese University of Hong Kong, Hong Kong, Hong Kong; [2]Shanghai Jiao Tong University, Shanghai, China; [3]New York University, New York, NY, Contact: shixinwang@cuhk.edu.hk

We study a robust mechanism design problem where a seller aims to sell a single item to a single buyer, knowing moments and support information of the buyer's WTP distribution. The seller wants to maximize the competitive ratio with respect to the hindsight optimal policy with full knowledge. We formulate the robust mechanism design problem into an LP problem, which can be solved efficiently if the support of the buyer's WTP is finite. When the support of the buyer's WTP is continuous and the seller knows the mean and support of the buyer's WTP, we show that the optimal mechanism is a piecewise-polynomial function with a degree at most 2. Moreover, we derive the closed-form competitive ratio corresponding to the optimal mechanism. Furthermore, when mean and variance are known to the seller, we propose a feasible piecewise-polynomial approximation with a degree at most 3.

3 Distributionally Robust Optimal Allocation with Costly Verification

Halil Ibrahim Bayrak[1], Cagil Kocyigit[2], Daniel Kuhn[3], Mustafa C Pinar[4], [1]Bilkent University, Ankara, Turkey; [2]University of Luxembourg, Luxembourg, Luxembourg; [3]Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, Switzerland; [4]Bilkent University, Ankara, Turkey. Contact: halil.bayrak@bilkent.edu.tr

A principal wishes to allocate a single good to multiple agents without monetary transfers. Each agent desires to receive the good and has a private type that represents the payoff to the principal if he gets the good. The principal can verify each agent's type at a cost and penalize false claims by withholding the good. We model the agents' types as a random vector governed by a probability distribution, which belongs to a commonly known ambiguity set. The principal aims to maximize the worst-case expected payoff across all type distributions in the ambiguity set. We consider three types of ambiguity sets: support-only, Markov, and Markov with independence. For each of these ambiguity sets, we show that a favored-agent mechanism, which we characterize implicitly, is optimal and Pareto-robustly optimal, and its qualifiers do not depend on the verification costs.

4 Designing Simple and Robust Auctions

Rishikesh Parma[1], Cagil Kocyigit[2], Benny Mantin[2], [1]University of Luxembourg, Luxembourg, Luxembourg; [2]University of Luxembourg, Luxembourg, Luxembourg. Contact: rishikesh.parma@uni.lu

We study the auction design problem of a seller who wants to sell a single item to multiple bidders. The seller only knows an upper bound on the bidders' values and does not know their probability distribution. We propose a simple second price auction (SPA) with a deterministic reserve price, which is a minimax regret optimal mechanism across all deterministic mechanisms. We show that this mechanism achieves a constant-factor approximation to the optimal revenue for different classes of distributions. We also compare the proposed auction with a previously proposed SPA with a random reserve price from the literature. We identify a condition on the distribution of the bidders' values under which our proposed mechanism outperforms the SPA with a random reserve price. A large class of distributions including all convex distributions satisfy this condition.

Tuesday, 12:30 PM–1:45 PM

TC65

M - Indiana B

Economics and Computation III

Award Session

Session Chair

Bhaskar Ray Chaudhury, 1</sup

1 [ec2022] Competitive Equilibrium with Chores: Combinatorial Algorithm and Hardness

Bhaskar Ray Chaudhury, University of Illinois at Urbana Champaign, Champaign, IL, Contact: braycha@illinois.edu

We study the computational aspects of finding a competitive equilibrium (CE) with chores when agents have linear preferences. CE is the most preferred mechanisms for allocating a set of items among agents. CE with equal incomes (CEEI), and Exchange are two fundamental economic models, where CEEI is a special case of exchange. When the items are goods, the CE set is convex even in the exchange model, facilitating several combinatorial polynomial-time algorithms. However, no combinatorial algorithms or hardness results are known for these models. In this paper, we give the first combinatorial algorithm to compute an approximate CEEI in polynomial time. Then, we show PPAD hardness for computing an approximate CE in the exchange model. This shows the first complexity separation between the CEEI and the Exchange model.

2 [ec2022] Core-stability in Assignment Markets with Financially Constrained Buyers

Eleni Batziou[1], Martin Bichler[2], Maximilian Fichtl[3], [1]Technical University of Munich, Munich, Germany; [2]Technical University of Munich, Garching B. München, Germany; [3]Technical University of Munich, Munich, Germany. Contact: batziou@in.tum.de

We study markets where indivisible items are sold to bidders with unit-demand valuations, subject to hard budget limits. Without financial constraints, a simple ascending auction maximizes welfare, is incentive-compatible and core-stable. Introducing budgets, strong additional conditions are required to maintain these properties. We design an algorithm that depends on a trivially verifiable ex-post condition and demand queries, and always yields a welfare-maximizing core-stable outcome. If these conditions do not hold, we cannot hope for incentive-compatibility and computing welfare-maximizing and core-stable outcomes is hard: Even with value queries, we prove that the problem becomes NP-complete. This raises doubts on the efficiency of simple auction designs as they are used in high-stakes markets, where budget constraints typically play a role.

3 [ec2022] Crowd Prediction Systems: Markets, Polls, and Elite Forecasters

Pavel D. Atanasov[1], Jens Witkowski[2], Barbara Mellers[3], Philip Tetlock[3], [1]Pytho LLC, Brooklyn, NY, [2]Frankfurt School of Finance & Management gGmbH, Frankfurt Am Main,

Germany; [3]University of Pennsylvania, Philadelphia, PA, Contact: pavel@pytho.io

We report the results of three large empirical studies on the impact of system features and individual skill on crowd accuracy. First, in an experimental test, logarithmic market scoring rules (LMSR) prediction markets significantly outperform continuous double auction prediction markets. Second, small, elite crowds produce more accurate forecasts than larger, sub-elite crowds, in both LMSR markets and prediction polls. Third, LMSR markets and prediction polls are equally effective in identifying elite forecasters, but polls produce more reliable performance rankings among sub-elite forecasters.

Tuesday, 12:30 PM–1:45 PM

TC66

M - Indiana C

Game Theory and Energy Market Modeling

General Session

Session Chair

Ramteen Sioshansi, The Ohio State University, Columbus, OH

Session Chair

Joseph Edward Duggan, University of Dayton, Grove City, OH

1 Flexible Supply Meets Flexible Demand: Prosumer Impact on Strategic Hydro Operations

Afzal Siddiqui[1,2], Farzad Hassanzadeh Moghimi[1], Yihsu Chen[3], [1]Stockholm University, Stockholm, Sweden; [2]Aalto University, Espoo, Finland; [3]University of California, Santa Cruz, Santa Cruz, CA, Contact: asiddiq@dsv.su.se

Climate packages envisage electrification of the wider economy and decarbonization of the power sector. Increased adoption of variable renewable energy (VRE) will, thus, necessitate flexible resources. Due to its conducive geography, the Nordic region's hydro reservoirs could mitigate VRE's intermittency. Yet, this increased need for flexibility and the advent of VRE-enabled prosumers may yield more leverage to hydro producers to exert market power. Using an equilibrium model, we find that strategic hydro reservoirs could exploit prosumers' net-sales patterns to manipulate prices more effectively via temporal arbitrage. By contrast, strategic thermal producers would be thwarted by prosumers' switching to becoming net sellers. Finally, a higher CO_2 price would benefit both types of strategic producers by limiting the response of flexible fossil-fuel plants.

2 Market Power in Power-to-gas? Preliminary Insights from The North-western European Electricity, Hydrogen, and Gas Markets

Camille MEGY[1], Olivier MASSOL[2], [1]CentraleSupelec, Gif-sur-Yvette, France; [2]IFP School & City, University of London, Rueil-Malmaison, France.

Power-to-hydrogen (PtH) technologies - and the flexibility they provide - are expected to facilitate the operation of renewable-dominated electricity systems. Yet, in markets where electricity, gas, and hydrogen are imperfectly competitive, one can wonder about a possible strategic use of PtH assets. To explore that, we develop a mixed-complementarity problem that conveys a stylized representation of the future Northwestern European energy scene. We use it to simulate and compare the market outcomes obtained under alternatives market structures representing various forms of PtH asset control. The results document the impacts imperfect competition has on: (i) the operation of PtH assets, (ii) the market outcomes, and (iii) the associated welfare implications.

3 Market Power Under Nodal and Zonal Congestion Management Techniques

Endre Bjørndal, Mette Bjorndal, NHH Norwegian School of Economics, Bergen, Norway. Contact: Endre.Bjorndal@nhh.no

European electricity day-ahead markets use simplified methods, such as uniform or zonal pricing, which only partly address congestion. The simplified methods may yield infeasible flows, and re-dispatch is typically needed to achieve feasibility. We study the exercise of market power in such a setting. Specifically, we discuss the model simplifications allowed in the Euphemia algorithm, i.e., the Available Transfer Capacity (ATC) and the Flow-Based (FB) approaches, and we compare to the benchmark case of nodal pricing. We show that, contrary to common beliefs, the simplified methods may give extra opportunities for exercise of market power compared to the benchmark case.

4 Social Welfare Implications of Carbon Capture and Storage Policies

Joseph Edward Duggan[1], Jonathan Ogland-Hand[2], [1]University of Dayton, Dayton, OH, [2]Carbon Solutions LLC, Bloomington, IN, Contact: jduggan1@udayton.edu

Carbon Capture and Storage (CCS) is increasingly being seen as a powerful tool in decarbonizing the power sector and ameliorating the effects of climate change. We examine a stylized model of carbon capture and storage given different regulatory and market structure regimes to examine the incentive effects and social welfare implications of proposed regulatory frameworks. We compare a standard regime without any CCS technology or CO2 emissions tax to one where the firm can undertake CCS activities and receive a subsidy payment from the government in return We find conditions under which a CCS subsidy alone may result in an increased level of CO2 emitting activity which suggests the potential benefits of a CCS subsidy being paired with a tax on emissions. We explore the implications for social welfare, net emissions, firm behavior, and policy design.

Tuesday, 12:30 PM–1:45 PM

TC67

M - Indiana D

RMP Flash Session II

Flash Session

Session Chair

Billy Jin, Cornell University, Ithaca, NY

1 Algorithmic Ranking: User Behavior, Platform Incentives, and Policy

Dan Huttenlocher[1], Liang Lyu[2], Asuman Ozdaglar[2], James Siderius[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: lianglyu@mit.edu

Social media platforms develop recommendation algorithms to optimize platform objectives such as user engagement. However, such algorithms can have socially undesirable consequences, such as the spread of misinformation. We propose a novel experiment where users interact with a news feed that resembles a social media platform. The feed is ranked by simple algorithms, prioritizing articles that cater to user preferences, shared by friends, or both. We compare user engagement versus a random feed to understand the impacts of ranking algorithms, and analyze if they recommend more exploitative content. Finally, we suggest interventions that align platform behavior with societal objectives.

2 Fair Scheduling of Heterogeneous Customer Populations

Justin Mulvany, Ramandeep Randhawa, University of Southern California, Los Angeles, CA

When managing congested service systems, it is common to use priority rules based on some operational criteria. In this paper, we consider the societal implications of such individual-focused priority policies, when individuals are considered as members of broader population groups. We find that optimal resource allocation policies such as the cμ-rule in scheduling can lead to significant inequity across population groups. We propose policies that can mitigate this inequity and can generate completely equitable outcomes across populations with little, or at times, even no additional system cost.

3 Pricing Under a Generalized Markov Chain Choice Model: Learning Through Large-scale Click Behaviors

Mo Liu[1], Junyu Cao[2], Zuo-Jun Max Shen[1,3], [1]University of California Berkeley, Berkeley, CA, [2]The University of Texas at Austin, Austin, TX, [3]HKU Business School, Hong Kong, Hong Kong. Contact: mo_liu@berkeley.edu

We study a generalized markov chain choice model (GMCCM) and analyze its optimal pricing policy. Given click and purchase data from different assortments, we propose a data-driven framework to learn customer's browsing and purchasing behavior. We utilize the low-rank structure of the transition matrix in GMCCM to reduce the sample complexity and improve the computational efficiency. Our analysis also shows that the higher click rate does not necessarily lead to higher optimal prices. For the online learning problem in GMCCM, we design an exploration-free online algorithm and prove the regret bound. Lastly, our numerical experiments demonstrate promising numerical performance results.

4 Inpatient Overflow Management with Proximal Policy Optimization

Jim Dai[1], Pengyi Shi[2], Jingjing Sun[3], [1]Cornell University & CUHK-Shenzhen, Ithaca, NY, [2]Purdue University, West Lafayette, IN, [3]Chinese University of Hong Kong, Shenzhen, Shenzhen, China. Contact: 221049026@link.cuhk.edu.cn

Overflow patients to non-primary wards is an efficient way to decrease congestion in hospital, while undesirable overflow causes other problems such as mismatched service quality. Therefore, we need to trade-off between congestion and overflow cost. This overflow management problem is modeled as a discrete-time infinite-horizon average cost Markov Decision Process with large state and action space. To overcome the curse-of-dimensionality, we use an actor-critic algorithm, Proximal Policy Optimization. Under different scale hospital settings, this algorithm generates policies which consistently outperforms some commonly used state-of-art policies significantly.

5 Deep Learning for Choice Modeling

Hanzhao Wang, Zhongze Cai, Kalyan Talluri, Xiaocheng Li, Imperial College Business School, London, United Kingdom. Contact: hw819@ic.ac.uk

Choice modeling has been a central topic in the study of individual preference or utility across many fields. While the vast majority of the literature on choice models has been devoted to the analytical properties that lead to managerial and policy-making insights, the existing methods to learn a choice model from empirical data are often either computationally intractable or sample inefficient. In this paper, we develop deep learning-based choice models under two settings of choice modeling: (i) feature-free and (ii) feature-based. Our model captures both the intrinsic utility for each candidate choice and the effect that the assortment has on the choice probability. Synthetic and real data experiments demonstrate the proposed models' performances in terms of the recovery of the existing choice models, sample complexity, assortment effect, and architecture design.

6 Does Size Matter in Loyalty Points Redemptions?

Yang Chen, Anton Ovchinnikov, Nicole Robitaille, Queen's University, Smith School of Business, Kingston, ON, Canada. Contact: chen.y@queensu.ca

Loyalty points redemptions are generally associated with increased loyalty. However, are all sizes of redemption equally good, and hence, should firms encourage any redemption? Numerous economical, behavioral, and psychological theories suggest that size might matter, but their predictions are often conflicting. Furthermore, the context of redemptions may also matter, since whether a reward feels large may be highly individual and subjective. With a large longitudinal proprietary data set, our study investigates the effect of reward redemption size on long term consumer loyalty. We find that size does matter in redemption and encouraging the "right" sized redemption can increase revenue.

7 Optimal Subscriptions for Ridesharing Platforms

Ben Berger[1,2], Hongyao Ma[2], David C. Parkes[3], Shreyas Sekar[4], [1]Tel Aviv University, Tel Aviv, Israel; [2]Columbia Business School, New York, NY, [3]Harvard University, Boston, MA, [4]University of Toronto, Toronto, ON, Canada. Contact: benberger1@tauex.tau.ac.il

We study the impact of subscriptions on the operational efficiency of ridesharing platforms such as Uber and Lyft. We model the operations of these platforms under network effects - a higher idle supply implies lower wait time for the riders and pickup times for the drivers. We show that real time prices alone cannot maximize welfare in equilibrium, but together with subscriptions they can if riders are homogeneous or differ in riding frequency. Finally, we show how such subscriptions can be designed using only information observable from a Walrasian equilibrium.

8 Online Bipartite Matching with Advice: Tight Robustness-consistency Tradeoffs for The Two-stage Model

Billy Jin[1], Will Ma[2], [1]Cornell University, Ithaca, NY, [2]Columbia University, New York City, NY, Contact: bzj3@cornell.edu

We study the two-stage vertex-weighted bipartite matching problem (Feng, Niazadeh, and Saberi (SODA '21)) in a setting where the algorithm has access to a suggested matching that is recommended in the first stage. We evaluate an algorithm by its *robustness*, which is its performance relative to that of the optimal offline matching, and its *consistency*, which is its performance relative to that of the advice. We characterize the tight robustness-consistency tradeoff for this problem.

Tuesday, 12:30 PM–1:45 PM

TC68

M - Indiana E

Analytics in Revenue Management and Beyond

General Session

Session Chair

Georgia Perakis, Massachusetts Institute of Technology, Belmont, MA

1 The Role of Driver Behavior in Moving The Electric Grid to Zero Emissions

Leann Thayaparan[1], Georgia Perakis[2], [1]Massachusetts Institute of Technology, Somerville, MA, [2]Massachusetts Institute of Technology, Belmont, MA, Contact: lpgt@mit.edu

As we move towards more renewable resources, the ability to produce electricity in time with demand diminishes. Instead, rises a need for energy storage or the ability to produce electricity when renewables allow and store it for when demand needs it later. Electric Vehicles (EVs) have been discussed as a way of providing a distributed energy storage resource to the electric grid. However before EVs can be used to support the grid, through optimal charging and discharging, highly complex, non-linear driver behavior must be accounted for. In this work we combine machine learning with optimization to model driver behavior in order to size the capacity of energy storage EVs can offer the grid.

2 Motem: Method for Optimizing over Tree Ensemble Models

Setareh Borjian Boroujeni[1], Kiran Panchamgam[1], Georgia Perakis[2], Rebecca Schubertruegmer[1], Leann Thayaparan[3], [1]Oracle, Burlington, MA, [2]Massachusetts Institute of Technology, Belmont, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: kiran.panchamgam@oracle.com

Machine learning tools have become core to forecasting but the most sophisticated models are not easily optimized over. When tree-based models, such as Random Forest or XGBoost, are used in optimization formulations they then require an exponential number of binary decision variables. These formulations do not scale well and result in intractable formulations. In this work, we propose a scalable approximation of the optimization formulation that can optimize over ensemble tree models in linear time while also showing theoretical bounds on the optimality gap and strong computational results. (Method for Optimizing over Tree Ensemble Models) is an algorithm for optimizing an objective function that is determined by an ensemble tree model.

3 Optimizing Objective Functions from Relu Neural Networks Via Sampling

Georgia Perakis[1], Asterios Tsiourvas[2], [1]Massachusetts Institute of Technology, Belmont, MA, [2]MIT, Cambridge, MA, Contact: atsiour@mit.edu

Optimization problems with objective functions that come from an already trained neural network occur in many real-world applications. Nevertheless, such problems are hard to solve in a reasonable amount of time. In this work, we introduce novel algorithms based on sampling for optimizing neural networks with ReLU activations. The algorithms take advantage of their piecewise linear and allow us to reduce the initial mixed-integer optimization problem into multiple easier-to-solve problems. We further show how these methods contribute to the post-training interpretability of neural networks and how they can be used to incorporate ReLU networks into operations management applications.

4 Learning Near-optimal Robust Solutions in Pricing and Beyond

Cristian Rares[1], Georgia Perakis[2], [1]MIT, Cambridge, MA, [2]Massachusetts Institute of Technology, Belmont, MA, Contact: raresc@mit.edu

In pricing applications, among others, it is crucial to perform the prediction and optimization jointly, as separating them can result in significantly suboptimal solutions. This is highly relevant in revenue management, where one needs to determine the optimal product pricing while having to make forecasts for future demand. Existing methods suffer from issues such as: (1) applying only to a narrow class of optimization tasks (2) being computationally expensive (3) having no mechanism to incorporate robustness. We address these by proposing a novel data-driven approach which recommends near-optimal decisions. We prove theoretical guarantees for the underlying regret and present a large case study of promotion planning showing our method increases revenue ranging from 6-12%.

Tuesday, 12:30 PM–1:45 PM

TC69

M - Indiana F

Queueing Theory and Its Applications in Pricing and Revenue Management

General Session

Session Chair

Nasser Barjesteh, University of Toronto, Toronto, ON, Canada.

1 Can Hybrid Priority Increase Revenue?

Mor Harchol-Balter[1], Vanshika Chowdhary[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: harchol@cs.cmu.edu

In a traditional (strict) priority system, there are high-priority customers who have full priority over low priority customers. The high-priority customers experience low delays and pay a high price, while the low-priority customers experience high delays and often pay a lower price.

But could we possibly increase the service provider revenue if we weren't limited to these strict definitions? Imagine a new type of priority system, where high-priority customers get priority, say 70 percent of the time, and low-priority customers get priority, say 30 percent of the time. We call this a hybrid priority system. In this talk, we introduce the hybrid priority system and show how to analyze per-class queueing delays in this system. We then investigate whether revenue and market share can be increased in a hybrid priority setting.

2 Revenue Management of a Two-server Queue with Two Types of Customers

Sha Chen[1], Izak Duenyas[2], Seyed Iravani[1], [1]Northwestern

University, Evanston, IL, [2]University of Michigan-Ann Arbor, Ann Arbor, MI
We study the optimal routing and admission control policies in a queueing system with two heterogeneous servers serving two types of customers. Serving each type of customer provides different revenue,. We characterize the structure of the optimal policy that maximizes the expected revenue and develop a queueing model that has the underlying dynamics for several close-to-optimal heuristics for routing and admission control.

3 Enhancing Make-to-Order Manufacturing Agility: When Flexible Capacity Meets Dynamic Pricing

Xu Sun[1], Anand Paul[1], Lingjiong Zhu[2], [1]University of Florida, Gainesville, FL, [2]Florida State University, Tallahassee, FL
We consider a make-to-order production environment with externally procurable on-demand capacity as well as the ability to adjust the price of the product. We start with a stochastic optimization model to capture the main features of the problem setting. Since the model is intractable, we convert the problem to a more tractable diffusion control problem, which we utilize to reveal the conditions under which employing external capacity is more advantageous than using fixed capacity in the traditional context. When leveraging external on-demand capacity is worthwhile, we provide a solution to the diffusion control problem that hints at how capacity and price adjustments might be carried out in an optimal manner. In doing so, we discover a rich interplay between capacity adjustment and dynamic pricing.

4 Dynamic Pricing of a Multiclass Make-to-stock Queue

Baris Ata[1], Nasser Barjesteh[2], [1]University of Chicago, Chicago, IL, [2]University of Toronto, Toronto, ON, Canada.
We consider a make-to-stock manufacturing system selling multiple products to price-sensitive customers. The system manager seeks to maximize the long-run average profit by making dynamic pricing, outsourcing, and scheduling decisions: First, she adjusts prices dynamically depending on the system state. Second, when the backlog of work is judged excessive, she may outsource new orders, thereby incurring outsourcing costs. Third, she decides dynamically on which product to prioritize in the manufacturing process, i.e., she makes dynamic scheduling decisions. We use an approximate analysis in the heavy-traffic regime and consider the resulting Brownian control problem. The optimal solution to the Brownian control problem is a two-sided barrier policy with drift rate control, which we derive in closed-form.

Tuesday, 12:30 PM–1:45 PM

TC70

M - Indiana G

Revenue Management and Pricing

Contributed Session

Session Chair

Xiao Xiao, University of Wisconsin, Milwaukee, Milwaukee, WI

1 Dynamic Price Competition in Variety Seeking Markets

Koray Cosguner[1], Seethu Seetharaman[2], Tat Y. Chan[3], [1]Indiana University, Bloomington, IN, [2]Washington University in St Louis, St Louis, MO, [3]Washington University, St. Louis, MO, Contact: kcosgun@iu.edu
Variety seeking (VS) has been found to be a commonly observed consumer behavior in many product categories. We study the pricing implications of VS between duopoly firms. We find that when the level of VS is sufficiently high, equilibrium prices charged by duopoly firms are higher than collusive prices, i.e., firm competition can reduce consumer welfare. The threshold level of VS, above which the competition lowers consumer welfare, is smaller when firms have higher production costs, consumers have lower product preferences, fewer firms compete in the market, and the level of staying cost diminishes less over time. Further, we show that a firm's improvement in production costs or consumers' preference for its own product can lead to an increase in profit for the rival firm, establishing that VS can create positive strategic spillovers across competing firms.

2 When Prices Should Stay Fixed: On The Limitations of Spot Pricing in Larger Markets

Ludwig Dierks, Makoto Yokoo, Kyushu University, Fukuoka, Japan. Contact: dierks@ifi.uzh.ch
Selling resources via auctions often seems profit optimal in theory. Yet in practice, providers often choose to sell homogeneous resources such as cloud computing instances at fixed prices. While it has been argued that relatively non-volatile demand distributions and highly competitive market environments explain this, these arguments only paint a partial picture. Through a game theoretic analysis, we show that the relative profit increase of spot pricing over selling at a fixed price is actually unbounded as long as a sufficiently competitive outside option exists, even if demand is very non-volatile. However, this does not mean that a spot market is actually optimal in practice. In a second step, we show how

even a small user bias against more complex spot pricing mechanisms can turn this around and derive a sufficient condition under which fixed prices are profit optimal.

3 Behavior-based Price Discrimination in a Horizontally and Vertically Differentiated Duopoly with Switching Costs

Masashi Umezawa, Tokyo University of Science, Chiyoda-Ku, Tokyo, Japan. Contact: m.umezawa@gmail.com

This paper analyses behavior-based price discrimination (BBPD) in an asymmetric duopoly with switching costs and including both vertical and horizontal differentiation. We demonstrate that there are two configurations of market share in equilibrium. We find when the equilibria arise in each of two configurations. We reveal the impact of switching costs on firm profits under BBPD as well as under uniform pricing, and show that with either high switching costs or large firm asymmetries, BBPD may benefit both firms. Moreover, we find that when switching costs are sufficiently high in the second market configuration, there are cases where social welfare is higher under BBPD than under uniform pricing.

4 Myopic and Far-sighted Pricing and Advertising Strategies in a Duopoly Market with Long-term Advertising Effect

Xiao Xiao[1], Jianghua Wu[2], Xiang Fang[3], Yuhong He[4], [1]University of Wisconsin-Milwaukee, Milwaukee, WI, [2]Renmin University of China, Beijing, China; [3]University of Colorado Denver, Denver, CO, [4]California State University-Fullerton, Fullerton, CA, Contact: xiaoxiao@uwm.edu

This study explores the impact of long- and short-term effects of advertising and product substitutability on the pricing and advertising strategies of firms in a duopoly market. A two-period repeated game is developed with symmetric firms producing substitutable products and facing the same market and advertising effects. The myopic strategy focuses only on maximizing profits in the short term, contrary to the far-sighted strategy, which tends to maximize profits in the long run. We develop a theoretical framework to analyze the interaction between advertising effects and substitutability, especially in view of a negative long-term advertising effect on the equilibrium strategies of firms. This study demonstrates that the equilibrium strategies of firms depend on the joint performance of long- and short-term effects of advertising and product substitutability.

Tuesday, 12:30 PM–1:45 PM

TC72

M - California

Detecting and Preventing Suicide Among Youth using Social Media Analytics

General Session

Session Chair

Priya Nambisan, University of Wisconsin - Milwaukee, Milwaukee, WI

1 Using Photo Voice Method in Social Media to Detect Suicidality and Prevent Suicide Among Transgender Youth

Priya Nambisan[1], Farrokh Alemi[2], [1]University of Wisconsin - Milwaukee, Milwaukee, WI, [2]George Mason University, McLean, VA, Contact: nambisap@uwm.edu

Social media platforms have allowed transgender communities to create their own social groups, follow trans celebrities and connect with others who are gender diverse. Such groups can be quite beneficial in fostering a supportive environment and providing positive experiences. However, outside of these groups, in social media, transgender youth are still subjected to the mainstream cisgender-oriented images and texts that become an echo chamber of what they endure outside of social media. This could bring out frustrations, sadness, loneliness, feelings of ‘rejection’ or ‘being left-out’, depression, and suicidal thoughts. In this study, we develop a design to use ‘photo voice’ method to capture the text and images as well as the triggered emotions and actions from transgender teens, as they scroll social media sites.

2 Using Time-series and Longitudinal Models in Detecting/predicting Suicide over Time

Niloofar Ramezani, George Mason University, Fairfax, VA, Contact: nramezan@gmu.edu

Suicide is a major global health concern and the fourth leading cause of death in people aged 15 to 29 worldwide (WHO, 2021). Therefore, it is crucial to use accurate modeling techniques to detect suicide. Traditional approaches to predict suicidality, such as logistic regression, have limited accuracy since they ignore the temporal patterns of suicide attempt risk over time (Franklin, 2017). Models such as survival analysis, which consider time-dependent covariates, outperform logistic regression (Wang et al. 2013). In this study, models that can accommodate data collected and censored over time, and account for each individual’s demographic, clinical, and behavioral factors, are discussed and compared. Models include generalized binary time series approaches, generalized linear mixed models, mixed effects Cox models, and generalized estimating equations.

3 Using Metamap for Social Media Data Analytics: An Exploratory Study to Understand The Link Between Physical Health Conditions and Suicide

Sammie Omranian, Priya Nambisan, University of Wisconsin - Milwaukee, Milwaukee, WI

Social media forums have become an important setting for people with different interests to share experiences on mental health. In this study, we used MetaMap, a natural language processing (NLP) tool developed at the National Library of Medicine (NLM), to identify biomedical concepts in social media text and explore the link between physical health conditions and suicidal thoughts. Prior research showed promising results in extracting physical health conditions by MetaMap. Several studies have looked into mental health conditions and suicide, which is a critical antecedent to suicide; however, chronic illnesses (e.g., chronic pain) could also lead to suicidal thoughts and suicidal attempts. The results will be presented at the conference.

4 Continuous Monitoring of Social Media Posts: Time-based NLP

Farrokh Alemi, George Mason University, McLean, VA, Contact: falemi@gmu.edu

In 11 studies, natural language processing has been used to classify posts in social media as depression/suicide related. The classification of social posts is not sufficient for predicting the depression/suicidality of the author. A pattern among the post should be used but no method is available in the literature for doing so. We show how risk-adjusted probability control charts can be used to classify the author of the social posts. In this approach, the current pattern of posts are compared to the historical trend for the author. In addition, we show how time between control charts can be used to analyze whether current time period (last 2 weeks) is different than historical trends. No data are presented only the theoretical issues in combining control charts and natural language processing are discussed. A number of unresolved analytical issues are also presented.

Tuesday, 12:30 PM–1:45 PM

TC74

M - Florida
Reinforcement Learning in Finance
General Session

Session Chair
Nan Chen, Chinese University of Hong Kong, Shatin N T, Hong Kong.

Session Chair
Min Dai, National University of Singapore, Singapore, Singapore.

1 Multi-agent Reinforcement Learning Under Partial Information

Renyuan Xu, University of Southern California, Los Angeles, CA

An oil company needs to negotiate with a counterparty, usually a foreign government, to gain the rights for oil exploration and extraction. The negotiation of an oil exploration project usually takes a few rounds until both parties agree on the price or the deadline arrives before any agreement is made. Both parties have their private but noisy information on the true value of the project.
Motivated by this example, we consider a multi-agent reinforcement learning problem in the linear-quadratic framework where each player observes a perturbed state process. We combine the policy gradient method and the Kalman filtering technique to approach this problem. Both theoretical and empirical results are demonstrated.
This is based on joint work with Ben Hambly (Oxford) and Huining Yang (Princeton).

2 Optimal Investment Under Block-shaped Order Books

Nan Chen[1], Min Dai[2], Qiheng Ding[1], Chen Yang[1], [1]The Chinese University of Hong Kong, Hong Kong, Hong Kong; [2]The Hong Kong Polytechnic University, Hong Kong, Hong Kong.

We study an optimal investment problem of a CARA investor trading in a block-shaped LOB market, which synergizes three key features of market microstructure: bid-ask spread, market depth, and resilience. One salient feature is finite resilience. We derive an explicit solution under a Bachelier model for the fundamental value of the asset, in which the investor's optimal trading strategy is characterized by a buy region, a sell region, and a no-trade region separated by two boundaries which admit an explicit form. Our result shows a significant impact of resilience on the optimal trading strategy. As resilience goes to infinity, our model is reduced to the classic model in Almgren and Chriss (2001). We also study an extension of the above model that incorporates return-predicting signals, where we derive an asymptotic expansion for the strategies under small signal changes.

Tuesday, 12:30 PM–1:45 PM

TC75

M - Illinois
Data Analytics in Operations Management
General Session

Session Chair
Jian Wu, Purdue University, West Lafayette, IN

Session Chair
Qi Annabelle Feng, Purdue University, West Lafayette, IN

1 Contextual Data-integrated Newsvendor Solution with Operational Data Analytics (ODA)

Jian Wu[1], Qi Annabelle Feng[1], George Shanthikumar[2], [1]Purdue University, West Lafayette, IN, [2]Purdue University, WEST LAFAYETTE, IN, Contact: wu1549@purdue.edu

We analyze the inventory decision for an unknown demand that may be learned from historical data of the demand and related covariates. We apply the operational data analytics (ODA) framework to formulate the data-integration model and the validation model. The ODA solution demonstrates superior performance with a finite sample size.

2 Optimal Policies for Dynamic Pricing and Inventory Control with Nonparametric Censored Demands

Boxiao (Beryl) Chen[1], Yining Wang[2], Yuan Zhou[3], [1]University of Illinois-Chicago, Chicago, IL, [2]University of Florida, Gainesville, FL, [3]UIUC, champaign, IL, Contact: bbchen@uic.edu

We study the fundamental model of joint pricing and inventory control with lost sales over T consecutive review periods. The firm does not know the demand distribution a priori and needs to learn it from historical censored demand data. When the reward function is concave, we develop online learning algorithms that achieve a tight regret of O(T^{1/2}). When the reward function is non-concave, the regret upper bound for our learning algorithm is O(T^{3/5}), and we also prove a matching regret lower bound.

3 Digital Privacy in Dynamic Personalized Pricing

Xi Chen[1], David Simchi-Levi[2], Yining Wang[3], [1]New York University, New York, NY, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]University of Florida, Gainesville, FL

The prevalence of e-commerce has made detailed customers' personal information readily accessible to retailers, and this information has been widely used in pricing decisions. When involving personalized information, how to protect the privacy of such information becomes a critical issue in practice. In this paper, we consider a dynamic pricing problem over T time periods with an unknown demand function of posted price and personalized information. Using the fundamental framework of differential privacy from computer science, we develop a privacy-preserving dynamic pricing policy, which tries to maximize the retailer revenue while avoiding information leakage of individual customers' information and purchasing decisions. This is joint work with Prof. Yining Wang from UT Dallas and Prof. David Simchi-Levi from MIT.

4 Data-driven Policies for Inventory Systems with Lead Time and Demand Features

Jingkai Huang[1], Kevin Shang[2], Yang Yi[3], Weihua Zhou[1], [1]Zhejiang University, Hangzhou, China; [2]Duke University, Durham, NC, [3]Zhejiang University, Zhejiang, China. Contact: jkhuang@zju.edu.cn

We study a single-stage inventory system in which demand depends on exogenous features in the finite horizon. Lead time is positive and unfilled demands are fully backlogged. We propose an effective data-driven heuristic policy based on feature aggregation and sample average approximation. We show that the proposed policy is near optimal with performance guarantees. We also verify its effectiveness with real data.

Tuesday, 12:30 PM–1:45 PM

TC76

M - Michigan
Environment, Sustainability, and Natural Resources Flash Session
Flash Session

Session Chair
Miguel Carrión, Universidad de Castilla - La Mancha, Toledo, Spain.

1 An Integer Program to Support Reorganization of The Wildland Fire Dispatching System in Colorado

Erin Belval, USDA, Fort Collins, CO

In 2019, decision makers in Colorado embarked on a project to reorganize the dispatching system. Potential changes to the dispatching system included dispatching zone boundaries, the number and location of dispatching centers throughout the state and center ownership. During the decision-making process, decision makers identified four key objective areas they hoped to address during the reorganization process, each of which have several specific objectives within them. Because the set of alternatives associated with the potential changes is large, an integer programming model was developed to identify an initial set of efficient solutions. In this presentation we will discuss the decision making context, we will present the integer program and results, and we will discuss how the results were presented to and used by decision makers.

2 Distribution of Pro-Environmental Incentives: Opportunities for OR

John Fontecha, Alexander Nikolaev, Jose L. Walteros, Zhenduo Zhu, University at Buffalo, Buffalo, NY, Contact: anikolae@buffalo.edu

In reference to the literature on quantitative methods for incentivizing behavior, this presentation scopes the existing body of work in three areas of global concern: energy, waste, and water. Classifying published contributions by method and impact (descriptive, predictive, or prescriptive), we point at a dire need for more scientific advances in support of effective distribution of pro-environmental incentives.

3 Opportunities for Advancing The Integration of Probabilistic Sub-seasonal to Seasonal Hydroclimatic Forecasts in Water Systems Operations and Management

Majid Shafiee-Jood[1], Paul Block[2], Justin Delorit[3], Matteo Giuliani[4], Megan Rivera[5], Nathalie Voisin[6], [1]University of Virginia, Charlottesville, VA, [2]University of Wisconsin-Madison, Madison, WI, [3]Air Force Institute of Technology, Wright-Patterson Air Force Base, OH, [4]Politecnico di Milano, Milano, Italy; [5]Hazen and Sawyer, Baltimore, MD, [6]Pacific Northwest National Lab., Seattle, WA

Water systems managers are increasingly under pressure to plan for and respond to growing water demands and more frequent climate extremes. Sub-seasonal to seasonal (S2S) hydroclimatic forecasts are strategic for the management of water systems by facilitating early planning and reducing uncertainty. In the last decade, numerous enhancements in S2S forecast skill, availability, and spatio-temporal resolution have occurred. However, the operationalization of S2S forecasts remains minimal and seems to stall. In this talk, we synthesize the current state of S2S forecasts integration into decision making, highlight methodological challenges, and provide future directions for researchers.

4 Carbon Reduction Investment and Market Response

Wenqing Zhang[1], Prasad Padmanabhan[2], Chia-Hsing Huang[3], Rajesh Rajaguru[4], [1]University of Minnesota Duluth, Duluth, MN, [2]St. Mary's University, San Antonio, TX, [3]SolBridge International School of Business, Daejeon, Korea, Republic of; [4]University of Tasmania, Hobart, Australia.

The adoption of green technologies by firms may provide benefits that do not exceed the costs of adoption many may seek alternate-green methods that can provide output that can achieve a satisfying level of strategic performance. We use a game-theoretic model to see how marketing sustainable practices through social media affect it.

5 Conceptualization to Development of a Decision Support Tool to Manage Building Water Quality

Harsha Sureshbabu, Md. Rasheduzzaman, Rajveer Singh, Patrick Gurian, Lakshmi Annapoorna Madireddy, Drexel University, Philadelphia, PA, Contact: harshasuresh2020@gmail.com

Opportunistic premise plumbing pathogens (OPPPs) are microbial inhabitants of premise plumbing that can pose a serious risk to human health and even cause death. To address this problem, we have developed a web-based premise plumbing water quality management tool, herein called "Plumbing Information and Performance Evaluation (PIPE) decision support tool (DST)." The PIPE tool provides a free resource for water quality management in buildings that takes input from building facility managers and outputs guidance specific to their buildings. The PIPE requires simple user inputs related to the building and its plumbing system's operational and design characteristics. In response, PIPE will help them assess if a water quality management plan is required for their building and identify those features that need the management most.

6 Value Recovery from Spent Li-ion Batteries: Optimizing The Economic and Environmental Impacts

Apurba K. Saha, University of Arizona, Tucson, AZ, Contact: apurbasaha@email.arizona.edu

This study aims to design an optimal reverse logistics network for the value recovery of spent Li-ion batteries (LIB). To this end, a bi-level mixed integer optimization model has been developed to maximize the economic and environmental benefits from LIB recycling. When applied to the US, the model suggests the optimal facility locations, processing capacities, recycling technology, and material flows for LIB recyclers. However, the domestic recycling business is only profitable when the recycling plants receive a financial incentive from the government. The model suggests an optimal strategy for providing incentives, which the government may adopt to promote LIB recycling inside the US.

7 Stochastic Generation Capacity Expansion Considering Hydrogen-fired Gas Turbines

Miguel Carrión[1], Hernán Gómez-Villarreal[1], Rafael Zárate-Miñano[2], Miguel Cañas-Carretón[1], [1]Universidad de Castilla-La Mancha, Toledo, Spain; [2]Universidad de Castilla-La Mancha, Almadén, Spain. Contact: miguel.carrion@uclm.es

Planning decarbonized power systems is one of the most relevant problems that power system planners are facing nowadays. In this process, hydrogen can be used to produce electricity in gas turbines. Considering this, we propose a generation capacity expansion that aims at designing a low-carbon power system considering the possibility of installing hydrogen-fired gas turbines, other generation technologies, batteries and hydro pumping units. The proposed model considers the installation of electrolyzers and hydrogen-storage facilities. The problem is formulated as a two-stage stochastic programming problem considering different uncertain parameters. A realistic case study based on a renewable-dominated power system is solved to test the proposed formulation.

Tuesday, 12:30 PM–1:45 PM

TC78

M - Utah

Impact of Information Technology

General Session

Session Chair

Fujie Jin, Kelley School of Business, Indiana University, Bloomington, IN

1 Blockchain Governance and Proposal Voting: A Study of Dash

Jing Tian, Pennsylvania State University, State College, PA, Contact: jtian9@gsu.edu

The transparent and immutable nature of the blockchain incentivizes organizations to create and implement a decentralized governance structure. The decentralized governance fundamentally changes the internal decision making of organizations as members exercising their voting rights on every single executive proposal regarding the organization. Although voting is not a new topic in organization governance, we rarely understand how it functions without the existence of any centralized decision making hubs. Based on Dash, the first cryptocurrency to establish on-chain voting, our study tends to reveal the mechanism through which voting achieves agreement and success in decentralized governance.

2 Artificial Intelligence, Lean Method and Startup Product Scaling

Xiaoning Wang, Lynn Wu, University of Pennsylvania, Philadelphia, PA

Despite variability in returns, many startups have adopted artificial intelligence (AI) to develop new products. Using a dataset of 2,000 startups from 2011 to 2020, we find that the AI investments tend to co-occur with the use of lean methods, and firms that adopt both AI and lean methods create more innovative products. Specifically, they tend to produce novel products instead of incremental changes to existing products. Our further analysis shows that the complementarity of AI and lean methods for developing novel products is due to the high market uncertainty associated with introducing novel products. Using lean method to provide experimentation data and AI to make sense of the data creates a virtuous cycle that can quickly find the optimal solutions in a search space and can thus alleviate some market uncertainties.

3 Dancing to The #challenge: The Effect of Tiktok on Closing The Artist Gender Gap

Yifei Wang[1], Jui Ramaprasad[1], Anandasivam Gopal[2], [1]University of Maryland, College Park, MD, [2]Nanyang Technological University, Singapore, Singapore. Contact: ywang269@umd.edu

While creative industries have a reputation for being liberal and tolerant, this has not translated into greater actual inclusivity. This study examines how a technological phenomenon called the “hashtag dance challenge” (HDC) may impact artists’ success on digital music streaming platforms and, importantly, help female artists get their work noticed. Using data from TikTok and leading music label analytics companies, we analyze the impact of HDCs on artists’ Spotify popularity growth. We find that HDCs are effective to help artists enhance their Spotify popularity; female artists are the main drivers of our results. We suggest that this results from the unique characteristics of HDCs that differentiate them from other social music platforms. Our findings shed new light on social media marketing in making the music industry more attractive to female artists.

4 Data-Driven Discovery of Technological Innovation Systems: Implications for Predicting Future Innovation

Junho Yoon[1], Gautam Pant[2], Shagun Pant[3], [1]University of Iowa, [2]University of Illinois Urbana-Champaign, Urbana-Champaign, IL, [3]University of Iowa, Iowa City, IA

We propose a data-driven framework to discover boundary-spanning technological innovation systems (TISs) by leveraging the textual information from millions of patents. We validate our framework in terms of the ability of discovered relationships to predict future innovation quantity and quality in different technology classes.

Tuesday, 12:30 PM–1:45 PM

TC79

JWM - Room 201

Advances in Theory and Application of Innovation and Product Development

General Session

Session Chair

Steve Yoo, University College London, London, United Kingdom.

1 Improving Large Scale Procurement Practices Using Naturallanguage Processing and Machine Learning

Xingyi Li[1], Onesun Steve Yoo[2], Bert De Reyck[3], [1]University College London, UCL School of Management, London, United Kingdom; [2]UCL School Of Management, University College London, London, United Kingdom; [3]Singapore Management University, Lee Kong Chian School of Business, Singapore, Singapore.

A primary challenge faced by manufacturers aiming to improve their procurement practice is that the vast amounts of purchase orders records in their system are in the form of unstructured text data. We present our work with a publicly listed food manufacturer in the UK to tackle this issue. We used natural language processing and machine learning to classify the suppliers and products into hierarchical categories. We also developed an accompanying decision support tool that helps identify the inefficiencies in their procurement spend and provides request for quote (RFQ) targets. Methodologically, our work is the first to provide an accurate 5-level hierarchical classification problem. Practically, our solution is the first to provide an accurate assessment of the currentstate of a large-scale procurement practice using a "soup" of unstructured text data.

2 The Effects of Learning Strategies on Entrepreneurial Pivots and Success: An Evolutionary Perspective

Konstantinos Ladas, Stylianos Kavadias, University of Cambridge, Cambrige, United Kingdom. Contact: s.kavadias@jbs.cam.ac.uk

To adapt and pivot their business model, entrepreneurs need to understand the business environment they operate in. These learning efforts can leverage two key strategies: experimentation or imitation (social learning) from other entrepreneurs. We present an evolutionary model that determines the optimum mix of these strategies given the complexity and instability of the business environment. We find that at the evolutionary stable strategy (ESS) equilibrium imitation enables better venture performance when the environment complexity is higher but its variability is moderate. Moreover, we analyse how biases in imitation favour or hinder its effect on performance.

3 Hybrid Entrepreneurship: An Operational Analysis

Zeya Wang[1], Morvarid Rahmani[2], Karthik Ramachandran[2], [1]Georgia Tech, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: karthik.ramachandran@scheller.gatech.edu

We investigate the debate between fully committed entrepreneurship and a hybrid approach in which the entrepreneur retains a stable "day job". A model-based investigation of the trade-offs reveals conditions under which the hybrid approach is optimal, and when it is optimal to make a full commitment. We also study how the entrepreneur's abilities and location may affect their strategy.

4 A Machine Learning Approach to Predicting Project Performance: Balancing Accurate Predictions and Interpretation

Xiaochen Gao[1], Sina Khorasani[1], Vish Krishnan[1], Jingbo Shang[1], Lakshminarayana Nittala[2], [1]University of California-San Diego, La Jolla, CA, [2]University of Dayton, Dayton, OH, Contact: xiaochen.gao@rady.ucsd.edu

We predict cost overruns and schedule delays in U.S. government contracts using advanced machine learning algorithms. We identify the most important predictors and offer recommendations that could lead to substantial time and budget savings for federal agencies.

Tuesday, 12:30 PM–1:45 PM

TC81

JWM - Room 203
Business Analytics
Contributed Session

Session Chair
Jonathan Fowler, Logicle Analytics, Greenville, SC

1 **Highway to The Danger Zone: Mathematical Underpinnings of Combat Air Patrols**
Ethan Salgado[1], Jesse Pietz[2], John V. Miller[3], [1]United States Air Force Academy, Colorado Springs, CO, [2]U.S. Air Force Academy, Monument, CO, [3]United States Air Force Academy, Gambrills, MD, Contact: c14ethan.salgado@gmail.com
Defensive counterair (DCA) operations are an important function of missile defense and essential to national security. Unfortunately, performing the required planning can be complicated and time consuming resulting in a simplified decision space or long computational wait times. These complications often yield a less than optimal decision. This paper explores the mathematical underpinnings of defensive counterair operations. We develop a closed form solution that can both determine aircraft requirements based on desired distances and determine required distances based on aircraft availability. Moreover, we explore fuel considerations for this operation and formalize expected tanker requirements for DCA operations of any length. Finally, we develop a methodology to determine how much area a DCA formation can protect.

2 **Real-Time Prediction of Employee Workload in Digital Railway Control Rooms**
Léon Sobrie[1], Marijn Verschelde[2,1], Bart Roets[3,1], [1]Ghent University, Ghent, Belgium; [2]IÉSEG School of Management, Lille, France; [3]Infrabel, Brussels, Belgium. Contact: leon.sobrie@ugent.be
Digitization and employee workload (im)balance are intertwined. To address undesirable workload peaks and lows, we propose a 2-step machine learning model to provide real-time workload analytics per controller in digital control rooms. Next to exploring different machine and deep learning approaches, we compare the performance of a model that predicts aggregate workload with the performance of the aggregate of different models that predict specific task loads. We develop a business application that utilizes the proposed model to provide detailed predictive analytics that opens the black box of workload imbalance and, in this way, empowers the control room manager with real-time insights.

3 **Sentiment Mining from Indian Hindi Language Blog Reviews**
Prabin Kumar Panigrahi, Indian Institute of Management Indore, Indore, India.
Limited work in sentiment analysis is carried out in Hindi, an Indian language and widely spoken in the Indian subcontinent. This paper explores the use of machine learning approaches for feature level sentiment categorization of Hindi blog reviews at unigram, bigram, trigram, and n-gram level. We proposed Lexicon and machine learning techniques to classify the sentiments. We used six types of machine learning techniques to study whether unigram, bigram, trigram, and n-gram will be used for sentiment mining at the feature level. Our study shows that bigram with SVM outperformed the other methods.

4 **The Effect of Data Culture Archetypes on Analytics Maturity**
Jonathan Fowler, Logicle Analytics, Greenville, SC, Contact: jonathan@logicle.us
As the discipline of data analytics becomes more indispensable to business success, organizations often aspire to establish data-driven cultures. Unlike software or infrastructure, these soft skills are more difficult to quantify and maintain. Analytics maturity assessments have typically examined culture but only at the organizational level. This leaves the diversity of abilities, perspectives, and challenges without a voice. The impact of these occupational cultures—that is, the work styles of separate divisions within an organization—on data analytics maturity remains unexplored. This research presents four primary data culture archetypes that can occur within divisions, how these archetypes work together, and how they impact data analytics maturity.

Tuesday, 12:30 PM–1:45 PM

TC82

JWM - Room 204
Healthcare Decision-making with OR and Data
General Session

Session Chair
Behshad Lahijanian, University of Florida

1 **Optimal Routing for Mobile Methadone Clinics**

Anthony Bonifonte[1], Erin Garcia[2], [1]Denison University, Granville, OH, [2]Auburn University, Auburn, AL, Contact: bonifontea@denison.edu

Methadone treatment is proven to be highly successful in combating opioid addiction and preventing overdoses, but many patients face geographic access restrictions. In 2021 the Drug Enforcement Agency changed regulations to allow for easier operation of narcotic treatment programs with a mobile component, also known as mobile methadone clinics. These mobile clinics can expand access to methadone in rural and underserved communities. In this talk we first estimate the demand for methadone in areas that do not currently have access. We then formulate the problem of planning optimal routes for mobile methadone clinics as a variant of the vehicle routing problem known as the Team Orienteering Problem with Overlaps. We solve the MIP to optimality and find mobile clinics can greatly expand access to methadone in underserved areas.

2 A Stochastic Programming Model of Health Insurance Plans Selection

Behshad Lahijanian[1], Michelle M. Alvarado[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of Florida, Gainesville, FL, Contact: blahijanian3@gatech.edu

Only 4% of the population in the United States comprehend basic health insurance terms. Selecting a health insurance plan is a complicated decision that can have severe health and financial consequences due to a lack of knowledge. A mean-risk stochastic program model is developed for the problem of selecting individual health insurance plans from the patient perspective to select a minimum-cost health insurance plan based on health premiums, covered/uncovered expenses, and deductibles for a whole year. The developed optimization model considers different network types to help people understand, compare, and choose the right health insurance plan to suit their specific needs. We present an insurance plan selection solving algorithm to determine which insurance option is recommended for an individual based on available plans.

3 A Stochastic Model for The Organ Shortage Crisis in Kidney Patients: A National Framework

Daniela Cantarino[1], Jorge Andrés Acuña[2], Mckenzi Heide[3], Monica Stevens[3], Jose L. Zayas-Castro[2], [1]University of South Florida, Tampa, FL, [2]University of South Florida, Tampa, FL, [3]University of South Florida, Tampa, FL, Contact: danieladuran@usf.edu

The organ shortage crisis has been a national issue for decades. Despite multiple attempts to reduce the waiting list, a new individual is added to the transplant waiting list every nine minutes, and an average of 17 people die each day waiting for an organ. The most significant supply-demand disparities are linked to kidney transplantations, whose unsatisfied demand exceeded 65,000 patients in 2021. This presentation discusses a stochastic approach to the national kidney shortage. Our organ allocation model considers the trade-off between post-transplantation survival rate and pre-transplantation mortality risk. Other factors considered include organ ischemic time, traveled distances and non-human organ supply. Chance-constraint optimization is applied to allow for the production of alternative organs to be satisfied with a given level of probability.

4 Long-term Care Facilities - Role of Health It in Financial, Operational, and Clinical Performance

Deepti Singh[1], Shivendu Shivendu[2], [1]California State University - Long Beach, Long Beach, CA, [2]University of South Florida, Tampa, FL, Contact: deepti.singh@csulb.edu

With a lack of understanding about the application and efficacy of IT in the long-term and post-acute care (LTPAC) facilities, we investigate how Health IT adoption and use affect the performance of these facilities. We employ both quantitative and qualitative methods to disentangle the business complexity of an organization that operates more than 200 long-term and post-acute care (LTPAC) facilities in multiple states.

Tuesday, 12:30 PM–1:45 PM

TC83

JWM - Room 205

Optimization for Practical Systems

Contributed Session

Session Chair

Sungho Shin, Argonne National Laboratory, Lemont, IL

1 Incorporating New Technologies in Eeio Models

Cindy Azuero Pedraza[1], Valerie Thomas[1], Wesley Ingwersen[2], [1]ISyE Georgia Tech, Atlanta, GA, [2]US Environmental Protection Agency, Center for Environmental Solutions and Emergency Response, Cincinnati, OH, Contact: cpedraza3@gatech.edu

We propose a methodology to add new technologies into Environmentally Extended Input Output (EEIO) models based on a Supply and Use framework. The methodology extends Input-Output tables under the assumption that a new commodity will partially substitute a functionally similar existing commodity of the baseline economy. We illustrate the method for the USEEIO model, for the addition of second generation biofuels. This methodology is designed to evaluate the environmental impacts of substituting products in the current US economy with bio-versions, produced by new technologies, that are intended to reduce negative environmental impacts. However, it can be applied for any new commodity for which the substitution assumption is reasonable.

2 Single Allocation Hub Interdiction Problems : Model Formulations and Solution Approaches

Prasanna Ramamoorthy, Saikat Mukherjee, Indian Institute of Technology Delhi, New Delhi, India. Contact: prasanna.r@dms.iitd.ac.in

Hub-and-spoke network systems have lots of applications in industrial sectors like transportation and logistics, power distribution, telecommunications, and finance. Interdiction problems on hub-and-spoke networks aims to find the critical hubs in the network. These problems are typically modeled as a bilevel static Stackelberg game between an adversary (*Stackelberg leader*) and the network operator (*follower*). Studies in literature have predominantly focused on the multiple allocation type, where non-hubs are allocated to more than one hub. In this work, we study single allocation version (non-hubs are allocated to exactly one hub) of the hub interdiction problem. We present alternate formulations to solve the problem efficiently. We also present a benders branch-and-cut reformulation which helps in solving large scale instances of the problem efficiently.

3 Text Classification and Sentiment Analysis of Reviews and Star System: A Comparison of Implicit and Explicit Expressions of Opinion

Mojtaba Talaei Khoei[1], Yiping Li[2], Asil Oztekin[3], Ann Kronrod[2], [1]University of Massachusetts Lowell, Lowell, MA, [2]University of Massachusetts Lowell, Lowell, MA, [3]University of Massachusetts Lowell, Lowell, MA, Contact: mojtaba_talaeikhoei@student.uml.edu

We performed sentiment analysis on Yelp restaurant reviews via VADER sentiment analyzer included with NLTK and kernel density estimation to estimate sentiment scores and the probability density function (PDF) of star ratings. We demonstrated that it is more probable that a customer implicitly expresses a positive opinion through text than explicitly gives a high star rating. Additionally, we used BERT transformer to perform text classification to predict star ratings based on the wordings of reviews. Comparing the text-based predicted star as an implicit measure of opinion to actual star rating as an explicit manifestation of sentiment highlights the complex relationships between the polarity of the text of the reviews and actual star ratings. We showed that 3-star system comparing to 5-star system aligned the sentiment of the texts and star ratings better.

4 NEAR-OPTIMAL PERFORMANCe of STOCHASTIC PREDICTIVE CONTROL

Sungho Shin[1], Sen Na[2], Victor M. Zavala[3], Mihai Anitescu[4], [1]Argonne National Laboratory, Lemont, IL, [2]University of California-Berkeley, Berkeley, CA, [3]University of Wisconsin-Madison, Argonne, IL, [4]Argonne National Laboratory, Argonne, IL, Contact: sshin@anl.gov

The computation of optimal decision policies for sequential decision-making under uncertainty has been recognized as a challenging problem. In online control, the intractability of multi-stage stochastic programs is typically addressed by a stochastic predictive control framework, which seeks to solve the full multi-stage problem by using a sequence of multi-stage stochastic programs with truncated prediction horizons. In this presentation, we show that the performance loss caused by truncation decays exponentially in the prediction horizon length under a linear-quadratic control setting and under robust stabilizability and detectability assumptions. That is, stochastic predictive control can achieve near-optimal performance.

Tuesday, 12:30 PM–1:45 PM

TC84

JWM - Room 206

Simulation and AI

General Session

Session Chair

Wei Xie, Northeastern University, Boston, MA

Session Chair

Ben Mingbin Feng, University of Waterloo, Waterloo, ON, Canada.

1 Nested Simulation in Financial Engineering: A Review

Xintong Li, Ben Mingbin Feng, University of Waterloo, Waterloo, ON, Canada. Contact: ben.feng@uwaterloo.ca

Nested simulation arises in financial engineering problems such as risk measurement for financial portfolios: Outer level generates plausible evolutions, or scenarios, of underlying risk factors. Given a scenario, inner simulations are run to estimate the portfolio loss in that scenario. The estimated losses are then used to estimate risk measures of interest. Innovative methods, such as the regression-based method, kernel smoothing, the likelihood ratio method, kernel ridge regression, etc., have been proposed to alleviate nested simulation's computational burden. We present a survey study to compare the experiment designs, convergence rates, and practical performances in different applications. Our study shows that some methods have consistently good performances while other methods' performances depend on problem structures like the dimensionality.

2 Multi-level Probabilistic Branch and Bound with Importance Sampling and Surrogate Modeling

Pariyakorn Maneekul[1], Hao Huang[2], Danielle Morey[3], Giulia Pedrielli[4], Zelda B. Zabinsky[1], [1]University of Washington, Seattle, WA, [2]Yuan Ze University, Taoyuan, Taiwan; [3]University of Washington, Seattle, WA, [4]Arizona State University, Tempe, Contact: parim@uw.edu

Probabilistic Branch and Bound (PBnB) approximates a level set by branching subregions and statistically classifying them as maintained (inside the level set) or pruned (no intersection with the level set). Whereas original PBnB uses uniform sampling and branches all unclassified subregions, multi-level PBnB uses importance sampling to identify promising subregions for classification. We propose to use Gaussian processes as a surrogate model to guide the importance sampling distribution and aid in classifying subregions. We present the proposed algorithm with a finite-time performance analysis in terms of incorrect pruning and maintaining of subregions of the solution space. Numerical experiments on benchmark problems are presented.

3 Green Simulation Assisted Policy Gradientto Accelerate Stochastic Process Control

Wei Xie[1], Hua Zheng[2], Ben Mingbin Feng[3], [1]Northeastern University, Boston, MA, [2]Northeastern University, Boston, MA, [3]University of Waterloo, Waterloo, ON, Canada. Contact: w.xie@northeastern.edu

To support the optimal and robust process control, we propose a general green simulation assisted policy gradient (GS-PG) framework for both online and offline learning settings. Basically, to address the key limitations of state-of-art reinforcement learning (RL), such as sample inefficiency and low reliability, we create a mixture likelihood ratio based policy gradient estimation that can leverage on the information from historical experiments conducted under different inputs, including process model coefficients and decision policy parameters. Then, to accelerate the learning of optimal and robust policy, we further propose a variance reduction based sample selection method that allows GS-PG to intelligently select and reuse most relevant historical trajectories.

4 Over-conservativeness of Variance-based Efficiency Criteria and Probabilistic Efficiency in Rare-event Simulation

Yuanlu Bai[1], Zhiyuan Huang[2], Henry Lam[1], Ding Zhao[3], [1]Columbia University, New York, NY, [2]Tongji University, Shanghai, China; [3]Carnegie Mellon University, Pittsburgh, PA, Contact: yb2436@columbia.edu

In rare-event simulation, an importance sampling (IS) estimator is regarded as efficient if its relative error, namely the ratio between its standard deviation and mean, is sufficiently controlled. It is widely known that when a rare-event set contains multiple “important regions” encoded by the dominating points, IS needs to account for all of them via mixing to achieve efficiency. We argue that missing less significant dominating points may not necessarily cause inefficiency, and the traditional analysis recipe could suffer from intrinsic looseness by using relative error, or in turn estimation variance, as an efficiency criterion. We propose a new efficiency notion called “probabilistic efficiency” to tighten this gap. The new notion is especially relevant in high-dimensional settings where the computational effort to locate all dominating points is enormous.

Tuesday, 12:30 PM–1:45 PM

TC85

JWM - Room 207

Management of Technology

Contributed Session

Session Chair

Thien Dong, Georgia Institute of Technology, Atlanta, GA

1 How Can Biotechs Unlock Value from Drug Development Collaborations?

Devashish Thakar[1], Sean Handley[1], Keith C. Skowronski[2], Manpreet Singh Hora[3], [1]University of South Carolina, Columbia, SC, [2]University of South Carolina, Columbus, OH, [3]Georgia Institute of Technology, Atlanta, GA

Drug development collaborations are highly sought after by pharma firms to source intellectual property from biotech firms. However, these collaborations are fraught with scientific uncertainty and incomplete information, forcing pharma firms to hedge their risk. This entails controlling collaborative value creation through control rights (value rights) and minimizing upfront payments (upfronts) to the biotech. Our empirical analysis suggests a nuanced interplay of pharma and biotech capabilities that determine the allocation of value rights and upfronts.

2 New Technology Product Introduction Strategy with Considerations for Consumer-targeted Policy Intervention and New Market Entrant

Hyunhong Choi[1], Yoonmo Koo[2], Jungwoo Shin[1], [1]Kyung Hee University, Yongin, Korea, Republic of; [2]Seoul National University, Seoul, Korea, Republic of. Contact: hongchoi@khu.ac.kr

This study investigates the optimal strategies for companies to adjust and forecast their product portfolio when the market is facing technological changes. Specifically, we consider the impact of relevant policies and market entrance of the new producer on such strategies for South Korean automotive market. The results show that stronger policy intervention and new market competition will motivate producers to introduce abundant and less-expensive BEVs in their product lines, thus significantly expanding the BEV market. Moreover, a product introduction strategy, which considers long-term policy interventions, could significantly improve market performance of new products by approximately 40%. Finally, the active response (plan adjustment) of the producers to competitions could significantly reduce competition-related losses by approximately 9%.

3 Maximizing Equipment Profitability Through Investments in Internet of Things for Preventative Maintenance

Mateus Ferreira-Lima[1], Elliot Bendoly[1], Nathan C. Craig[2], [1]The Ohio State University, Columbus, OH, [2]Ohio State University, Columbus, OH, Contact: doregoferreiralima.1@buckeyemail.osu.edu

We develop an analytical model for maximizing equipment profitability considering maintenance events and Internet of Things (IoT). Our work highlights current efforts of industries to move towards condition-based approach that uses abundant and real-time data with high accuracy from devices embedded into the equipment to guide maintenance decisions. Our study was inspired by logistics companies that use forklifts for warehouse operations and private jet operators. In both cases, there is an interest from both the original equipment manufacturers and the business customer in the data collected from IoT. Managerial implications from our study involve considerations on 1) optimal technology investment to maximize equipment lifetime, and 2) degradation of equipment quality for the design of buy-back contracts.

4 Keep Your Enemies Closer: The Appropriation Risk to Start-ups Receiving Cvc Funding

Thien Dong, Georgia Institute of Technology, Atlanta, GA, Contact: mythien@gatech.edu

Empirical findings of the performance implications for CVC-backed ventures are equivocal. We seek to answer how potential benefits of CVC investments for the investee venture may be compromised by the extent to which the latter is deemed as a direct competitor to the parent corporation in both commercial and technological terms. We employ unsupervised ML, CEM, IV estimation, and panel data to control for endogeneity. Our results suggest that the negative effects are mitigated by the extent to which the venture's product boosts the demand for the parent firm's technology. Problem space overlap, and to a lesser extent, technology proximity are positively correlated with the likelihood of the venture being acquired by the corporate parent, who is also expected to acquire the invested venture at a discount.

Tuesday, 12:30 PM–1:45 PM

TC99

CC - Exhibit Hall D
Tuesday Poster Competition
Poster Session

Session Chair
Jun Zhuang, University at Buffalo, Buffalo, NY

Session Chair
Changhyun Kwon, University of South Florida, Tampa, FL

Poster Competition

Changhyun Kwon, University of South Florida, Tampa, FL, Contact: chkwon@usf.edu

Finalists will be chosen during the Sunday and Monday Poster session and will present again in the competition.

Tuesday, 2 PM–3:15 PM

TD01

CC - Room 101
Machine Learning Applications and Data-centric AI
General Session

Session Chair
Ozlem Cosgun, Harrisburg University of Science and Technology, Mechanicsburg, PA

Session Chair
Nguyen Quoc, Ho Chi Minh, Viet Nam.

Session Chair
Quoc Quoc, 1</sup

Session Chair
Trung Le, North Dakota State University, Fargo, ND

1 **Determination of The Most Significant Covid-19 Related Factors in The Efficiency Prediction of The Nursing Homes Using The Integration of DEa and ML Approaches**
Ozlem Cosgun, Amjad Umar, Harrisburg University of Science and Technology, Harrisburg, PA, Contact: ocosgun@harrisburgu.edu
Performance assessment of the nursing homes and the improvement of the inefficient nursing homes have the highest priority because nursing homes constitute a large and costly part of the overall health care industry, and the high percentage of the COVID-10 deaths are among the older people. Efficiency prediction of the nursing homes and understanding of the most significant factors that affect their efficiency are also so crucial to take proactive actions to improve their efficiencies. So, we used a hybrid approach that integrates DEA and ML techniques to assess and predict the performance of the nursing homes and make a comparison between the regions of PA state, and then determine the most significant factors that affect the efficiency of the nursing homes.

2 **Presenter**
Burak Cankaya, Embry Riddle Aeronautical University, Lake Mary, FL

3 **Estimating Freight Arrival Time from Historical Procurement Data: An Electronics Complete/Semi-Knock-Down Case**
Juhuhn Kim[1], Jong-Seok Lee[2], [1]Sungkyunkwan University, Suwon, Korea, Republic of; [2]Sungkyunkwan University, Suwon, Korea, Republic of. Contact: juhuhn@skku.edu
Freight arrival time estimation is an important factor in freight transportation punctuality, especially in the electronics manufacturing industry. Despite technical advancements, because of the countless combinations of parts packaged together, the current electronics sector still relies on manual efforts to predict freight arrival time. This research proposes a data-driven method to predict the estimated time of arrival (ETA) to resolve inefficiency and improve freight transportation punctuality. Using stacked random forest, the proposed method calculates the ETA of multimodal freight transport. Its validity is proved using data from a real-world electronics company that operates complete knock-down and semi-knock-down procurements.

4 **Evacuation Order Effectiveness and Community Behavior: Enabling Strategic Data-driven Decision Making Through Big Data**
Harsh Anand, Majid Shafiee-Jood, Negin Alemazkoor, University of Virginia, Charlottesville, VA, Contact: yyf8rj@virginia.edu
Enforcement of hurricane preparedness plans, such as the issuance of evacuation orders, is an imperative step toward reducing social vulnerability, in terms of both human suffering and economic loss. Yet are these evacuation orders actually effective? To address this question, our study (1) analyzes evacuation decisions as a function of government-issued evacuation orders and (2) examines how the evacuation behavior of communities varies based on socio-economic and demographic factors. We leverage big data (including high-fidelity mobility and demographic data) to consider the interdependence between emergency management and community mobility. Our analysis can help emergency managers and policymakers develop a strategic decision-support aid to maximize the effectiveness of evacuation orders.

Tuesday, 2 PM–3:15 PM

TD02

CC - Room 102
Recent Advances on Computation and Learning of Mean-field Games and Control
General Session

Session Chair
Junzi Zhang, Amazon.com Services LLC, Palo Alto, CA

Session Chair
Jiacheng Zhang, 1</sup

1 **Entropy-Regularized Mean-Field Games and Graphon Mean-Field Games**
Kai Cui, Technische Universität Darmstadt, Darmstadt, Germany.

In this talk, we begin by considering discrete-time finite MFGs subject to finite-horizon objectives. We show that all non-trivial finite MFGs fail to be contractive as often assumed, barring convergence via fixed point iteration. Instead, we incorporate entropy-regularization and softmax policies into the fixed point iteration. As a result, we obtain provable convergence to approximate fixed points, potentially reaching the original goal of approximate Nash equilibria. In the second half of the talk, we briefly discuss a generalization of discrete-time MFGs to dense graphs -- graphon mean field games (GMFG). On the theoretical side, we show existence of solutions as well as the approximate Nash property in large, finite graph systems. On the practical side, we provide learning algorithms by discretization, as well as by recasting the GMFG as a classical MFG.

2 Machine Learning Approaches for Solving Stackelberg Mean Field Game

Gokce Dayanikli, Columbia University, New York, NY, Contact: day.gokce@gmail.com

In this talk, we discuss a one-level numerical approach that uses machine learning techniques to solve bi-level Stackelberg mean field game problem between a principal and a mean field of agents evolving on a continuous state space. The agents play a non-cooperative game and choose their controls to optimize their individual objectives by interacting with the principal and other agents in the society through the population distribution. The principal can influence the resulting mean field game Nash equilibrium through incentives so as to optimize its own objective. We analyze this game by using a probabilistic approach. We then propose a generalized one-level numerical approach to solve the Stackelberg mean field game. We look at different applications such as the systemic risk model for a regulator and many banks. Finally, if time permits, we discuss convergence results.

3 Reinforcement Learning Algorithm for Mixed Mean Field Control Games

Jimin Lin, University of California, Santa Barbara, Santa Barbara, CA

We present a new combined Mean Field Control Game (MFCG) problem which can be interpreted as a competitive game between collaborating groups and its solution as a Nash equilibrium between the groups. Within each group the players coordinate their strategies. An example of such a situation is a modification of the classical trader's problem. Groups of traders maximize their wealth. They are faced with transaction cost for their own trades and a cost for their own terminal position. In addition they face a cost for the average holding within their group. The asset price is impacted by the trades of all agents. We propose a reinforcement learning algorithm to approximate the solution of such MFCG problems.

Tuesday, 2 PM–3:15 PM

TD03

CC - Room 103

Data Analytics in Manufacturing Industry

General Session

Session Chair

Dohyun (Norman) Kim, Myongji University

1 Classification Algorithm Based on Label Embedding Using Contrastive Learning

Jeongjoon Hwang, Somi Ha, Dohyun (Norman) Kim, Myongji University, Yongin-si, Gyeonggi-do, Korea, Republic of. Contact: hjj1216@mju.ac.kr

Most classification algorithms do not use label information, but only use feature information of the data to solve classification problems in manufacturing industry. In this study, a new classification algorithm has been proposed to consider label and feature information simultaneously. To this end, we consider the classification problem as a feature and label embedding problem. The proposed algorithm classifies observations as well as identifies relationships between features and labels by embedding them in the same latent space using contrastive learning.

2 Class Imbalance Handling in Latent Space Using Deep Neural Network

JeongEul Kwon, Ki Jeong Choi, Dohyun (Norman) Kim, Myongji University, Yongin-si, Gyeonggi-do, Korea, Republic of. Contact: 60192466@mju.ac.kr

Class imbalance issues often arise when analyzing the manufacturing process data. Typically, resampling methods are utilized to solve the problems. However, these methods often generate data points that do not help train a classification model. Therefore, we propose a novel data resampling method in the latent space of hidden layers of the trained neural network, rather than the input space. Experimental results show that the proposed method helps to build a classification model with better generalization performance by generating data suitable for training the model in the unbalaned class problem.

3 Deep Learning Based Recommender System Using Cross Convolutional Filters

Seungyeon Lee, Columbus
Recommender systems have increasingly attracted attention in various domains. The recommender system supports the users' decision making by recommending items that are more likely to be preferred. Many studies in the field of deep learning-based recommender systems have attempted to capture the complex interactions between users' and items' features for accurate recommendation. In this paper, we propose a recommender system based on the convolutional neural network using the outer product matrix of features and cross convolutional filters. The proposed method can deal with the various types of features and capture the meaningful interactions between users and items, giving greater weight to important features. Experiments showed that the proposed method outperforms the existing methods, by capturing important interactions and alleviating the overfitting.

4 An Analysis Framework of Customer Survey Data About Quality Experience for B2b Companies

Eunbeom Jung[1], Hansub Song[1], Shin Hwan Kim[1], Youngtae Jeon[1], Jungwoo Pyun[1], Sangwoo Pae[1], Seung Hoon Tong[2,3], [1]Samsung Electronics, Hwaseong-si, Korea, Republic of; [2]Samsung Electronics, Yongin-Si, Korea, Republic of; [3]Samsung Institute of Technology (SSIT), Yongin-si, Korea, Republic of.
Customer survey data for quality is shared in a non-unified format for each B2B customer and contains various topics that reflect customer experiences. In this case, data pre-processing based on a unified format is essential for survey data management and in-depth analysis. A unified classification structure of survey data was developed under considering customer emotions, experiences. We then utilized conventional data science and/or mining methodologies such as statistical hypothesis test, control charts, text mining, etc. We suggested an analysis framework to quantify, compare and trace periodically the status of customer satisfaction. And it was applied effectively to real-world customer survey data from a global memory semiconductor company.

Tuesday, 2 PM–3:15 PM

TD04

CC - Room 104

Data-driven Sequential Decision Making: Bandits and Reinforcement Learning

General Session

Session Chair

Min-hwan Oh, Seoul National University, Seoul, Korea, Republic of.

1 Learning Temporally-extended Actions with Risk-sensitive Q-learning

Joongkyu Lee[1], Seung Joon Park[1], Yunhao Tang[2], Min-hwan Oh[1], [1]Seoul National University, Seoul, Korea, Republic of; [2]DeepMind, London, United Kingdom. Contact: jklee0717@snu.ac.kr
In reinforcement learning, temporal abstraction in action space is a common approach to simplifying the learning process of policies through temporally-extended courses of action. In recent work, temporal abstractions are often modeled as repeating the chosen action for a certain duration. A major drawback to prior work is that reckless action repetitions may lead to sub-optimal behavior, seriously degrading performance. We propose a novel uncertainty-aware action repetition method named Risk-Sensitive Action Repetition (RiSAR), which leverages ensemble methods to calibrate uncertainty. With a risk sensitive hyper-parameter, RiSAR can induce exploration-favor or risk-averse policy. We empirically demonstrate the efficacy of RiSAR on both simple grid and Atari2600 environments, showing better performance over alternative algorithms.

2 Model-based Reinforcement Learning with Multinomial Logistic Function Approximation

Taehyun Hwang, Min-hwan Oh, Seoul National University, Seoul, Korea, Republic of. Contact: th.hwang@snu.ac.kr
We study model-based reinforcement learning (RL) for episodic Markov decision processes (MDP) whose transition probability is given by a multinomial logistic model with an unknown transition core and features of state and action. To balance the exploration-exploitation trade-off, we propose an upper confidence bound-based algorithm. We show that our proposed algorithm achieves ⍰$(dH^{3/2}T^{1/2})$ regret bound where d is the dimension of the transition core, H is the horizon, and T is the total number of steps. To the best of our knowledge, this is the first model-based RL algorithm with multinomial logistic function approximation with provable guarantees. We also comprehensively evaluate our proposed algorithm numerically and show that it consistently outperforms the existing methods, hence achieving both provable efficiency and practical superior performance.

3 Near-optimal Algorithm for Linear Contextual Bandits with Hybridization by Randomization

Wonyoung Kim[1,1], Min-hwan Oh[2], Myunghee C. Paik[3], [1]Columbia University, New York, NY, [2]Seoul National University, Seoul, Korea, Republic of; [3]Seoul National

University, Seoul, Korea, Republic of. Contact: eraser347@snu.ac.kr

We propose a provably near-optimal algorithm for linear contextual bandits with O(√d√T√log T) regret bound, where d is the dimension of contexts and T is the time horizon. To our knowledge, this is the fastest-rate regret bound for linear contextual bandits. Our proposed algorithm is equipped with a novel estimator in which exploration is embedded through explicit randomization. We establish a self-normalized bound for our estimator, which allows a novel decomposition of the cumulative regret into *additive* dimension-dependent terms instead of multiplicative terms. We also prove a novel lower bound of Ω(√d√T) under our problem setting and the regret of our proposed algorithm matches the lower bound up to logarithmic factors.The numerical experiments support the theoretical guarantees and show that our proposed method outperforms the existing linear bandit algorithms.

4 Bayesian Design Principles for Frequentist Bandit and Reinforcement Learning

Yunbei Xu, Assaf Zeevi, Columbia University Graduate School of Business, New York, NY, Contact: yunbei.xu@gsb.columbia.edu

We propose a general framework to study frequentist bandit and reinforcement learning, where concepts from Bayesian inference are essential for algorithm design and regret analysis. We develop general algorithm design principles and study related complexity measures that apply in various bandit and reinforcement learning problems. In particular, we propose to design "algorithmic priors" instead of frequentist estimators; and rely on posterior updates instead of traditional frequentist decision rules. Regret behavior for this class of algorithms can often be shown to be best possible. Moreover, the algorithms are simple and often efficient to implement.

Tuesday, 2 PM–3:15 PM

TD05

CC - Room 105

Recent Developments in Statistical Models and Analytical Methods for Engineering and Business Applications

General Session

Session Chair

Wenbo Wu, University of Texas at San Antonio, San Antonio, TX

1 On Sufficient Variable Screening Using Log Odds Ratio Filter

Wenbo Wu, University of Texas at San Antonio, San Antonio, TX

For ultrahigh-dimensional data, variable screening is an important step to reduce the scale of the problem, hence, to improve the estimation accuracy and efficiency. In this paper, we propose a new dependence measure which is called the log odds ratio statistic to be used under the sufficient variable screening framework. The sufficient variable screening approach ensures the sufficiency of the selected input features in modeling the regression function and is an enhancement of existing marginal screening methods. In addition, we propose an ensemble variable screening approach to combine the proposed fused log odds ratio filter with the fused Kolmogorov filter to achieve supreme performance by taking advantages of both filters. Extensive simulations and a real data analysis are provided to demonstrate the usefulness of the proposed procedure.

2 Corporate Probability of Default: A Single-index Hazard Model Approach

Shaobo Li, University of Kansas, Lawrence, KS, Contact: shaobo.li@ku.edu

We propose a default-prediction single-index hazard model (DSI) and discover an interesting "V-shaped" relationship between the probability of default and company's financial characteristics based on the U.S. publicly traded firms. The proposed DSI model passes the Hosmer-Lemeshow goodness-of-fit test while neither does two popular benchmark models. In an economic value analysis, we find that this may translate to as much as three times of profit comparing to the linear hazard model. We also conduct a simulation study and show the effectiveness of the proposed method. Furthermore, we reexamine the distress risk anomaly via the popular three- and five-factor asset pricing models. We find that the anomaly has weakened or even disappeared during the extended period including 2008 financial crisis.

3 A Nonparametric Method of Detecting General Correlation Between a Continuous Dependent Variable and a Group of Independent Variables and Some Preliminary Applications

Nuo Xu[1], Xuan Huang[2], [1]University of Alabama, Birmingham, AL, [2]University of Alabama at Birmingham, Birmingham, AL, Contact: nuoxu@uab.edu

In a previous paper of ours, we constructed a general correlation coefficient that uses the absolute value of first difference on adjacent ranks of one variable with respect to the other. We were approached by users of this coefficient asking whether this coefficient can be generalized from bivariate into multivariate relationship. In this talk, we present a method of generalizing this coefficient to capture general correlation coefficient between a continuous independent variable and a group of N dependent variables. Some preliminary application results in bioinformatics are shared.

4 How Should Firms Communicate on Social Media During Disasters? a Competing Value Framework for Disaster Management

Feng Mai[1], Bei Yan[1], Chaojiang Wu[2], Xiaolin Li[3], Rui Chen[4], [1]Stevens Institute of Technology, Hoboken, NJ, [2]Kent State University, Kent, OH, [3]Towson University, Towson, MD, [4]Iowa State University, Ames, IA

Little research has theorized and evaluated firms' social media strategies during disasters despite the availability of online datasets. Developing the competing values framework (CVF) in disaster management, we conceptualize firms' social media communication strategies as four disaster management values (i.e., control, create, collaborate, compete) based on two competing value dimensions (internal vs. external and stable vs. flexible). We propose a novel natural language processing (NLP) model to measure the disaster management values in Facebook messages posted by Russell 3000 firms on multiple disasters between 2007 and 2021. We further extend the framework by assessing the impact of disaster management values on social media engagement.

Tuesday, 2 PM–3:15 PM

TD06

CC - Room 106

Multimodal Fusion with Application to Medicine, Military, and Beyond (Part 2)

General Session

Session Chair

Nathan B. Gaw, Air Force Institute of Technology, Beavercreek, OH

1 Federated Learning on Telemonitoring of Parkinson's Disease Patients

Brandon Harvill[1], Chancellor Johnstone[1], Nathan B. Gaw[2], [1]Air Force Institute of Technology, Wright-Patterson AFB, OH, [2]Air Force Institute of Technology, Beavercreek, OH

Federated Learning (FL) is a budding technique that seeks to keep data private, while overcoming the difficulties of Big Data. It does this by training a machine learning model over a distributed network of devices. FL is especially useful for healthcare data, for which there is a high priority to keep patient-specific data private and to consider a high level of heterogeneity between the patients. We use an FL technique on a Parkinson's Disease (PD) Telemonitoring dataset where physiological data is gathered from voice signals and tapping modalities to determine the severity level in patients. We seek to optimally combine the information across the two modalities to assess the accuracy of the FL technique, compared to a traditional cloud model, and understand the underlying sources that contribute to PD progression.

2 Generalized Robust Feature Selection

Bradford "Levi" Lott[1], Mark A. Gallagher[2], Bruce Cox[3], [1]Air Force Institute of Technology, Wright Patterson AFB, OH, [2]Air Force Institute of Technology, Columbus, OH, [3]USAF, Oakwood, OH

Our algorithm may be applied to both supervised and unsupervised datasets. If unsupervised, clustering is performed and used as a categorical response. Our approach identifies salient features robust to the subsequent predictive model. The proposed algorithm considers all provided variables, square variables, and two-way interactions as an extended data set. The algorithm implements a forward selection approach, based on correlation with the response, while fitting deep neural networks to the selected variables. These deep neural networks maintain an adaptive architecture which mirrors a full factorial experimental design. These networks assess both numeric and categorical values for both features and responses. Compared to existing methods including the family of Boruta techniques, our method maintains fewer features and improves predictive accuracy.

3 Data Fusion for Multi-scale Mixed Modality Microstructure Characterization to Find Failure Modes in Titanium Metal Armor of Aircraft

Nathan Johnston[1], John Wertz[2], Erik Blasch[3], Matthew Cherry[2], Sean O'Rourke[2], Nicholas Lorenzo[4], Laura Homa[4], Nathan Gaw[1], [1]Air Force Institute of Technology, Dayton, OH, [2]Air Force Research Laboratory, Wright Patterson Air Force Base, OH, [3]Air Force Research Laboratory, Arlington, VA, [4]University of Dayton Research Laboratory, Dayton, OH

Some aircraft engine failures have been linked to early onset fatigue cracking initiating at microtexture regions within titanium alloy-based engine components. These microtexture regions can be characterized using scanning electron microscopy; however, this laboratory-based characterization method cannot be feasibly applied to large-scale engine components. We propose using an automatic image registration technique to fuse the data from two different sources (scanning acoustic microscopy and eddy current testing) in an effort to reduce the resource requirements to characterize microtexture regions in titanium engine components.

4 Multimodal Modeling for Post-traumatic Headache of Student Athletes

Byungmoo Kim[1], Nathan B. Gaw[2], [1]Air Force Institute of Technology, Dayton, OH, [2]Air Force Institute of Technology, Beavercreek, OH, Contact: byungmoo.kim@afit.edu

Approximately 1.7 million people suffer from traumatic brain injury (TBI) annually. Among these, post traumatic headache (PTH) is the most common symptom following TBI, which can either resolve or continue into persistent PTH (PPTH), and can eventually lead to lasting brain damage or even death. However, recognizing PTH in the early stages and getting treatment quickly dramatically increases a patient's chance of PTH being cured. Using data from NCAA athletes, this project builds a multi-modality machine learning model of clinical measures among student athletes to predict PTH persistence and recognize highly relevant biomarkers.

Tuesday, 2 PM–3:15 PM

TD07

CC - Room 107

Bringing the CAP to Life Within Your Organization

General Session

Session Chair

Matthew A. Lanham, Purdue University, Lafayette, IN

1 Presenter

Aaron Burciaga, ECS, LEESBURG, VA

2 Analyzing The Profile of The Informs Certified Analytics Professional (cap)

Matthew A. Lanham, Purdue University, Lafayette, IN

The INFORMS Certified Analytics Professional (CAP) has potential to improve outcomes of organizations that employ those whom have earned this credential. However few organizations are "CAP Preferred Employers" as the value of the credential is still being measured. We provide an analysis of the profile of a CAP and aCAP, where they work, what skills differentiate CAPs from popular analytics roles (e.g. Data Analysts, Data Scientists, etc.), and how roles have changed pre-post CAP achievement.

3 Raising The Bar on Analytics Professional Development: What Distinguishes The Certified Analytics Professional (cap) from The Rest of The Pack

Shaun Doheney, Amazon Web Services (AWS), Stafford, VA

Certifications measure your knowledge and skills against industry- and vendor-specific benchmarks to prove to employers that you have the right skillset. In a rapidly expanding sea of analytics-related certifications, how does one choose the certification that will provide them an edge in an analytics career? Is formal education enough to set you apart from the rest in the hiring process? Hiring managers prize well-rounded, hardworking, and industrious candidates technically skilled in their professional field. In this presentation, we will discuss the differences between technology- or vendor-focused certifications, the Certified Analytics Professional (CAP) certification, and professional development strategies that raise the bar to identify, recruit, and retain top analytics talent.

Tuesday, 2 PM–3:15 PM

TD08

CC - Room 108

Big Data Analytics and Decision Optimization for Precision Agriculture

General Session

Session Chair

Shouyi Wang, University of Texas at Arlington, Arlington, TX

Session Chair

Linh Ho Manh, 1</sup

1 A Crop Yield Prediction Model for The Us Corn Belt Integrating Crop Simulation Model with Ensemble Model

Saiara Samira Sajid, Guiping Hu, Iowa State University, Ames, IA, Contact: sajids@iastate.edu

In precision agriculture, reliable crop yield prediction plays a vital role. We proposed a crop yield prediction model that combines a crop simulation model (APSIM) with machine learning (ML) models. The proposed model is an ensemble model where optimized weight is assigned to based models. The optimum weight was selected by minimizing the ensemble model's Root Mean Squared Error (RMSE). This model was evaluated by predicting the corn yield of 12 states of the US Corn Belt from 2018 to 2019. The model had an average Relative Root Mean Squared Error (RRMSE) of 9.28%. Intending to apply the model on a vast scale, it is necessary to have some interpretability of the model performance. Hence, with additional analyses, it was discovered that areas (counties or crop reporting districts) with higher cropland ratios have lower errors compared to areas with lower cropland ratios.

2 Integrated Sprayer Routing Problem and Synchronized Mobile Tanker for Precision Agriculture

Faisal M. Alkaabneh, Rabiatu Bonku, North Carolina A&T State University, Greensboro, NC, Contact: fmalkaabneh@ncat.edu

This work is motivated by solving a problem related to assigning sprayers to various locations on a big farm to perform spraying operations, combining sprayers' visits into efficient routes, and the assignment of tanker to refill the sprayers' tanks once they run out of chemicals. We model this unique problem as an integrated vehicle routing problem with a synchronized schedule between the sprayers' and the tanker for refilling due to the fact that the sprayers' tank capacity is significantly less than the tanker's tank capacity. Hence, it is a challenging problem to tackle mainly due to the interdependence problem that stems from the Spatio-temporal synchronization requirement between the sprayers and the tanker. We propose a matheuristic to solve large-scale instances efficiently.

3 Crop Green Water Footprint Estimation Using Earth Observation, Physics Model and Ai

Kamal Das[1], Jagabondhu Hazra[2], Ranjini Bangalore[1], Jitendra Singh[3], Shantanu Godbole[1], [1]IBM Research, Delhi, India; [2]IBM Research India, Bangalore, India; [3]IBM Research, Delhi, India. Contact: kdas3@in.ibm.com

Without a doubt, water shortages will contribute to the future global crisis of available resources and climate change exacerbating water scarcity. Therefore, increasing water use efficiency and better management of existing resources have become substantially important. The agricultural sector is responsible for around 80% of global freshwater withdrawal. The water footprint (WF) of any agricultural product has three components: green, blue and grey water and is generally determined by the yield and the volume of water used during the crop-growing period. Estimation of crop water footprint is first step towards water sustainability under changing climate and regional crop management practices. In this talk, we present new technique to estimate crop green WF using earth observations and ML to address WF variations for a specific crop for multiple climate zones.

4 A Multi-task Learning Based Model with Enhanced Interpretability for Grape Yield Prediction

Luning Bi, Guiping Hu, Iowa State University, Ames, IA

Accurate yield estimation techniques which can provide information for management decision-making is of critical importance in precision agriculture. Instead of using growing degree days (GDD) for grape yield prediction, this paper presents a deep learning-based method to extract the information from time-series weather data. Then the model is pre-trained to learn the multiple tasks related to the yield prediction, e.g., bloom date, veraison date, etc. Furthermore, some assumptions prior knowledge about the input variables and yield are incorporated into the model. The results of the case study show that compared to GDD method and other baseline models, the proposed approach can reduce the error percentage by up to 15%.

5 Decision Support System for Agricultural Markets

Xaimarie Hernandez Cruz[1], J. Rene Villalobos[1], George Runger[2], Grace Neal[2], Francisca Quijada Dibarrart[1], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, AZ, Contact: xhernan5@asu.edu

Recent events such as diet trends and the COVID-19 pandemic have shed light on several inefficiencies of the traditional fresh fruits and vegetables (FFV) supply chains (SCs). One of the challenges that has been identified is the lack of market information that is available to aid horticultural planning. In this work, we present a set of tools created to include market intelligence in the agricultural SC in order to reduce losses related to market prices and demands, avoid scarcity events in which food availability and affordability decrease, and aid small growers by alerting them of future market opportunities. Statistical monitoring techniques and supervised learning models are used to develop a market intelligence framework for agriculture applications.

Tuesday, 2 PM–3:15 PM

TD09

CC - Room 109

PSOR Flash Session II

Flash Session

Session Chair
Deniz Emre, University of Oklahoma, Norman, OK

1 A Bilevel Define-Combine Formulation with Applications to Political Redistricting

Ian G. Ludden[1], Douglas M. King[2], Sheldon H. Jacobson[1], [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]University of Illinois Urbana-Champaign, Urbana, IL

In the recently proposed define-combine procedure (DCP) for political redistricting, one party, the definer, draws 2N subdistricts which are then paired up by the other party, the combiner, to produce an N-district map. The definer problem is balanced, connected graph partitioning, and the combiner problem is max-weight perfect matching on the adjacency graph of the definer's subdistrict plan. In this talk, we introduce DCP-IP, a bilevel mixed-integer linear programming formulation for DCP. Results are reported for DCP-IP on synthetic and real-world redistricting instances. We conclude with a discussion of the limitations of DCP and potential applications beyond redistricting.

2 Consideration of Mobile-based Floating Population Data in Assigning Cooling Shelters During Heat Waves

Sang Jin Kweon, Ulsan National Institute of Science and Technology, Ulsan, Korea, Republic of.

We present an integer linear programming model for allocating cooling shelters during heat waves with the two conflicting objectives of maximizing coverage for the heat-vulnerable population and minimizing the total operating cost of the cooling shelters. We include the temperature-humidity index measuring the level of heat waves and also introduce data analysis procedures using mobile-based floating population data to track the hourly number and locations of heat-vulnerable population. The proposed model is applied to Ulsan Metropolitan City in South Korea in which heat-vulnerable people are assigned to existing and potential cooling shelters. We categorize and prioritize heat-vulnerable people into several groups, and we suggest effective policy recommendations, so the most vulnerable people are provided cooling services first.

3 Distrix and Fastmap: Addressing America's Gerrymandering Problem with a Puzzle Book, Strategy Game, and Computer Algorithm

Matthew Petering, University of Wisconsin-Milwaukee, Milwaukee, WI, Contact: mattpete@uwm.edu

We describe three recent projects aimed at increasing the fairness of political districts in the USA. The Distrix Puzzle Book contains 90 brainteasers which challenge readers to draw election districts that are rigged in favor of different parties or made fair. The award-winning Distrix game system introduces a new method for political redistricting in which two players form election districts in a high-stakes duel, one voting precinct at a time. The FastMap computer algorithm considers 15 redistricting criteria when creating maps of congressional, state legislative, and local election districts. It generated the most politically fair maps of Wisconsin's legislative districts during the 2020 redistricting cycle and the maps that best adhered to the Wisconsin Supreme Court's "least change" ruling issued on Nov. 30, 2021. Our experiences with these projects are shared.

4 Using Data to Uncover Commercial Sex Communities

Nickolas Freeman, Burcu B. Keskin, Gregory Bott, University of Alabama, Tuscaloosa, AL

Sex trafficking arrests have been linked to commercial sex ads. We use graph analytics to uncover community patterns that exist in a dataset summarizing millions of ads. Our analysis yields insights regarding collaborations among law enforcement agencies that can assist in the fight against sex trafficking.

5 A Decision Theoretic Approach to Pretrial Detention

Gerald W. Evans, University of Louisville, Louisville, KY, Contact: gwevan01@louisville.edu

Decisions concerning pretrial detention for the accused are difficult and complex for many reasons, including 1) the many stakeholders and decision makers involved, 2) the multiple objectives that need to be considered (associated with various categories of costs and benefits), and 3) the variety of uncertainties and associated risks involved. This talk will provide an illustrative example of a model for these decisions. The model involves the use of a multiple attribute utility function to represent preferences over multi-dimensional, probabilistic outcomes and a decision tree to represent the sequence of decisions and outcomes over time.

6 International Migration and Human Trafficking Networks

Priscila de Azevedo Drummond, Kayse Lee Maass, Northeastern University, Boston, MA, Contact: deazevedodrummond.p@northeastern.edu

At farms in the US, there is a constant shortage of labor. From 2010 to 2019, the H2A applications have almost quadrupled. New border restrictions during COVID-19 reduced the availability of workers. Thus in 2020, the DHS relaxed some of the H-2A rules. Sadly, these workers are usually subject to a high degree of vulnerability. And human trafficking is an opportunist crime that takes advantage of those vulnerabilities, as well as migration demand and policies. To understand the relationship between these two phenomena equilibrium flow models with the possibility of network disruption is considered. The goal is to gain insight into this relationship while considering the utility and costs of movement.

7 Long-term Refugee Resettlement with a Time-varying Minimum Cost Flow Problem Approach

Deniz Emre[1], Buket Cilali[2], Kash Barker[2], Andres D. Gonzalez[2], [1]University of Oklahoma, Norman, OK, [2]University of Oklahoma, Norman, OK, Contact: denizemre@ou.edu

Existing refugee resettlement studies mainly focus on short-term planning, but such problems are continues and require long-term planning. Motivated by temporal networks, we design a time-varying network to handle the dynamic structure of long-term planning. We create temporal layers, and each layer is a static representation of the network at a different point in time. In the proposed model, we solve a minimum cost flow problem from the first to final layers while synchronously solving a facility location problem in each layer and managing the temporal opening or expansion of resettlement locations. The proposed model also considers the integration success by using integration measures.

Tuesday, 2 PM–3:15 PM

TD10

CC - Room 110

Retail Management I

Contributed Session

Session Chair

Ji Soo Park, Georgia Institute of Technology, Atlanta, GA

1 Assortment Optimization Using An Attraction Model in An Omnichannel Environment

Andrey Vasilyev[1], Sebastian Maier[2], Ralf W. Seifert[1,3], [1]EPFL, Lausanne, Switzerland; [2]University College London (UCL), London, United Kingdom; [3]IMD, Lausanne, Switzerland. Contact: andrey.vasilyev@epfl.ch

Assortment optimization is a major task for omnichannel retailers. Choice modeling lies at the core of this challenge, yet existing models do not sufficiently account for the complex shopping behavior of customers in an omnichannel environment. We thus introduce a discrete choice model called the multichannel attraction model (MAM) which is designed to account for both the product substitution behavior of customers within each channel and the switching behavior between channels. We formulate the corresponding assortment optimization problem as a MILP and provide an extremely efficient heuristic method to solve it. We also describe several methods to estimate the MAM parameters. Finally, we derive properties of the optimal assortments and carry out numerical experiments to provide additional insights into their structure.

2 Operational Competition and Collaboration Amongonline/offine Retailers in Omni-channel Retail

Zhenyang Shi[1], Lin Liu[2], Yi Yang[1], Ziying Zhang[1], [1]Zhejiang University, Hangzhou, China; [2]Beihang University, Beijing, China. Contact: zhangziying@zju.edu.cn

We study the inter-firm pricing competition and operational cooperation in an omnichannel retail system. A buy-online ship-from-store (BOFS) business model is implemented, such that consumers' online orders laid to an e-tailer are fulfilled by multiple offline retailers, with the associated revenues shared among firms. Compared to a decentralized multichannel system, price competition is alleviated when there are fewer retailers in the market, while intensified otherwise under the BOFS model. We show that the BOFS model can improve each retailer's profit, if the relative hassle cost in online shopping is low compared to the geographical density of offline retailers, and an intermediate level of the proportion of revenue is allocated to offline retailers. The consumer group also gets better off under a well-designed cooperation contract.

3 Multi-dealer Showcasing Optimization in Hyperconnected Omnichannel Retailing

Ji Soo Park[1], Benoit Montreuil[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: jisoopark@gatech.edu

With fast replenishment, the need to store inventory for sale in offline locations can be eliminated and the role of offline retailers then shifts to showcasing. From the distributer's perspective, the aim is to optimize the portfolio for a set of retail locations to maximize the overall purchasing probability for a group of retailers. Given the geography of the customers and retailers, and demand for each region, we need to account for travel distances by the customers and showcase the relevant features in that region. In this context, we introduce a multi-dealer showcasing portfolio optimization approach maximizing expected sales, subject to spatial and budget constraints. We formulate the problem as a mixed-integer optimization problem. We provide empirical results for a case study and contrast the centralized multi-dealer approach with the single-dealer model.

Tuesday, 2 PM–3:15 PM

TD11

CC - Room 111
Economic and Social Impacts of AI
General Session

Session Chair
Weiguang Wang, University of Rochester

1 **AI Intensity and Firm Resiliency: Evidence from Firm Performance Under Disaster Shocks**
Miaozhe Han[1], Xiaoquan (Michael) Zhang[2], Hongchuan Shen[1], Jing Wu[3], [1]The Chinese University of Hong Kong, Hong Konng, Hong Kong; [2]Tsinghua University and The Chinese University of Hong Kong, Shenzhen, China; [3]The Chinese University of Hong Kong, Hong Kong, Hong Kong. Contact: miaozhehan@link.cuhk.edu.hk
There has been an ongoing debate regarding AI productivity but the empirical evidence remains limited. Our work supplements this debate by focusing on the impact of AI to firm performances in turbulent times. We use a comprehensive dataset of online job postings to measure AI intensity, and study its impact on firm operations and market valuations under shocks. We find AI gives companies a competitive edge: Employing AI skills notably mitigates performance volatility. To address endogenous issues, we construct an instrumental variable that combines the within-firm geographical variation in employment with arguably exogenous regional variation in AI development. Our paper identifies an important aspect of AI effectiveness - by improving operational agility and relieving capital constraints, AI provides companies resilience in rough times.

2 **How Does Worker Mobility Affect Business Adoption of a New Technology? The Case of Machine Learning**
Ruyu Chen[1], Natarajan Balasubramanian[2], Chris Forman[3], [1]Stanford Univerisity, Stanford, CA, [2]Syracuse University, Syracuse, NY, [3]Cornell University, Ithaca, NY, Contact: ruyuchen@stanford.edu
We investigate how worker mobility influences the adoption of a new technology. Using data on over 153,000 establishments from 2010 and 2018, and state-level changes to the enforceability of noncompete agreements as an exogenous shock to worker mobility, we find that changes that facilitate worker movements are associated with a significant decline in the likelihood of adoption of machine learning by establishments. Moreover, we find that the magnitude of decline depends upon the size of the establishment, the extent of predictive analytics adoption in its industry, and the number of large establishments in the same industry-location. These results are consistent with the view that increases in outward worker mobility increase costs for adoption of a new technology that involves significant downstream investments in innovation.

3 **Knowledge Trap: Encyclopaedical Experts Think too Much of Details to Team with Concentrated Ai**
Weiguang Wang[1], Xiaopei Liu[2], Xi Zhang[2], [1]University of Rochester, Rochester, NY, [2]Tianjin University, Tianjin, China. Contact: wwang90@simon.rochester.edu
In human-AI teaming, AI outperforms human in predefined tasks while humans possess broader knowledge. Therefore, AI is currently positioned as augmented intelligence for cognitively non-routine tasks. Complex decision making relies on human for final decisions. However, human's broad knowledge is not always beneficial. We show a phenomenon of *knowledge trap*, where human's broad knowledge hurts the performance compared with AI. In an experiment of video cover selection, covers selected by human experts attract fewer clicks than AI. The is due to human's too much consideration on the coverage of details. While details are helpful to certain subgroups, such as long videos, an inverted U-shaped relationship between click and level of details is observed. Compared with AI's pure focus on visual features, overemphasis on details by domain expertise becomes a knowledge trap.

Tuesday, 2 PM–3:30 PM

TD12

CC - Room 113
Advances in Decision Support Analysis through Optimization and Simulation
General Session

Session Chair
Matthew JD Robbins, Air Force Institute of Technology,

Wpafb, OH

1 Military Defensive Task Prioritization for Autonomous Escort of a Moving High-value Asset

Joseph M. Liles[1], Matthew JD Robbins[2], Brian J. Lunday[3], [1]Air Force Institute of Technology, Dayton, OH, [2]Air Force Institute of Technology, Wpafb, OH, [3]Air Force Institute of Technology, Beavercreek, OH

Military air battle management in a defensive scenario is a complex, dynamic task requiring rapid decisions governing the use of limited resources to defend a set of high-value assets from an unpredictable enemy. The notion of defending a quickly moving asset is a critical discussion topic given the present military focus on the development of autonomous unmanned escort aircraft. In this research, we formulate an MDP model of this scenario and solve it with an ADP methodology alongside an original simulation environment. We compare the solution quality of a traditional temporal difference learning technique with a more contemporary approach using a neural network. We design a series of computational experiments to optimize the neural network architecture.

2 A New Approach to Career Field Matching for Commissioning Cadets

Daniel G. Laird[1], Jesse Wales[2], [1]Air Force Personnel Center, Universal City, TX, [2]United States Air Force, Washington Twp, OH, Contact: griffenlaird007@gmail.com

The current method of assigning graduating cadets from the United States Air Force Academy and Reserve Officers' Training Corps detachments to their career fields uses an integer programming model to maximize ``global" Air Force utility, subject to several Air Force-defined constraints. To better represent the problem, we apply a Value-Focused Thinking framework, in conjunction with an optimization model using the framework, to measure overall solution quality for an alternative assignment of cadets to career fields using piece-wise linear value functions. Our optimization model can effectively determine solutions that more accurately capture decision maker values.

3 Simulating Autonomous Cruise Missile Swarm Behaviors in An Anti-Access Area Denial (A2AD) Environment

Kyle Goggins, Air Force Institute of Technology, Wright-Patterson AFB, OH, Contact: kyle.goggins.1@us.af.mil

The increasing anti-access area denial (A2AD) threat imposed by the modern integrated air defense system (IADS) has prompted Air Force senior leaders to invest in radically changing the nature of air power moving forward. A key element of this vision is weapon swarming, which aims to address this by overwhelming the IADS with huge numbers of attritable aerial assets. We propose a framework for classifying the levels of autonomous capability along three independent dimensions—namely ability to act alone, ability to cooperate, and ability to adapt. We construct a combat model in order to simulate an engagement between a friendly air strike package, featuring a penetrating bomber and an autonomous cruise missile swarm, and an enemy IADS. Analyzing the results reveals which dimensions and levels of autonomy are most impactful for survivability and lethality for this scenario.

4 GPU-Accelerated Graph Algorithms: DARPA Graph Challenge

Rakesh Nagi[1], Samiran Kawtikwar[2], [1]U of Illinois at Urbana-Champaign, Urbana, IL, [2]U of Illinois at Urbana-Champaign, Urbana, IL, Contact: nagi@illinois.edu

Since 2017, DARPA has engaged the community in analytics for sparse graphs emerging from sensor feeds, social networks, and alike. We will present a summary of GPU-accelerated algorithms for triangle counting, finding connected structures, and sparse DNN computations. In addition, we will discuss subgraph matching for identifying isomorphic structures that might represent a intelligence requirements from an evidentiary graph. These algorithms are implemented on general purpose Graphics Processing Units (GPUs) to leverage massive parallelism and provide highly efficient solutions to large graphs than have been possible in the past.

Tuesday, 2 PM–3:15 PM

TD13

CC - Room 114

Artificial Intelligence Applications in Network and Location Problems

General Session

Session Chair

Abdullah Konak, Penn State Berks, Reading, PA

1 Adaptive Evolutionary Algorithms Using Reinforcement Learning

Abdullah Konak[1], Tsung-Che Chiang[2], Thammarsat Visutarrom[2], Sadan Kulturel-Konak[1], [1]Penn State Berks, Reading, PA, [2]National Taiwan Normal University, Taipei, Taiwan. Contact: konak@psu.edu

We propose a reinforcement learning technique to control the parameters of evolutionary algorithms adaptively. The proposed ideas and algorithms are examined using continuous optimization test cases. Experimental results showed positive effects of our proposed methods and the competitive performance of our algorithms.

2 Combinatorial Game Theory Problems with Multiple Players Using Regret-based Nash Equilibrium Sorting Genetic Algorithm

Sadan Kulturel-Konak, Abdullah Konak, Penn State Berks, Reading, PA, Contact: sadan@psu.edu

Applications of evolutionary algorithms to noncooperative simultaneous games have been limited due to challenges in guiding the evolutionary search toward equilibria, which are usually inferior points in the objective space. We propose a regret-based approach to select candidate decision options of the players for the next generation in a multi-population genetic algorithm called Regret-Based Nash Equilibrium Sorting Genetic Algorithm (RNESGA). We show that RNESGA can converge to multiple Nash equilibria in a single run using two and three-player competitive knapsack games and other games from the literature. We also show that pure payoff-based fitness assignment strategies perform poorly in three-player games.

3 Incorporating Diversity and Equity in Agency Location Problems

Lauren Berrings Davis, North Carolina A&T State University, Greensboro, NC

Food banks are non-profit organizations working to mitigate food insecurity by working in partnership with community agencies such as food pantries. These partner agencies increase the accessibility of food to people in need. This needs to be improved in terms of stating what the problem is. Since food banks that operate a model where distribution to the food insecure is made through partnering agencies, the number of partner agencies and where to recruit the agencies is an important decision component during expanding their network. In this work, we present a data-driven framework to identify how to grow a food bank's network through agency recruitment while simultaneously considering their goals of increasing access to food to diverse populations.

Tuesday, 2 PM–3:15 PM

TD14

CC - Room 115

e-Commerce

Contributed Session

Session Chair

Ali Tosyali, Rochester Institute of Technology, Rochester, NY

1 The Economics of Bestsellers: Consumer Search, Sales Ranking, and Social Learning

Wentao Lu[1], Man Yu[2], [1]HKUST, Hong Kong, Hong Kong; [2]Hong Kong University of Science and Technology, Hong Kong, Hong Kong. Contact: wluaj@connect.ust.hk

Motivated by major e-commerce platforms' diverse practices in bestseller information provision, we examine consumers' learning, searching, and purchasing behavior under uncertainty about products' values. We find that a bestseller list constitutes a noisy signal whose informativeness is determined by the granularity of the bestseller information. Our results suggest that the platform may withhold some information at the cost of consumers.

2 Granularity Matters: The Operational Implications of Displayed Rating Scale in Online Marketplaces

Kyungmin Lee, Nan Zhang, Heng Xu, American University, Washington, DC, Contact: bradlee@american.edu

This study assesses the optimal review-system design in an online marketplace platform. Specifically, we address the role of the review system in shaping the incentive structure for sellers. We start by providing a modeling framework to examine the impact of a rating scale (e.g., binary vs five-star) in a moral hazard setting. Theoretically, we show that the choice of revenue-maximizing rating scale depends on the distribution of sellers' private type. With the framework, we empirically evaluate different review-system designs (i.e., equi-width vs. nonuniform-width system) using Amazon review data. We show that having a distinct scale with the equi-width system for each category can enhance the expected revenue by 3.2%. Moreover, the findings reveal that the nonuniform-width system can further enhance platform revenue compared to the equi-width system (up to 50.83%).

3 Detecting Fake Review Buyers Using Network Structure: Direct Evidence from Amazon

Sherry He[1], Brett Hollenbeck[1], Gijs Overgoor[2], Davide Proserpio[3], Ali Tosyali[2], [1]University of California Los Angeles, Los Angeles, CA, [2]Rochester Institute of Technology, Rochester, NY, [3]University of Southern California, Los Angeles, CA

Online reviews have a significant impact on consumer purchase decisions and on the success of e-commerce platforms. Despite this, review platforms like Amazon, Yelp, or Tripadvisor have struggled since their inception with the problem of fake reviews. We use a novel dataset on a large number of Amazon sellers buying fake reviews to test different approaches for platforms to detect them. We compare methods based on the network structure between sellers to those based on review features, including text and image features. We find that fake review buyers are highly clustered based on having reviews from a common set of reviewers. The result is that network-based detection strategies outperform all others and that even a small number of simple network features are highly accurate for detecting fake review buyers.

Tuesday, 2 PM–3:15 PM

TD15

CC - Room 120

Appointment Scheduling and Related Issues

Contributed Session

Session Chair

Ilyas Ustun, DePaul University, Chicago, IL

1 Dynamic Appointment Scheduling

Roshan Mahes, University of Amsterdam, Amsterdam, Netherlands. Contact: a.v.mahes@uva.nl

We consider appointment scheduling in a setting in which the schedule of all future clients can be adapted. First, we schedule the next client at every client arrival, which we call *dynamic scheduling*. The approach relies on dynamic programming, with the state information being the number of clients waiting, the elapsed service time of the client in service, and the number of clients still to be scheduled. The service times are fit using a phase-type-based approach. Hereafter, we consider a heuristic with which schedules can be updated at any point in time. The performance of this heuristic is assessed by comparing it with the dynamic scheduling method. The gain achieved by rescheduling is illustrated through a set of numerical experiments.

2 Appointment Book Design in The Case of Multiple Servers

Robert Lee, Alex Kuiper, University of Amsterdam, Amsterdam, Netherlands. Contact: r.h.lee@uva.nl

Appointment schedules in healthcare often have the dual objective of maximizing utilization while keeping patient waiting time low. A common assumption is that patients arrive singly and are seen by a single physician. Relaxing both of these assumptions one can investigate the efficiency of various appointment book designs. We examine in particular singular-arrival multi-server systems (*pure pooling*) and multi-arrival multi-server systems (*batch pooling*), finding that *batch pooling* captures many of the efficiency gains of *pure pooling* while retaining a pleasing appointment book design.

3 Simulation-based Optimization of Dynamic Appointment Scheduling Problem with Patient Unpunctuality and Provider Lateness

Secil Sozuer[1], Robert H. Storer[1], Miao Bai[2], [1]Lehigh University, Bethlehem, PA, [2]University of Connecticut, Storrs, CT, Contact: ses515@lehigh.edu

We address a particular healthcare scheduling problem, dynamic and stochastic appointment scheduling with patient unpunctuality and provider lateness. We asses the optimal schedule start time for the patients in order to minimize the expected cost incurred from patient waiting time, server idle time, and server overtime. By conducting perturbation analysis for the gradient estimation, a Sample Average Approximation (SAA), a Robust Stochastic Approximation (Robust SA), and adaptive Stochastic Approximation (ad-SA) algorithms are used. The structural properties of the sample path cost function and expected cost function are studied. Numerical experiments show the computational advantages of using perturbation-based gradient information over CPLEX and interior point methods for our problem.

4 Predictive Modeling to Assess Patient No-show Risk in Healthcare

Ilyas Ustun, DePaul University, Chicago, IL, Contact: iustun@depaul.edu

This study uses a 41-day Brazilian healthcare facility medical appointment dataset with approximately 110k records to develop machine learning models where the goal is to predict patient no-shows. The analysis is carried out in two phases. The first phase builds models that can predict patient no-shows from appointment data. The second phase focuses on patients to assess the risk of a patient missing an appointment. Based on the first phase, it is found that lead time (days between schedule and the appointment) and age are the two most important variables as identified by the classifier models. The decision tree-based ensemble models trained on oversampled data performed significantly better than those models trained on original data. An AUC score of

~0.70 suggests the viability of the model.
Key terms: No-show, missed appointment, machine learning, healthcare analytics

Tuesday, 2 PM–3:15 PM

TD16

CC - Room 121

OR and Machine Learning Methods and Application to Healthcare Delivery

General Session

Session Chair

Mark P. Van Oyen, University of Michigan, Ann Arbor, MI

Session Chair

Arlen Dean, 1</sup

1 Studying The Effect of Team Familiarity in Surgical Teams

Gulin Tuzcuoglu, Dan Adelman, Cagla Keceli, Josh Morris-Levenson, Hunter Witmer, Turaga Kiran, University of Chicago, Chicago, IL, Contact: gulin@uchicago.edu

We study the effect of team familiarity in surgical teams to maximize team performance in a real hospital's operating room setting. We analyze all types of procedures in our data as opposed to focusing on a single procedure type as many other studies did. Our approach takes the team members' individual and collaborative experience into account, which we quantify using a novel metric. We report on results based on data from a high-volume academic medical center.

2 Online Routing with Stochastic Anytime Constraints: A Pessimistic-optmisitc Approach

Xin Liu[1], Pengyi Shi[2], Bin Li[3], Lei Ying[4], [1]ShanghaiTech University, Shanghai, China; [2]Purdue University, West Lafayette, [3]Pennsylvania State University, University Park, PA, [4]The University of Michigan, Ann Arbor, Ann Arbor, MI, Contact: liuxincell@gmail.com

This work considers constrained online dispatch with unknown arrival, linear bandit reward, and unknown general constraints. We propose a novel online algorithm, named POND, standing for Pessimistic-Optimistic oNline Dispatch, which achieves $O(\sqrt{T\log T})$ regret and $O(1)$ anytime constraint violation. Both bounds are sharp. As far as we know, this is the first result that specifically characterizes both the regret bound and anytime constraint violation in one framework for constrained linear bandit settings. We substantiate our theoretical results with extensive numerical experiments in the context of hospital inpatient routing and real datasets. We show that POND achieves low regret with minimal constraint violations, where the key design of a time-varying slackness constant in the proof is indeed critical for good empirical performance.

3 Flexible Analytic Model to Inform Multi-stakeholder Pediatric Vaccine Scheduling Decisions

Zhuoting Yu[1], Pinar Keskinocak[1], Joel Sokol[1], Yao-Hsuan Chen[2], [1]ISyE Georgia Tech, Atlanta, GA, [2]MSD (UK) Ltd., London, United Kingdom. Contact: zyu334@gatech.edu

Pediatric immunization is essential to prevent life-threatening infectious diseases in children. With the increasing number of vaccine-preventable diseases, available candidate vaccines, and complex medical interactions among them, it has become challenging to recommend a vaccination schedule considering personal preferences and prior immunization history. Therefore, we developed a discrete optimization model and embedded it into a decision-support tool that was built in Microsoft Excel with Python implementation to offer a solution. We illustrate in this talk the broad applicability of our model with vaccine scheduling challenges commonly encountered by various stakeholders in the US.

4 Dynamic Care Unit Placements Under Unknown Demand with Learning

Arlen Dean[1], Mohammad Zhalechian[2], Mark P. Van Oyen[2], [1]Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI

We study the problem of deciding patient to hospital care unit placements in real-time. We develop a dynamic resource allocation algorithm to decide unit placements by learning the care needs of different patient types. We model hospital beds as reusable resources and assume decision feedback is not immediately available but rather delayed for an unknown, random length of time. Lastly, for robustness, we also consider the demand unknown and allow patient arrivals to be arbitrarily sequenced. The applicability of our algorithm is demonstrated with real-patient data from a hospital collaborator, where we evaluate our proposed approach using unplanned readmission rates as the performance metric.

Tuesday, 2 PM–3:15 PM

TD17

CC - Room 122

Health Care and Processes Flash Session

Flash Session

Session Chair

Afrooz Moatari-Kazerouni, Widener University, Chester, PA

1 Assessing Mental Health of Healthcare Workers Amidst Covid-19 Pandemic

Lin Li, Awate Ergai, Kennesaw State University, Marietta, GA

The mental health of healthcare workers is significantly affected by the COVID-19 outbreak. This study aims to examine various factors which are associated with the mental health outcomes of healthcare workers in a health system during the first peak of the pandemic. A cross-sectional survey of 388 healthcare workers was conducted, and the data is analyzed using chi-square statistics and multivariate regression models to identify significant drivers.

2 The Role of Non-clinical Call Handlers on Patient Service: Evidence from Nhs Helpline

Emmanouil Avgerinos, IE Business School, Madrid, Spain. Contact: emmanouil.avgerinos@ie.edu

Healthcare organizations rely on a mix of clinical and non-clinical workforce in delivering health services. Although non-clinical workers are vital in many healthcare delivery settings today, their impact on quality of patient service has not been examined in the operations management literature. While they can offer significant cost and patient access advantages in providing healthcare services such as medical helplines, determining the right staffing level and skill mix of health workforce is a major challenge in such settings. In this study, making use of a novel dataset based on National Health Service's 111 non-emergency helpline in England, we demonstrate and quantify the effects associated with employing a mix of call handlers and clinical advisors in delivering patient service.

3 Impact of Health Homes on Emergency Room Visits: An Empirical Investigation

Jiajia Qu[1], Ying-Chih Sun[2], Raj Sharman[3], Pamella Howell[4], Chet Fox[5], [1]University of Texas Permian Basin, Odessa, TX, [2]Harrisburg University, Harrisburg, PA, [3]State University of New York at Buffalo, Buffalo, NY, [4]California State University Los Angeles, Los Angeles, CA, [5]Greater Buffalo United Accountable Health Network (GBUAHN), Buffalo, NY, Contact: jiajiaqu@buffalo.edu

Keeping patients healthy often leads to a reduction in avoidable emergency room visits and consequent lowering Medicaid costs. To accomplish this goal, health homes integrate and coordinate all primary, acute, and behavioral health to offer long-term services and support to Medicaid patients. But has the Health Homes met their promise? Our research analyzes data from a Health Homes program located in the Northeast part of the US to investigate the impact of health homes on reducing emergency room visits and provides. Our findings provide evidence that enrollment in a Health Home is effective in reducing emergency room visits by 9.26%. For critical patients with diabetes, this number can increase to 35.46%.

4 Exploring The Role of Provider-related Factors Influencing Quality of Services in Healthcare

Arwa Ghassan Al Nuairi[1], Mecit Can Emre Simsekler[1], Abroon Qazi[2], Andrei Sleptchenko[1], [1]Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates; [2]American University Sharjah, Sharjah, United Arab Emirates.

Several organizational factors impact the quality of services provided in hospital settings. While earlier studies provided substantial insights on organizational factors, there is limited research investigating their interdependencies. This study aims to develop a Bayesian network model that explores the role and relative importance of provider-related factors influencing quality outcomes. Further, the additional analyses, such as diagnostic and scenario-based analyses, provide deeper insights into the effect of different hypothetical interventions and how the system responds. This study mainly guides healthcare managers and practitioners in understanding the role of various provider-related factors in supporting quality improvement.

5 Analysis of Diabetes Medication Usage Patterns Using Sequential Pattern Mining

Peng Zhang[1], Hyojung Kang[2], Jennifer Mason Lobo[3], Soyoun Kim[4], Min-Woong Sohn[5], [1]University of Illinois Urbana-Champaign, Urbana, IL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]University of Virginia, Charlottesville, VA, [4]Ewha Womans University, Seoul, Korea, Republic of; [5]University of Kentucky, Lexington, KY, Contact: pengz3@illinois.edu

Individuals with diabetes often have poly-medication treatment due to the complexity and chronicity of the condition. The American Diabetes Association has a guideline for intensification of treatment for patients with type 2 diabetes. However, less research has been done on temporal changes in medication use and their associations with outcomes. This study aims to extract common patterns of medication intensifications among Medicare beneficiaries using sequential pattern mining, and then examine patient characteristics and outcomes by intensification pattern.

6 An RFID-based Decision-making Framework for Healthcare Emergency Departments

Afrooz Moatari-Kazerouni, Amin Keramati, Widener

University, Chester, PA, Contact: amoatarikazerouni@widener.edu

RFID traceability systems are adopted in healthcare for tracking equipment, people and efficient medical data access. As healthcare moves into era of big data, livestreaming RFID data tap real-time decision making at e.g. Emergency Departments (ED). Lack of coordinated primary care drives individuals to ED as gateways. As volumes increase and become complex, along with inadequate downstream capacity, bottlenecks and wait times rise. This study develops an RFID decision-making framework to capture large volumes of data on patient and staff activities at ED; through which recommendations for improving the ED's team configuration, workload, and process design will be provided.

7 Dynamic Inter-day and Intra-day Scheduling

Christos Zacharias[1], Nan Liu[2], Mehmet A. Begen[3], [1]University of Miami Herbert Business School, Coral Gables, FL, [2]Boston College, Chestnut Hill, MA, [3]Ivey Business School, Western University, London, ON, Canada. Contact: czacharias@bus.miami.edu

The joint consideration of dynamic inter-day and intra-day scheduling decisions is an established theoretical and practical problem that has remained open due to its highly stochastic nature, complex structure, and the curse of dimensionality. We develop the first analytical optimization model and theoretical results addressing this joint problem within a computationally tractable optimization framework with theoretical performance guarantees. Our theoretical results in discrete convex analysis are novel on their own, independent of our model and underlying problem. They relate to the theory of discrete opimization and its applications within and beyond appointment scheduling.

Tuesday, 2 PM–3:15 PM

TD18

CC - Room 123

OR/MS/Analytics in the Diagnosis and Treatment of Neurological Diseases

General Session

Session Chair

Anahita Khojandi, University of Tennessee, Knoxville, TN

Session Chair

Jeremy Watts, University of Tennnessee, Knoxville, TN

1 Partially Observable Semi-Markov Model for Optimal Medication Response in Parkinson's Disease

Jeremy Watts[1], Anahita Khojandi[2], Ritesh Ramdhani[3], [1]University of Tennnessee, Knoxville, TN, [2]University of Tennessee, Knoxville, TN, [3]University of Donald and Barbara School of Medicine at Hofstra/Northwell, New York, NY, Contact: gkm819@vols.utk.edu

There is a growing need for personalized decision models to optimize medication treatment plans for various illnesses. While HMMs have been previously applied in this context, these models do not fully account for the evolution of a patient's health state or history. In this study, we leverage a partially observable semi-Markov decision process (POSMDP) to model the pharmacodynamics and pharmacokinetics of individualized medication response. Parkinson's disease is a progressive neurological disorder, the cardinal symptoms of which can be primarily controlled via dopaminergic medication. However, these medications are notoriously difficult to optimize. Using wearable sensor data to calibrate the model, we optimize patients' treatment plans to account for physician/patient preferences.

2 Individualized ALS Progression and Care Via Data Analytics

F. Safa Erenay[1], Haoran Wu[2], Brian Crum[3], Kalyan Pasupathy[4], Osman Ozaltin[5], [1]University of Waterloo, Waterloo, ON, Canada; [2]SUN YAT-SEN UNIVERSITY, Guangzhou ,, China; [3]Mayo Clinic-Rochester, Waterloo, ON, Canada; [4]University of Illinois at Chicago, Chicago, IL, [5]North Carolina State University, Raleigh, NC, Contact: ferenay@uwaterloo.ca

ALS leads to motor neuron degeneration and functionality loss in limb/bulbar functions. We defined a staging system of 25 disease tollgates to analyze ALS progression. We developed binary classification models to map the conventional ALSFSR-R staging systems to ours using data from Mayo Clinic. We then augmented 6000 patients' data from PRO-ACT database with tollgate information and derived time trajectories of passing ALS tollgates using interval-censored Kaplan-Meier curves. We used classification trees to identify risk groups with different tollgate time trajectories and determined their specific assistive device needs. We then used analytical models to derive individualized ALS care policies.

3 The Role of Digital Health Technology in Neurological Disease Staging

John M. Templeton, Florida International University, Miami, FL, Contact: jmtempleton.phd@gmail.com

Due to the complex nature of Parkinson's Disease (PD), several current subjective tools (e.g. staging schemes, clinical assessments, and questionnaires) are used in practice; however, none of these include objective assessments of all functional areas of neurocognition. We will present the foundation for a new staging schema that uses digital health technology to expand current staging protocols that encompasses objective, symptom-specific assessments of all neurocognitive functional areas using inherent device capabilities (e.g. device sensors and human device interactions). As individuals with PD manifest differing symptoms with varying progressions, the modernization of assessments that include objective, symptom-specific monitoring is imperative in the formation of disease prediction models, personalized medicine, and quality of life.

4 Classification and Biomarker Discovery of Persistent Post-traumatic Headache (PPTH) Using Deep Learning on Structural Brain MRI Data

Md Mahfuzur Rahman Siddiquee[1], Jay Shah[1], Todd Schwedt[2], Catherine Chong[2], Simona Nikolova[2], Gina Dumkrieger[2], Katherine Ross[3], Visar Berisha[1], Jing Li[4], Teresa Wu[1], [1]Arizona State University, Tempe, AZ, [2]Mayo Clinic, Phoenix, AZ, [3]Phoenix VA Health Care System, Phoenix, AZ, [4]Georgia Institute of Technology, Tempe, AZ, Contact: mrahmans@asu.edu

What are the brain regions different in PPTH patients than in healthy individuals (HC)? The answer can provide us with essential biomarkers, but a manual exploration to find the answer is tedious, expensive, and error-prone. Hence, we utilized deep learning to classify PPTH (total 49 MRIs) vs. HC (total 532 MRIs) using a 3D ResNet-18 architecture that automatically identifies the structural differences. The model achieved 91.67% accuracy, 100% sensitivity, and 83.33% specificity on the test dataset. Once trained, we used GradCAM to extract the brain regions showing differences in PPTH patients. Some of these brain regions are the cerebellum, middle temporal, inferior temporal, inferior parietal, and superior parietal.

Tuesday, 2 PM–3:15 PM

TD19

CC - Room 124

The Impact of Telehealth

Contributed Session

Session Chair

Pritom Kumar Mondal, Texas Tech University, Lubbock, TX

1 Using Data Analytics for Telehealth Utilization: A Case Study in Arkansas

Aysenur Betul Cengil[1], Burak Eksioglu[1], Sandra D. Eksioglu[1], Hari Eswaran[2], Corey J. Hayes[2], Cari A. Bogulski[2], [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas for Medical Sciences, Little Rock, AR

The gap between healthcare demand and supply has been increasing in recent years. Telehealth may allow clinics to service more patients without increasing the number of providers. We use data analytics techniques to understand patient profiles that utilize telehealth. Specifically, we build a random forest regression model to identify the important factors in telehealth utilization and use SHAP (SHapley Additive exPlanations) to explain the predictions by computing the contribution of each factor to the prediction. We also analyze how telehealth services impact waiting time and appointment length to determine if healthcare providers should continue to provide telehealth services.

2 Analyzing and Managing Telemedicine Care Delivery

Opher Baron[1], Fanying Chen[2], Abraham Seidmann[3], [1]University of Toronto, Toronto, ON, Canada; [2]Boston University, Boston, MA, [3]Boston University, Newton, MA, Contact: fanying@bu.edu

Acute medical labor shortages, capacity limits in hospitals and clinics are two crucial factors that impact the health-care providers' revenues. Telemedicine may help in building a more efficient care model that should mitigate part of these two critical problems. Previous work studied the relationship between the patient's distance from her specialist, her choice of medical care, and the specialist's service capacity decisions. We analyze how the creative design of the telemed services topology affects the patient's choices, the revenue-maximizing specialist's choices of the optimal service capacity, and the HMO managerial reaction function.

3 Enhancing The Admission Process of a Psychiatric Hospital Using Telemedicine

Pritom Kumar Mondal, Bryan A. Norman, Texas Tech University, Lubbock, TX, Contact: pritom.k.mondal@ttu.edu

Psychiatric patients who become decompensated in an outpatient setting are often referred for potential transfer to a psychiatric hospital. The transfer decision is based on a thorough examination process. Portions of this process can be done either remotely via telemedicine or face to face. We explore different policies for employing telemedicine and explore their pros and cons and overall impacts on the admissions process. A discrete event simulation model with dynamic decision rules is developed to determine a cost-effective patient transfer policy and distribute capacity between the telemedicine and on-site admission process.

Tuesday, 2 PM–3:15 PM

TD20

CC - Room 125

Advances in Solving Complex Decision Models

General Session

Session Chair

Manel Baucells, Darden School of Business, Playa Vista, CA

1 Optimal Control of Business Activity During a Deterministic Pandemic

Lin Zhao[1], Manel Baucells[2], [1]Southwestern University of Finance and Economics, Beijing, China; [2]University of Virginia, Charlottesville, VA, Contact: zhaolin@iss.ac.cn

The Covid-19 pandemic has put in the forefront the need to balance the health benefits and the economic costs when it comes to imposing constraints on business activity. Comparing lives and livelihoods is not easy. A second tricky aspect of the problem is that opening up business has an immediate positive effect in business metrics, but a delayed negative effect on health costs. A third non-intuitive aspect is the dynamics of infected cases, which explode and decay in exponential fashion. We formulate a continuous objective function that capture these tricky aspects and obtain explicit solutions to the optimal control policy under one-wave as well as multi-wave situations. We rule out many sub-optimal policies, provide insight, and justify a rich variety of optimal possibilities for different parameters.

2 Predicting The Present Equivalent of Future Streams

Alessandra Cillo[1], Manel Baucells[2], [1]LIUC University, Castellanza, Italy; [2]Darden School of Business, Playa Vista, CA

Present equivalents of future payouts elicited from individuals exhibit a high variability in the underlying discount rate, suggesting that multiple factors influence discounting. One such factor---shown to be robust---is the magnitude effect, whereby small future payouts are discounted more than larger ones. When individuals are confronted with more than one future payout, it is unknown whether the magnitude effect is driven by the sum of cash flows, or the highest cash flow, or the first, or the last, or the lowest; or perhaps each cash flow has a magnitude-dependent discount rate. We address these questions by eliciting the discount rate of diverse cash flows following a ceteris paribus design.

3 Managerial Mental Accounting and Downstream Project Decisions

Manel Baucells[1], Yael Grushka-Cockayne[2], Woonam Hwang[3], [1]Darden School of Business, Playa Vista, CA, [2]Darden School of Business, Charlottesville, VA, [3]University of Utah, Salt Lake City, UT, Contact: woonam.hwang@eccles.utah.edu

Managers are responsible for planning, controlling, and revising projects. As a project unfolds, the manager evaluates the project's progress by comparing ongoing costs and scope to a baseline plan, and considers potential revisions. We offer a general model of managerial mental accounting, which includes loss aversion, reference point updating, and narrow framing; and examine how it impacts downstream decisions. Our model predicts insufficient adjustments of project scope and cost at revisions, resulting in reduced financial profit. Loss aversion is harmful but only up to a point; and reference point updating may lessen or worsen insufficient adjustments. We show that the choice of measure to quantify the project progress affects the updating of the reference point, and hence the downstream decisions.

Tuesday, 2 PM–3:15 PM

TD21

CC - Room 126

Empirical Public Sector Operations

General Session

Session Chair

Anqi Wu, University of Illinois, Champaign, IL

1 On The Frontline: Health Worker Training to Reduce Last-mile Stock-outs in Developing Countries

Amir Karimi[1], Anant Mishra[2], Karthik Natarajan[2], Kingshuk K. Sinha[3], Omar Balsara[4], Barabara Lamphere[4], [1]The University of Texas at San Antonio, San Antonio, TX, [2]Carlson School of Management, University of Minnesota, Minneapolis, MN, [3]University of Minnesota SCO, Minneapolis, MN, [4]John Snow, Inc. (JSI) Research & Training Institute, Inc., Arlington, VA, Contact: mish0049@umn.edu

We examine factors that affect the effectiveness of health worker training using the staggered roll-out of a public health supply chain initiative in Indonesia called The MyChoice Project. The initiative was launched in 2016 with the objective of mitigating the last-mile stock-outs of contraceptive methods in Indonesia through training of frontline health workers on inventory management.

2 Stopping The Revolving Door: An Empirical and Textual Study of Crowdfunding and Teacher Turnover

Samantha Meyer Keppler[1], Jun Li[2], Andrew Wu[2], [1]University of Michigan, Ann Arbor, MI, [2]Ross School of Business, University of Michigan, Ann Arbor, MI, Contact: srmeyer@umich.edu

The public K-12 education system has been plagued by high teacher turnover and poor retention rates. This study provides the first empirical evidence that new technology platforms such as education crowdfunding could effectively reduce teacher turnover. Combining (1) identified data on the characteristics and employment record for all teachers in the Pennsylvania public education system, (2) crowdfunding data on DonorsChoose—the largest online education crowdfunding portal, and (3) unstructured data on individual project essays and need statements, we demonstrate that funded projects on DonorsChoose, averaging only about $400 in value, significantly reduces turnover rates of funded teachers by 2.66 percentage points (pp)—a 22% reduction against a mean turnover rate of 12 percent—by improving teacher working environments and autonomy.

3 FDA Plant Inspections and Drug Shortages

Gopesh Anand[1], Yixin Iris Wang[2], George Ball[3], Hyunwoo Park[4], [1]University of Illinois-Urbana Champaign, Champaign, IL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]Operations and Decision Technologies, Kelley School of Business, Indiana University, Bloomington, IN, [4]Seoul National University, Gwanak-gu, Korea, Republic of. Contact: gopesh@illinois.edu

The Food and Drug Administration (FDA) is the regulator tasked with both overseeing drug manufacturing quality and avoiding drug shortages. The key tool to manage drug quality is recurring FDA plant inspections. There are fewer similar tools used by the FDA to manage drug shortages though it has become a recent regulatory focus. A recent, predominantly descriptive analysis from the Government Accountability Office (GAO) finds that when the FDA assigns their lowest quality inspection score, plants develop shortages soon thereafter, a possible sign of onerous FDA corrective actions that may come at the cost of market supply. We examine whether FDA inspections help or hinder drug supply using a rigorous econometric approach.

4 Effects of Federal Education Policy Announcement on Online Crowdfunding

Anqi Wu[1], Aravinda Garimella[2], Ramanath Subramanyam[1], [1]University of Illinois, Champaign, IL, [2]University Of Illinois - Urbana-Champaign, Seattle, WA, Contact: anqiwu2@illinois.edu

Over past decades, education policymakers have been making periodic efforts to address issues of adequacy and equity in the US public education. More recently, grassroots altruism, enabled through online platforms such as DonorsChoose.org, has resulted in the successful funding of essential public school projects across the country. This study focuses on how top-down efforts driven by education policy makers interact with bottom-up efforts facilitated by online platforms. With data compiled from multiple sources, we examine the impact of the announcement of the Every Student Succeeds Act (ESSA) signing on online fundraising platforms. We find simultaneous evidence of two contrasting donor tendencies following the announcement: an overall reduction in funding (global crowding out) and a redistribution to local initiatives (local crowding in) on the platform.

Tuesday, 2 PM–3:15 PM

TD22

CC - Room 127

Nonprofit OM III

General Session

Session Chair

Iman Parsa, Tempe, AZ

1 A Field Experiment to Improve The Availability of Health Products for Community Health Entrepreneurs

Lisanne van Rijn[1], Harwin de Vries[2], Luuk Veelenturf[2], [1]Erasmus School of Economics, Erasmus University, Rotterdam, Netherlands; [2]Rotterdam School of Management, Erasmus University, Rotterdam, Netherlands. Contact: vanrijn@ese.eur.nl

Community health entrepreneurs (CHEs) are former community health workers trained to sell health products in their community. Key challenges they face are 1) they are severely cash constrained and 2) they have limited

inventory management skills. In the context of a delivery frequency of once per month, this easily leads to stock-outs. We estimate that currently CHEs lose half of their sales due to stock-outs. We conduct a field experiment that explores two interventions aimed at improving the availability of health products in collaboration with social enterprise Healthy Entrepreneurs. To investigate the availability of health products, we measure CHE sales and stock-outs prior to starting the intervention and four months after the intervention.

2 Accommodating Missions' Variety in Demand Planning: Data-driven Procedures in a Humanitarian Organization

Maximilian Löffel, Stephan M. Wagner, ETH Zurich - Swiss Federal Institute of Technology Zurich, Zurich, Switzerland. Contact: mloeffel@ethz.ch

International humanitarian organizations (IHO) deal with huge variety throughout their missions, be it through local conditions for aid delivery or types of programs. Although decentralized management in missions has a long history in IHO and efforts towards localization tend to shorten supply chains, especially critical items must be managed globally. Hence, organizations need processes to deal with such variety. Through analyses of operational data in a large IHO we find that resulting delivery performance differs significantly between missions and varies considerably over time. Current automated planning systems cannot adequately accommodate variation, as forecast accuracy and necessary manual interventions show. We, therefore, combine insights about data-driven planning with an analysis of the organization's overall demand planning process.

3 Developing a Fleet Sizing and Outsourcing Optimization Model for Humanitarian Organizations

Sarah Schaumann[1], Stephan M. Wagner[2], [1]Swiss Federal Institute of Technology Zurich (ETH Zurich), Zurich, Switzerland; [2]Swiss Federal Institute of Technology Zurich (ETH Zurich), Zuerich, Switzerland. Contact: sschaumann@ethz.ch

Studies indicate that fleets in humanitarian organizations are frequently oversized and that outsourcing opportunities have not been utilized. Right-sizing and outsourcing of fleets are therefore two important levers to increase the effectiveness and efficiency of humanitarian operations. We develop a user-friendly, practice-based, and cost-effective decision support tool for strategic humanitarian transport planning and optimization. Given different trip types and transportation modes (own vehicles, rental vehicles, taxis), the model allocates transportation modes to trips and determines the number of vehicles necessary. The objective is to minimize the total cost subject to operational constraints for humanitarian organizations. We closely collaborate with an organization throughout the project that applies the model in various practical setting.

Session Chair

Lisanne van Rijn, Rotterdam, Netherlands.

Tuesday, 2 PM–3:15 PM

TD23

CC - Room 128

Disaster & Humanitarian OM

General Session

Session Chair

Andrew N. Arnette, University of Wyoming, Laramie, WY

1 Characterizing Logistics Operations Within a Federal Staging Area for Hurricane Response: A Qualitative Analysis of Federal, State and Local Perspectives

Jannatul Shefa, University of Arkansas, Fayetteville, AR, Contact: jshefa@uark.edu

A successful deployment of logistics operations following a disaster is a collective contribution of federal, state and local entities to ascertain an efficient and effective response. This paper analyzes data from interviews with disaster response logistics experts from these entities. The objective is to investigate the information sources and planning processes used in these organizations to plan vehicle routes for critical resource deliveries to impacted areas. Special attention is directed to the impacts of incomplete knowledge of infrastructure status, such as road disruptions due to flooding. Supported by both qualitative and quantitative evidence, this research reveals both similarities and differences in logistical decision making among these organization types.

2 Online Optimization of Single-source Multi-destination Canadian Traveler Problem with Multiple Agents

Neel Chanchad[1], Ashlea Bennett Milburn[2], [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas, Fayetteville, AR

Road networks can become highly disrupted due to disasters such as hurricanes. Finding paths to impacted locations to deliver essential supplies such as food and water is a challenging task for first responders when the precise locations of disrupted roads are only partially known at the time of planning. This problem can be modeled as a multi-agent and multi-destination variant of the Canadian Traveler Problem. One-to-one assignments are made between agents and destinations and the goal is to find robust shortest paths from the source to each destination, given road network uncertainty. As they traverse the network, agents share information they discover about roads with each other and can replan paths based on new information. Unsurprisingly, results indicate that agents benefit from information discovered by other agents, evidenced by improved paths to destinations.

3 Domain-sensitive Pandemic Opinion Leadership Analyzer in Online Social Networks

Behnam Malmir, Christopher W. Zobel, Virginia Tech, Blacksburg, VA, Contact: malmir@vt.edu

Public health (PH) officials face plenty of challenges when a pandemic occurs in bringing guidance-related information to the public. Leadership strategies, one of the fascinating areas in information systems, can be used to address this problem. Opinion leaders (OLs) serve as trustworthy information providers and influence the general populace to follow the directives issued by PH officials. OLs can help public health professionals spread information rapidly and effectively at a lower cost during pandemics. This paper introduces a framework for finding domain-sensitive pandemic OLs in online social networks based on explicit and implicit data. Using this framework, we first determine the practical characteristics of pandemic OLs on public attitudes and then identify domain-sensitive OLs of COVID-19 on Twitter based on the discovered characteristics.

4 Disaster Recovery in Information Systems - Barter or Balance

Varada Krishnaswamy, Virginia Tech, Chantilly, VA

One underlying assumption in information system disaster recovery is that disaster recovery is not a business function. The functional business requirements are described separately from disaster recovery. We recognize that by making disaster recovery a characteristic business function goal, we may be able to convert it into an operational requirement. As exemplified by software requirements practice and research, one prevalent assumption in the literature regards disaster recovery as a non-business function requirement. However, the proposal is to test the current validity of the dominant assumption.

Tuesday, 2 PM–3:15 PM

TD24

CC - Wabash 1

Aviaga / Gurobi Optimization

Technology Tutorial

1 From Algorithm to Production App. Low Code, High Performance

Martin Shell, Avaiga, Somerville, MA, Contact: martin.shell@avaiga.com

Data scientists focus on the challenges of developing algorithms to solve complex predictive and prescriptive analytics problems. The greatest challenge often is turning these models into applications accessible to business users. We will present the two components of Taipy; Taipy GUI and Taipy Core. Taipy GUI is a low-code highly responsive visualization framework that facilitates the development of interactive web applications built on data-centric algorithms. Taipy Core facilitates the management of data flow through multi-stage pipelines and scenario management. Working in concert, these two components bridge the gap between data science and production-grade application.

2 Fundamentals of Ill Conditioning

Ed Klotz, Gurobi Optimization, Incline Village, NV, Contact: klotz@gurobi.com

Highly ill conditioned mathematical programming models can pose time-consuming challenges to practitioners regarding both solver run time and accuracy of solutions. This tutorial will present fundamental concepts and definitions that can help the practitioner more effectively assess the level of ill conditioning in a model and reduce development and maintenance work. Some common but easily remedied model characteristics that can cause ill conditioning will be described, and some practical examples will be discussed.

Tuesday, 2 PM–3:15 PM

TD25

CC - Wabash 2

Operations Research on Mobile-enabled Financial Inclusion: a Roadmap to Impact

Tutorial Session

Session Chair

Mabel Chou, National University of Singapore, SG, SG, Singapore.

1 **Operations Research on Mobile-Enabled Financial Inclusion: a Roadmap to Impact**
Karthik Balasubramanian, Howard University School of Business, Washington, DC
In the developing world, the lack of access to high-quality financial instru-ments has severely hampered the health and general well-being of poor peo-ple. This article explores the causes, results, and emerging solutions to “finan-cial exclusion,” as well as how Operations Research (OR) scholars can help. This article provides a primer on the financial lives of the poor, the promise of “mobile money”, as well as academically fruitful and practically important research avenues that OR scholars (and scholars of adjacent fields) can pursue to make an impact. This article outlines three mobile money topics that are ripe for further research: mobile money agent incentives are explored with a game-theoretic framework, inventory decision support is explored with a reg-ulated Brownian motion framework, and agent network optimization is de-scribed in terms of classical OR problems like facility location, assignment, and traveling salesman.

Tuesday, 2 PM–3:15 PM

TD26

CC - Wabash 3
Facility Location Analysis
General Session

Session Chair
Bahareh Kargar, 1</sup

1 **On Exploiting Hidden Structures in Facility Location Problems**
Hannah Bakker[1], Stefan Nickel[2], [1]Karlsruhe Institute of Technology, Karlsruhe, Germany; [2]Karlsruhe Insitute of Technology, Karlsruhe, Germany. Contact: hannah.bakker@kit.edu
While the capacitated facility location problem is a core problem of location science, the analysis of solutions in the decision space is insufficiently addressed. A closer look reveals that while some facilities are of essential importance to the achievement of the objective value, other facilities can easily be replaced. More intriguingly, while some candidates can be shown to be optimal on their own, some candidates are only optimal in combination with others. We present new measures to capture the importance of individual location decisions as well as to quantify the degree to which they depend on other candidates. We move on to investigate how the knowledge of these differences can help to solve large-scale location problems.

3 **The Quickest Evacuation Location Problem (QELP) in Humanitarian Operations: Introduction, Applications and a Matheuristic Approach**
Xiaochen Feng, Diego Ruiz-Hernandez, Antonino Sgalambro, The University of Sheffield, Sheffield, United Kingdom. Contact: xfeng9@sheffield.ac.uk
This paper introduces the Quickest Evacuation Location problem (QELP) a novel optimization approach aimed at supporting humanitarian operations by combining quickest flows and discrete facility location problems. The goal is to enhance evacuation networks design and planning by identifying the optimal set of shelters among a finite set of candidates. To secure flexible and realistic decision support, a multi-objective mixed integer programming model is developed, looking for minimizing the evacuation makespan and the total budget required to install and operate the shelters, while balancing the load of evacuees directed to each active shelter. Robust Augmented epsilon-constraint method is adopted as a solution scheme, and successfully combined with a tailored Matheuristic approach for efficiently exploring Pareto optimal solutions at increasing network size.

4 **Optimal Strategic Planning of a Multiple Level Remanufacturing Supply Network in a Circular Economy Framework**
Azar Mahmoum Gonbadi, Andea Genovese, Antonino Sgalambro, The University of Sheffield, Sheffield, United Kingdom. Contact: a.mahmoum@sheffield.ac.uk
Closed-Loop Supply Chains (CLSCs) can operationalise Circular Economy principles, beingaimed at circling back end-of-life products through reusing, remanufacturing and recyclingactions. The literature on CLSC optimisation presents a gap for models addressing thenumber of remanufacturing levels to consider while concurrently designing a supplynetwork. This study develops a comprehensive CLSC framework, characterised by a compactand multi-objective MIP model, supporting all major strategic design decisions at a supplychain level - supplier selection, facility location, manufacturing and distribution choices -while determining the number of market channels to be activated in the reverse element ofthe supply chain. Computational results are illustrated, showing the encouraging potentialrelated to the application of such compact optimisation model.

Tuesday, 2 PM–3:15 PM

TD27

CC - Room 138

On-demand Service Platforms: Workers and Responsiveness

General Session

Session Chair

Terry Taylor, University of California at Berkeley, Piedmont, CA

Session Chair

Ming Hu, University of Toronto, Minneapolis, MN

1 **Human in The Loop Automation: Ride-hailing with Remote (tele-) Drivers**

Saif Benjaafar, Zicheng Wang, Xiaotang Yang, University of Minnesota, Minneapolis, MN

By putting the human back "in the loop," tele-driving has recently emerged as a more viable alternative to fully automated vehicles, with ride-hailing (and other on-demand transportation-enabled services) being an important application. We examine the impact of tele-driving on the efficiency of ride-hailing. Among our findings, we show that having fewer (tele) drivers than vehicles can surprisingly improve performance (mitigating the wild goose chase phenomenon) or stabilize an otherwise unstable system.

2 **Implications of Worker Classification in On-demand Economy**

Ming Hu[1], Zhoupeng J. Zhang[1], Jianfu Wang[2], [1]Rotman School of Management, University of Toronto, Toronto, ON, Canada; [2]College of Business, City University of Hong Kong, Kowloon, Hong Kong. Contact: zhoupeng.zhang@rotman.utoronto.ca

How should gig workers be classified? We study this policy question focusing on the welfare of long-term (LT) workers, who depend on gig jobs as primary income sources. We identify two issues with uniform classifications: when all workers treated as contractors before are reclassified as employees, a profit-maximizing company may undercut workers, and LT workers' welfare can decrease; when all are reclassified as contractors+, which offers incomplete employee benefits but allows flexibility, workers can overjoin such that LT workers' welfare may not be enhanced due to low utilization. We show that discriminatory approaches such as to classify gig workers according to their needs or to operationally prioritize LT workers can Pareto improve over uniform classifications. We empirically calibrate the model and apply our insights to the ride-hailing market in California.

3 **Delivery Systems: Controlling Capacity and Response Time**

Gerard P. Cachon, University of Pennsylvania, Philadelphia, PA

There is growing interest in the operations of delivery systems to achieve fast response times. For example, how should workers be dispatched in local food delivery or robotics be implemented for deliveries within a fulfillment center? We provide a lower bound performance over all possible policies and use the bound to identify relatively simple and effective policies. We find that the capacity requirements to achieve fast response times (say 2 hours or less) are highly sensitive to the parameters of the system.

4 **Shared-ride Efficiency of Ride-hailing Platforms**

Terry Taylor, University of California at Berkeley

Ride-hailing platforms offering shared rides devote effort to improving *shared-ride efficiency* (i.e., reducing the trip-lengthening detours that accommodate fellow customers' divergent transportation needs). This paper shows: greater customer sensitivity to shared-ride delay and greater labor cost can *reduce* the value of improving share-ride efficiency; an increase in shared-ride efficiency can prompt a platform to *add* individual-ride service; and increasing shared-ride efficiency *pushes wages to extremes* (i.e., pushes low wages even lower, and pushes high wages even higher).

Tuesday, 2 PM–3:15 PM

TD28

CC - Room 139

Empirical Research in Healthcare

General Session

Session Chair

Guihua Wang, The University of Texas at Dallas

1 **Principal-Agent Decision Making when Facing Uncertainty: Application in U.s. Dialysis Industry**

Reza Roshangarzadeh[1], TI Tongil Kim[2], Shervin Shahrokhi Tehrani[3], [1]UT DALLAS, Dallas, TX, [2]University of Texas at Dallas, Richardson, TX, [3]University of Texas-Dallas, Richardson, TX, Contact: rxr180002@utdallas.edu

This study analyzes decision making under uncertainty in the principal-agency problem in a setting where the agent (i.e., physician) makes recommendations about treatment options for the principal (i.e., patient). Using 2013-2015 data on U.S. end-stage renal disease patients and their referring physicians who recommend a set of dialysis centers for the new patients, we aim to model patients' dialysis center selection process. Our model accounts for physicians' uncertainty about the characteristics of dialysis centers and the match values of specific centers to their heterogeneous patients, as well as the patients' uncertainty about the fitness of each recommended center to their needs. Given our framework, we can empirically recover the agents' recommendation which allows us to explore ways to improve quality-of-care through counterfactual analyses.

2 Reverse Cross Subsidization in Healthcare Capitation Programs: Evidence from Medicare Advantage

Zhaowei She[1], Turgay Ayer[2], Bilal Gokpinar[3], Danny Hughes[4], [1]Singapore Management University, Singapore, Singapore; [2]ISyE Georgia Tech, Atlanta, GA, [3]UCL School of Management, London, United Kingdom; [4]Georgia Institute of Technology, Atlanta, GA

Capitation payment models have been increasingly adopted by payers in the U.S. healthcare market during the past decade. However, early study shows that Medicare Advantage (MA), the largest capitation program in the U.S., tends to under-provide healthcare services to the old and the sick but over-provide to the relatively younger and healthier patients. This paper empirically shows that MA unintentionally incentivizes providers (MA health plans) to reallocate parts of the capitation payments from the old and the sick to cross subsidize the young and the healthy. By exploiting a policy induced exogenous shock on MA capitation payments, we identify this reverse cross subsidization incentive through a difference-in-difference (DID) design. Furthermore, we empirically demonstrate that this reverse cross subsidization incentive causes risk selection in MA.

3 Ride-to-health: The Impact of Ridesharing on Patients' Emergency Care Access

Ayush Sengupta, Shu He, Miao Bai, Xinxin Li, University of Connecticut, Storrs, CT, Contact: ayush.sengupta@uconn.edu

Transportation is an obstacle to appropriate access to healthcare. Emergency Department (ED), the "safety net" of healthcare, provides around-the-clock care for life-threatening conditions. We investigate if ridesharing alleviates the transportation concern. We empirically examine how Uber's entry affects ED access in California. Leveraging the sequential entries in different locations as a natural experiment setting, we use the staggered difference-in-differences model. Uber leads to more high-severity ED visits. This impact is smaller for EDs that provide more comprehensive care, treat more uninsured patients, and are in smaller areas. It decreases low acuity visits, allows patients to select distant EDs, increases the waiting time, but reduces the mortality. Our findings and implications contribute to the research on the social effects of sharing economy.

4 Investigating The Consequences of Emergency Department Boarding on Downstream Patient Outcomes and Hospital Processes

Huifeng Su[1], Lesley Meng[2], Rohit Sangal[3], Edieal J. Pinker[1], [1]Yale School of Management, New Haven, CT, [2]Yale School of Management, Yale University, New Haven, CT, [3]Yale School of Medicine, New Haven, CT, Contact: huifeng.su@yale.edu

Emergency Department (ED) boarding refers to the delayed transfer of admitted patients from the ED to inpatient units. Prior studies on the impact of boarding on clinical outcomes have shown mixed results. We study this relationship through a causal lens to investigate the consequences of boarding on downstream patient outcomes.

Tuesday, 2 PM–3:15 PM

TD29

CC - Room 140

Emerging Topics on the Interface of Operations and Finance

General Session

Session Chair

Yuqian Xu, UNC-Chapel Hill Kenan-Flagler Business School, Durham, NC

1 Operational Risk Management: Optimal Inspection Policy

Youngsoo Kim[1], Yuqian Xu[2], [1]University of Alabama, Tuscaloosa, AL, [2]UNC-Chapel Hill Kenan-Flagler Business School, Durham, NC, Contact: ykim@cba.ua.edu

Motivated by the importance of operational risk and its current regulation in the financial services industry, we study how a financial firm can optimally design inspection policies to manage operational risk losses. We propose a continuous-

time principal-agent model framework to examine a financial firm's optimal inspection policy and their employees' effort towards lowering the risk event occurrences. We first consider two commonly used inspection policies, namely, random and periodic policies. We find that random policy is not always optimal, and it is dominated by periodic policy if the inspection cost is sufficiently low. Also, we construct a hybrid policy that strictly dominates random policy and weakly dominates periodic policy, which suggests that a proper reduction of the random element in the inspection policy can always improve its performance.

2 Supply Chain Information Transparency and The Value of Trade Credit Platforms

Jiding Zhang[1], S. Alex Yang[2], Xiangfeng Chen[3], [1]NYU Shanghai, Shanghai, China; [2]London Business School, London, United Kingdom; [3]Fudan University, Shanghai, China. Contact: jiding@nyu.edu

In this paper, we empirically study the value of trade credit platforms. Using a recent dataset, we derive the benefit of having more information transparency on such platforms.

3 Pathwise Optimization for Reinforcement Learning Beyond Optimal Stopping

Bo Yang[1], Selvaprabu Nadarajah[2], Nicola Secomandi[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Information and Decision Sciences, University of Illinois at Chicago, Chicago, IL

Pathwise optimization is a reinforcement learning approach that has been successfully applied to intractable Markov decision processes in optimal stopping contexts. The version of its underlying linear program that has polynomial size becomes unbounded for models that lack a stopping structure, such as those that arise in switching option settings. We address this issue by adding pseudo-stopping actions associated with feasible nonanticipative policies. Applied to realistic energy storage instances, the proposed methodology leads to near optimal policies and bounds that are competitive with the ones of least squares Monte Carlo, a state-of-the-art methodology for this application.

4 Economics of Multi-tier Supply Chain Financing Enabled by Blockchain

Volodymyr O. Babich[1], Yoko Shibuya[2], [1]Georgetown University, Washington, DC, [2]Stanford University, Stanford, CA, Contact: vob2@georgetown.edu

We compare immediate-tier with remote-tier supply chain financing by solving for equilibrium among multiple firms in a supply chain and their investors, in the model with moral hazard, stochastic collateral assets, and dynamic forecasts of those assets. Interestingly, remote-tier financing enabled by Blockchain does not emerge as the dominant choice even if the immediate and remote-tier buyers are identical in all operational and financial characteristics. We identify two reasons: risk spillover from downstream tiers to upstream ones and accumulation of noise in the forecast. We provide conditions for the remote-tier financing to be preferred, compare preferences of individual firms and the supply chain, and discuss how this affects Blockchain adoption. We determine the economic boundary on the number of tiers in a supply chain financing solution.

Tuesday, 2 PM–3:15 PM

TD30

CC - Room 141

Managing Congestion-prone Service Systems with Strategic Customers

General Session

Session Chair

Philipp Afeche, University of Toronto, Toronto, ON, Canada.

1 The Cost of Decentralized Persuasion

Niloufar Mirzavand Boroujeni[1], Krishnamurthy Iyer[2], William L. Cooper[1], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota, Saint Paul, MN

We consider the problem of information sharing in a service system composed of multiple components in order to convince an arriving customer to join one of the components. The customer's utility upon joining a component depends on the component's (localized) state. We analyze the static setting where each component's state is independent of the states of other components, and the state distributions are exogenous. We study centralized signaling mechanisms, where the system shares a single signal containing information about all components, and decentralized signaling mechanisms, where each component shares a signal containing information only about its localized state. We analyze the relative loss in throughput between the optimal centralized and decentralized signaling mechanisms, and provide a tight upper bound that depends on the number of components.

2 On Pricing a Quality-diversified Service with An Option to Stall

Ricky Roet-Green[1], Aditya Shetty[2], [1]University of Rochester, Rochester, NY, [2]Simon Business School, Rochester, NY, Contact: ricky.roet-green@simon.rochester.

edu

We study the revenue maximization problem of a service provider who operates two heterogeneous servers. The servers may differ in their reward and/or their expected service times, making one server more preferable to customers. When offered service by the less preferred server, customers may stall and continue waiting for the more preferred server to become available. Additionally, an arriving customer may balk. We analyze how the service provider can use pricing as a lever to simultaneously manage this stalling and balking behavior in order to maximize revenue. We consider a single price regime, where the provider charges the same price for both servers, and a dual price regime, where different prices are charged for each server. We find that a single price can only control balking behavior whereas a dual price can control both balking and stalling behavior.

3 Benefits of Information in Service Systems

Vikas Deep[1], Ramandeep Randhawa[2], Achal Bassamboo[1], [1]Northwestern University, Evanston, IL, [2]University of Southern California, Los Angeles, CA, Contact: vikas.deep@kellogg.northwestern.edu

We study the problem of the use of Bayesian persuasion techniques in the service systems. We show that uncertainty in service capacity could be more beneficial for the service provider by persuading the Bayesian customers. We characterize the optimal persuasion strategy as a convex program. We compare the performance of optimal persuasion strategy in our system with the system in which there is an average fixed service capacity.

4 Potty Parity: Process Flexibility Via Unisex Restroom

Setareh Farajollahzadeh, Ming Hu, Rotman School of Management, Toronto, ON, Canada. Contact: setareh.farajollahzadeh@rotman.utoronto.ca

We study the problem of inequitable access to public restrooms by women and the LGBTQ+ community. We adopt a queueing system with horizontally differentiated customer preferences and analytically show the benefits enabled by the unisex restroom. (1) improving wait time parity, (2) enhancing utility parity among users, and (3) increasing safety perception. We propose utility parity as an inclusive measure of potty parity and provide insights on how to retrofit restrooms to be more efficient and inclusive.

Tuesday, 2 PM–3:15 PM

TD31

CC - Room 142

Session 4: Socially and Environmentally Responsible Supply Chains

General Session

Session Chair

Yen-Ting (Daniel) Lin, University of San Diego, San Diego, CA

1 Manufacturer's Voluntary Environmental Efforts Under Product Ban

Wenli Xiao[1], Natalie Ximin Huang[2], Aditya Vedantam[3], [1]University of San Diego, San Diego, CA, [2]University of Minnesota, Minneapolis, MN, [3]State University of New York at Buffalo, Williamsville, NY, Contact: huangx@umn.edu

We study a manufacturer's voluntary environmental efforts as a preemptive strategy against potential regulatory action to ban future sales of its products. We show how a potential future product ban impacts the manufacturer's recycling rate decision on an existing product and its effort to develop a greener substitute product.

2 Avoiding Fields on Fire: Information Dissemination Policies for Environmentally Safe Crop-residue Management

Mehdi Farahani[1], Milind Dawande[2], Ganesh Janakiraman[3], Shouqiang Wang[2], [1]University of Miami, Coral Gables, FL, [2]The University of Texas at Dallas, Richardson, TX, [3]University of Texas- Dallas, Richardson, TX, Contact: mehdihos@mit.edu

Agricultural open burning, i.e., the practice of burning crop residue to prepare land for sowing a new crop, is a major contributor to climate change. An agricultural machine, called Happy Seeder, which can sow the new seed without removing the residue, has emerged as the most effective alternative. We study how the government can use effective information-disclosure policies to minimize open burning. A Happy Seeder is assigned to process a group of farms in an arbitrary order. Farmers decide whether to burn their farms or to wait for the Happy Seeder, given the information provided by the government about the Happy Seeder's schedule. We propose the class of dilatory policies that provide no information until a pre-specified period and then reveal the entire schedule. We show that the use of an optimal dilatory policy can significantly reduce CO_2 and black carbon emissions.

3 Supply Chain Relationship Impacts on Firms' Environmental CSR Practices

Marcus A. Bellamy[1], Elliot Bendoly[2], Erin McKie[2], [1]Boston University, Boston, MA, [2]The Ohio State University, Columbus, OH, Contact: bellamym@bu.edu
Our study emphasizes how a firm's corporate social responsibility (CSR) efforts are linked to their supply chain entities. Specifically, we examine how changes in Environmental CSR occur across members of their supply chains using supply chain relationship and environmental data over a 10-year period. Based on these findings, we discuss the implications of firms' supply chain engagements and selections.

Tuesday, 2 PM–3:15 PM

TD32

CC - Room 143
Business and Climate Change
General Session

Session Chair
Christian Blanco, University of California-Los Angeles, Columbus, OH

1 Environmental Disclosure in Supply Networks
Jie Lian[1], Yan Dong[2], Sining Song[3], Natalie Ximin Huang[4], [1]University of South Carolina, Columbia, SC, [2]University of South Carolina, Columbia, SC, [3]University of Tennessee Knoxville, KNOXVILLE, TN, [4]University of Minnesota, Minneapolis, MN, Contact: Jie.Lian@grad.moore.sc.edu
Firms in supply chains have increasingly adopted environmental disclosure to improve environmental performance. This research studies the spillover effect of a firm in disclosing its environmental performance on its suppliers' decision to do the same. The firm's disclosure creates both a pressure to disclose and an opportunity to free ride. Using panel data and econometric analysis, we investigate the outcome of this tradeoff in supply chains.

2 Voluntary Corporate Carbon Targets
Christian Blanco[1], Oznur Ozdemir[2], Erdinc Akyildirim[3], [1]The Ohio State University, Columbus, OH, [2]Sabanci University, Istanbul, Turkey; [3]University of Zurich, Zurich, Switzerland. Contact: blanco.58@osu.edu
We use ten years of data across 1,637 firms to compare the carbon performance of companies that set voluntary carbon targets to those that do not. We find that only 24% of firms that set voluntary targets successfully meet them. We provide recommendations on the design of the target to increase the likelihood of its success.

3 Presenter
Mateus do Rego Ferreira Lima, [1]</sup

4 Presenter
Jayashankar M. Swaminathan, University of North Carolina Chapel Hill, Chapel Hill, NC

Tuesday, 2 PM–3:15 PM

TD33

CC - Room 144
Inventory Management I
Contributed Session

Session Chair
Youssef Boulaksil, UAE University, Al Ain, United Arab Emirates.

1 Asymptotic Optimality of Semi-open-loop Policies in Markov Decision Processes with Large Lead Times
Xingyu Bai[1], Xin Chen[2], Menglong Li[3], Aleksandr Stolyar[4], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]UIUC, Urbana, IL, [3]UIUC, Savoy, IL, [4]University of Illinois at Urbana-Champaign, Urbana, IL, Contact: xingyub3@illinois.edu
We consider a Markov decision process (MDP) with two controls: one control taking effect immediately and other control whose effect is delayed by a positive lead time. The purpose of this work is to establish asymptotic optimality of semi-open-loop policies, which specify open-loop controls for the delayed action and closed-loop controls for the immediate action.
First, we consider generic MDPs under the assumptions of fast mixing and a uniformly bounded cost function, and show that periodic semi-open-loop policies are asymptotically optimal.
We then consider MDPs defined on Euclidean spaces. For such MDPs, we introduce the notion of reset state distribution, and impose mild assumptions to build a framework to establish the asymptotic optimality of semi-open-loop policies. The applicability of this framework is then illustrated through several operations models.

2 Demand Fulfilment Probability Under Pareto-distributed Demand
Adrian Perez[1], Canan Gunes Corlu[1], Cas Rosman[2], Benjamin Harris[1], [1]Boston University, Boston, MA, [2]Eindhoven Institute of Technology, Netherlands,

Netherlands. Contact: adrianbu@bu.edu
We study a multi-item inventory setting where the goal is to maximize demand fulfillment probability subject to a budget constraint on the total inventory investment. Assuming that the individual item demands are Pareto-distributed, we formulate the optimization problem and investigate the impact of Pareto parameters on the optimal inventory levels. We also compare the inventory levels obtained under Pareto-distributed demand to inventory levels obtained under normal distributed demand.

3 A Modified Base-stock Ordering Policy for Perishable Products with Demand Estimates

Maryam Motamedi[1], Na Li[2], Douglas Down[3], [1]McMaster Univeristy, Hamilton, ON, Canada; [2]University of Calgary, Calgary, AB, Canada; [3]McMaster University, Hamilton, ON, Canada. Contact: motamedm@mcmaster.ca

We consider a single-item, periodic-review inventory model for perishable products with wastage and shortage costs and where an estimate of demand for the next period is available. We show that a modified, state-dependent, base-stock policy is optimal for a finite time horizon. We also investigate the monotonicity properties of the optimal order and show that the optimal order is monotone in the state. Further, we use a heuristic to calculate the state-based base-stock values, using an affine function of the demand estimate. We show that this heuristic serves as a good approximation for the optimal ordering policy.

4 Adaptive Inventory Replenishment Using Structured Reinforcement Learning by Exploiting An Optimal Policy Structure

Hyungjun Park[1], Dong Gu Choi[2], Daiki Min[3], [1]Pohang University of Science and Technology, Pohang, Korea, Republic of; [2]Pohang University of Science and Technology (POSTECH), Pohang, Gyeongbuk, Korea, Republic of; [3]Ewha Womans University, Seoul, Korea, Republic of. Contact: hjhjpark94@postech.ac.kr

We design a structured reinforcement learning algorithm that efficiently adapts the replenishment policy to changing demand without any prior knowledge. Our proposed method integrates the known structural properties of an optimal inventory replenishment policy with reinforcement learning. By exploiting the optimal policy structure, we tune reinforcement learning to characterize the inventory replenishment policy. This novel reinforcement learning algorithm ensures efficient convergence behavior and lowers algorithmic complexity for solving practical problems. The numerical results demonstrate that the proposed algorithm adaptively updates the policy to changing demand and raises operational efficiency. Moreover, we apply our method to real-life retail management, and the case study demonstrates its superiority in practical applicability.

5 Multi-echelon Stochastic Dual Sourcing Inventory Management

Sadeque Hamdan[1], Youssef Boulaksil[2], Kilani Ghoudi[2], Younes Hamdouch[3], [1]University of Kent, Canterbury, United Kingdom; [2]UAE University, Al Ain, United Arab Emirates; [3]Zayed University, Dubai, United Arab Emirates. Contact: youssef.boulaksil@gmail.com

This study examines a multi-echelon dual sourcing inventory system. In each echelon, the decision-maker faces a dual sourcing situation wherein the item can be replenished from a slow regular supplier or a more expensive and faster emergency supplier. We compare the performance of two policies: the dual-index policy (DIP) and the tailored base-surge (TBS) policy. TBS policy is found to outperform DIP in the number of echelons. Furthermore, the impact of demand disruption, as has been observed during COVID-19 crisis, is studied. Our results show that upstream suppliers are relatively more utilized under TBS than under DIP. Upstream suppliers are hardly utilized in several cases, such as when the level of demand uncertainty is high. Further, DIP is preferred in short networks when a sudden drop in demand occurs, while TBS is preferred when the demand faces a spike.

Tuesday, 2 PM–3:15 PM

TD34

CC - Room 145

Resource Allocation in Natural Disasters

Contributed Session

Session Chair

Demetra Protogyrou, North Carolina State University, Clayton, NC

1 Multi Criteria Decision Making in Post Disaster Resource Management

Sarthak Swarup S. Mishra[1], Joon-Yeoul Oh[2], [1]INTELLECTT INC., Iselin, NJ, [2]Texas A & M University, Kingsville, Kingsville, TX, Contact: justinsarthak1993@gmail.com

A well-organized disaster preparation and recovery plan can minimize casualties and damages. This research aims to develop an efficient method to distribute limited resources for minimizing the recovery time. There will be various damages depending on the type of disaster, and they can be categorized according to their nature. Due to the limited recovery resources, the categorized damages are prioritized for recovery planning. This research develops various scenarios and their recovery plans accordingly. The results of test cases show that it provides an efficient resource allocation. The proposed method can play a significant role in the decision support system for disaster recovery.

2 Enhancing Equity in Disaster Relief Resource Allocation Via Data Driven Optimization

Zhenlong Jiang, Ran Ji, George Mason University, Fairfax, VA, Contact: zjiang@gmu.edu

We study a two-stage bi-objective equity-driven stochastic program model to design an equitable humanitarian relief logistics with uncertainties in demand, the remaining inventory level, and travel time in the post-disaster stage. The model decides the locations of relief facilities, inventory levels and transportation plans. We aim to take both efficiency and equity into account; thus, we develop two objective functions that minimize: (i) the total expected cost, including inequity penalty, and (ii) disaster preparedness weighted arrival time. We employ the Gini's mean absolute difference of relief supplies at per-capita accessed as the equity measure. Moreover, for the first time, disaster preparedness was taken into account in humanitarian relief models. A case study focused on the Gulf Coast area of the US illustrates the application of the proposed model.

3 A Lagrangian Relaxation Approach for Resource Location Problem with Capacity and Priority Constraints

Demetra Protogyrou[1], Leila Hajibabai[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC

This research evaluates a capacitated facility location model with an addition of priority constraints for an emergency response problem after a hurricane. The priority constraints require the demand points to be within a particular distance from selected facilities. A Lagrangian relaxation technique was implemented to solve the problem by relaxing both capacity and priority constraints. The numerical results confirm the quality and efficiency of the solutions.

4 Stochastic Resource Allocation for Post-Disaster Resilience

Weimar A. Ardila Rueda[1], Alex Savachkin[2], Daniel Romero Rodriguez[3], [1]University of South Florida, Tampa, FL, [2]University of South Florida, Tampa, FL, [3]Universidad del Norte, Barranquilla, Colombia. Contact: weimar@usf.edu

There are two significant components in the notion of resilience, the absorptive and the recovery dimensions. The recovery dimension is the ability to return to normal operating conditions, and the post-disaster response is related to a system's recovery ability. We can model it as a Markov process since a system performance improves during the recovery and involves factors with random behavior. In addition, many actions that aim to strengthen resilience suppose conflict efficiency and cost reduction. This paper proposes a stochastic dynamic optimization model based on a finite horizon Continuous-Time Markov Decision Process to minimize the total recovery cost in physical systems, given the initial performance loss. The main objective is to find a balance between intervention investment and systems' post-disaster response.

Tuesday, 2 PM–3:15 PM

TD39

CC - Room 201

OPT/Computational Optimization and Software Flash Session

Flash Session

Session Chair

Paul Eugene Coffman, Ford Motor Company, Redford Township, MI

1 Bonus Algorithm for Real-world Optimization Under Uncertainty with Black-box Models

Urmila Diwekar, Vishwamitra Research Institute, Crystal Lake, IL

This flash talk presents real-world case studies involving optimization in the face of uncertainties. These case studies are from the areas of energy, environment, and sustainability, where large-scale simulators (black-box) are used. Better Optimization of Nonlinear Uncertain Systems (BONUS) algorithm provides efficient and effective solutions for these problems.

2 Flash Talk: Interpretable Output Analysis for Black-box Optimization

Sara Shashaani, North Carolina State University, Raleigh, NC

This study explores the importance of uncertainty quantification in output analysis, particularly in data-driven modeling and machine learning. Our findings emphasize the importance of probabilistic analysis in modeling and validation with case studies in coastal risk analysis.

3 Optimal Response of Supply Chain and Manufacturing Networks Subject to Disruptions

Daniel Ovalle Varela[1], Ignacio E. Grossmann[2], Carl Laird[3], Yixin Ye[4], Kyle Harshbarger[5], Scott Bury[6], [1]Carnegie Mellon University, PITTSBURGH, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Carnegie Mellon University, Fayetteville, AR, [4]The Dow Chemical Company, Houston, TX, [5]Dow, Inc., Midland, MI, [6]Dow Chemical Company, Sanford, MI

We address the problem of mitigating the impact of disruptions on multi-product supply chains with a novel optimization model that minimizes the operational cost once the disruptions occur. The proposed model, a multi-period Mixed-Integer Program, considers information about material shipments, possible routes, plant production, and order schedules to predict the best possible reaction plan for operation.

4 Nonlinear Programming Approaches for Estimation of Spatio-temporal Transmission Parameters in Infectious Disease Models

Carl Laird, Carnegie Mellon University, Fayetteville, AR

Nonlinear programming is a valuable capability for parameter estimation in dynamic systems. In this presentation, we will discuss the use of nonlinear dynamic optimization approaches for estimation of temporally changing transmission parameters in infectious diseases. We discuss applications to childhood infectious diseases (e.g., measles) and COVID-19.

5 State-of-the Art in Numerical Optimization Software

Hans Mittelmann, Arizona State University, Tempe, AZ

The current state of optimization software will be sketched based on our benchmarking effort.

6 Recent Developments in The Baron Project

Nick Sahinidis[1,2], [1]Georgia Institute of Technology, Atlanta, GA, [2]The Optimization Firm, Atlanta, GA

We discuss recent developments in the BARON project, including the implementation of a new presolve and lift-and-project cuts for mixed-integer nonlinear programs.

7 Results of Fuzzy Re-sorting in Dynamic Bin Packing

Paul Eugene Coffman[1], Stephany Coffman-Wolph[2], [1]Ford Motor Company, Redford Township, MI, [2]Ohio Northern University, Ada, OH, Contact: gcoffman@ford.com

Many algorithms for dynamic sequencing leverage bin packing like heuristics that rely on fast and efficient sort algorithms executed multiple times (to reorder jobs by new criteria or because additional items have been added to the queue). The authors will discuss the results of applying a fuzzy sort to a sequencing algorithm compared to traditional sorting algorithms. Additionally, the authors will present the advantages and disadvantages of "fuzzifing" a sort algorithm in the context of job sequencing.

Tuesday, 2 PM–3:15 PM

TD40

CC - Room 202

Recent Advances in Robust and Stochastic Optimization

General Session

Session Chair

Nan Jiang, Virginia Tech, Blacksburg, VA

Session Chair

Weijun Xie, Virginia Tech, Blacksburg, VA

1 Mean-Covariance Robust Risk Measurement

Viet Anh Nguyen[1], Soroosh Shafieezadeh Abadeh[2], Damir Filipovic[3], Daniel Kuhn[4], [1]Stanford, Palo Alto, CA, [2]CMU, Pittsburgh, PA, [3]EPFL, Lausanne, Switzerland; [4]Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, Switzerland.

We introduce a universal framework for mean-covariance robust risk measurement and portfolio optimization. We model uncertainty in terms of the Gelbrich distance on the mean-covariance space, along with prior structural information about the population distribution. Our approach is related to the theory of optimal transport and exhibits superior statistical and computational properties than existing models. We find that, for a large class of risk measures, mean-covariance robust portfolio optimization boils down to the Markowitz model, subject to a regularization term given in closed form. This includes the finance standards, value-at-risk and conditional value-at-risk, and can be solved highly efficiently.

2 Uncertainty Propagation Via Optimal Transport Ambiguity Sets

Liviu Aolaritei, Nicolas Lanzetti, Hongruyu Chen, Florian Dörfler, ETH Zürich, Zürich, Switzerland. Contact: aliviu@ethz.ch

We present a novel principled way of performing uncertainty propagation through nonlinear, corrupted by noise, transformations, when the input is characterized by distributional uncertainty, i.e., its probability distribution is only partially known (e.g., we only have access to samples). Our methodology employs tools from Optimal Transport to capture the distributional uncertainty within an Optimal Transport ambiguity set, and our main findings can be condensed as follows: Despite the nonlinearity and stochasticity of the transformation, the result of the propagation is again an Optimal Transport ambiguity set in the majority of cases, and can be tightly upper bounded by one in the remaining of cases. Importantly, this allows us to connect the two layers of the ubiquitous pipeline consisting of Uncertainty Quantification followed by Robust Decision-Making.

3 ALSO-X#: Convex Approximations for Distributionally Robust Chance Constrained Programs

Nan Jiang, Weijun Xie, Virginia Tech, Blacksburg, VA, Contact: jnan97@vt.edu

This paper proposes a new ALSO-X# algorithm for solving distributionally robust chance constrained programs (DRCCPs). We show that when ALSO-X admits a unique optimal solution, ALSO-X# always outperforms ALSO-X, where the latter is recently proven to outperform the conditional value-at-risk (CVaR) approximation of a regular chance constrained program (Jiang and Xie, 2020). We also show that ALSO-X# can deliver an optimal solution to a DRCCP and numerically demonstrate its efficiency.

4 Self-adapting Network Relaxations for Weakly Coupled Markov Decision Processes

Selvaprabu Nadarajah[1], Andre Augusto Cire[2], [1]Information and Decision Sciences, University of Illinois at Chicago, Chicago, IL, [2]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada. Contact: andre.cire@rotman.utoronto.ca

Weakly coupled Markov decision processes (WDPs) arise in dynamic decision-making and reinforcement learning. These models are often high dimensional but decompose into smaller systems when relaxing the coupling constraints. We present a new class of WDP approximations, dubbed feasibility network relaxations (FNR), that embed an exact network encoding of the coupling constraints into a linear programming flow model. The relaxation matches the bounds and policies from the approximate linear programming (ALP) approach, but is substantially smaller in size, even polynomially sized when existing ALP formulations are exponentially large. We also demonstrate the theoretical benefits and tradeoffs with respect to the classical Lagrangian relaxation to inform model choice, showing a numerical analysis on multi-armed bandits and maintenance applications.

Tuesday, 2 PM–3:15 PM

TD41

CC - Room 203

Bilevel Stochastic Methods for Optimization and Learning

General Session

Session Chair

Tommaso Giovannelli, Lehigh University, Bethlehem PA

Session Chair

Luis Nunes Vicente, Lehigh University, Bethlehem, PA

1 Linearly Constrained Bilevel Optimization: A Smoothed Implicit Gradient Approach

Prashant Khanduri, University Of Minnesota, Minneapolis, MN, Contact: prashant.kec@gmail.com

This work develops analysis and algorithms for solving a class of bilevel optimization problems, where the lower-level problems have linear constraints. Most of the existing approaches for constrained bilevel problems rely on value function based approximate reformulations, which suffer from issues such as non-convex and non-differentiable constraints. In contrast, we develop an implicit-gradient based approach, which is easy to implement and is amenable for machine learning applications. We provide an in-depth understanding of the problem, by showing that the objective function for such problems is in general non-differentiable. However, if we add a small perturbation to the LL objective, the resulting problem becomes differentiable. This key observation opens the door for developing gradient-based algorithms similar to unconstrained bi-level problems.

2 A Primal-dual Approach to Bilevel Optimization with Multiple Inner Minima

Daouda Sow[1], Kaiyi Ji[2], Ziwei Guan[1], Yingbin Liang[1], [1]The Ohio State University, Columbus, OH, [2]University of Michigan, Ann Arbor, MI, Contact: sow.53@buckeyemail.osu.edu

Bilevel optimization has found extensive applications in modern machine learning problems such as hyperparameter optimization, neural architecture search, meta-learning, etc. While bilevel problems with a unique inner minimal point are well understood, such a problem with multiple inner minima remains to be a challenging and open. In this work, we adopt a reformulation of bilevel optimization to constrained nonconvex optimization, and solve the problem via a primal-dual bilevel optimization (PDBO) algorithm. PDBO not only addresses the multiple inner minima challenge, but also features fully first-order efficiency without involving second-order Hessian and Jacobian computations.

3 Making Bilevel Machine Learning Fast, Scalable and Flexible

Kaiyi Ji, University of Michigan, Ann Arbor, Ann Arbor, MI, Contact: kaiyiji@umich.edu

Recent tremendous successes of deep learning highly rely on the revolutions of a broad range of learning technologies. Many of these technologies, such as hyperparameter optimization and meta-learning, require bilevel optimization structures. With the increasing scale of datasets and models, large-scale bilevel optimization emerges recently as an exciting but challenging research topic in deep learning. In this talk, I will first discuss some limitations of existing bilevel methods on the scalability with big data and deep neural networks. I will then present two novel algorithms, inspired by Neumann Series (NS) and Evolution Strategy (ES) in stochastic optimization, for addressing these challenges. I also present the theoretical guarantee of the computational efficiency to support our design principles, where some analysis tools can be of independent interest.

4 Robust Multi-objective Bilevel Optimization with Applications in Machine Learning

Alex Gu[1], Songtao Lu[2], Parikshit Ram[3], Lily Weng[4], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]IBM, White Plains, NY, [3]IBM Research, Atlanta, GA, [4]University of San Diego, La Jolla, CA

We consider the generic min-max form of a multi-objective bilevel nonconvex optimization problem where we have (i) n objectives at both the levels, (ii) the upper level variable is shared across all objectives at both the levels, and (iii) every lower level variable is limited to one objective in each of the upper and lower levels. Such a problem appears in various machine learning applications such as representation learning and hyperparameter optimization. We propose a gradient descent-ascent based single-loop two-timescale algorithm, building upon recent single objective bilevel optimization schemes. Our theoretical analyses show that this algorithm converges to the first-order stationary point at a rate of $O(\sqrt{n}\, T^{-2/5})$ for a class of nonconvex problems, where n is the number of objectives at each level, and T is the number of algorithm iterations.

Tuesday, 2 PM–3:15 PM

TD42

CC - Room 204

Inverse Optimization and Preference Learning

General Session

Session Chair

Ian Yihang Zhu, University of Toronto, Toronto, ON, Canada.

1 Generalized Mixed Integer Inverse Optimization as a Technology of Perceiving and Diagnosing Congressional Gerrymandering

Ari Smith[1], Justin J. Boutilier[2], [1]University of Wisconsin - Madison, MADISON, WI, [2]University of Wisconsin - Madison, Fitchburg, WI, Contact: ajsmith44@wisc.edu

Popular debates on quantifying political gerrymandering (wherein legislative districts are drawn to distribute voting power unevenly across social groups) invoke metrics that align with sociopolitical values, whose analysis may ignore how a state's political geography produces bounds on what can be achieved, especially when there are competing metrics that cannot be simultaneously optimized. We introduce the use of generalized inverse optimization in this field, which allows for the full range of achievable districtings and metrics underneath a particular political geography to inform how we understand a legislative districting (modeled as the solution to an optimization problem) to enact a prioritization of some sociopolitical values *over* others, which can provide more nuanced and convincing arguments that a districting should be considered gerrymandered.

2 Online Convex Optimization Perspective for Learning from Dynamically Revealed Preferences

Violet (Xinying) Chen[1], Fatma Kilinc-Karzan[2], [1]Stevens Institute of Technology, Hoboken, NJ, [2]Carnegie Mellon University, Pittsburgh, PA

We study the problem of online learning (OL) from revealed preferences: a learner wishes to learn a non-strategic agent's private utility function through observing the agent's utility-maximizing actions in a changing environment. We adopt an online inverse optimization setup, where the learner observes a stream of agent's actions in an online fashion and measures the learning performance with regrets based on a loss function. Through defining a new convex loss function, we design a flexible OL framework that enables a unified treatment of usual loss functions from literature and supports a variety of online convex optimization algorithms. Our framework (coupled in particular with the online Mirror Descent) has advantages in terms of regret performance and solution time over other OL algorithms from the literature and bypasses the previous technical assumptions.

3 **Learning Personalized Diabetic Retinopathy Screening Preferences**

Zahed Shahmoradi[1], Fariha Kabir Torsha[2], Taewoo Lee[3], [1]Norfolk Southern Corporation, Atlanta, GA, [2]University of Houston, Houston, TX, [3]University of Pittsburgh, Pittsburgh, PA

Diabetic retinopathy (DR) is the leading cause of vision loss in working-age Americans. With the recent advent of accessible and convenient DR screening techniques such as teleretinal imaging, personalized DR screening has received increasing attention. In this study, we model the DR screening decision-making problem as a partially observable Markov decision process (POMDP) and use inverse optimization to infer the patient's reward function from past screening decisions and adherence behavior. The inferred reward function is then used to generate personalized screening recommendations.

Tuesday, 2 PM–3:15 PM

TD43

CC - Room 205

Data-driven Planning and Scheduling Optimization

General Session

Session Chair

Shujin Jiang, Purdue University, West Lafayette

1 **Stochastic Optimization Methods for Integrated Hurricane Relief Logistics and Evacuation Planning**

Sudhan Bhattarai, Yongjia Song, Clemson University, Clemson, SC, Contact: sudhanb@g.clemson.edu

We consider an integrated and coordinated disaster relief logistics planning and evacuation planning for an impending hurricane event. The key objective of the problem is toevacuate the affected population to shelters that are prepared with sufficient relief items in a timely fashion. The challenge is that the hurricane's information is uncertain and evolving over time. We propose a variety of stochastic optimization models and approaches to solve the problem, and discuss their pros and cons in different situations.

2 **A Shared Mobility Based Framework for Evacuation Planning and Operations Under Forecast Uncertainty**

Kati Moug, Huiwen Jia, Siqian Shen, University of Michigan, Ann Arbor, MI, Contact: klmoug@umich.edu

Ridesharing is a flexible, cost-effective evacuation mode for carless populations that requires planning ahead. At the same time, emergency evacuation patterns vary based on the nature and intensity of a disaster. To make efficient volunteer recruitment decisions that mitigate the risk of unserved demand, we develop two-stage stochastic integer programming formulations that optimize shared-mobility-based evacuation under geographic and temporal uncertainty in ride requests. We consider expected-penalty-based, chance-constrained, and conditional-value-at-risk (CVaR)-constrained formulations. We test our models with instances based on Charleston County, SC, an area that experienced a mandatory evacuation for Hurricane Florence, and compare the benefits and disadvantages of each formulation in mitigating risk of unserved demand.

Tuesday, 2 PM–3:15 PM

TD44

CC - Room 206

Applications and Theory of Discrete Optimization under Uncertainty

General Session

Session Chair

Yiling Zhang, University of Minnesota, Minneapolis, MN

1 **A Machine Learning-aided Stochastic Programming Model for Scheduling College Counseling Appointments**

Youssef Hebaish, Lewis Ntaimo, Hrayer Aprahamian, Sohom Chaterjee, Texas A&M University, College Station, TX, Contact: hebaish@tamu.edu

We consider a stochastic programming model for appointment scheduling in college counseling centers. At the beginning of each semester, counseling centers directors have to decide on a scheduling framework to be used by counselors to serve students' mental-health needs. The stochastic nature of student arrivals and the indefiniteness of students' treatment plans impose a challenge to the scheduling operations. We use this stochastic programming model to determine the optimal scheduling policy to minimize the waiting time for the first appointment and the waiting time for students seeking emergency help. The model is parameterized through service types, arrivals, and treatment plans. We use a neural network model to aid the SP model in determining the optimal treatment plan. We apply this model to a case study based on CAPS at Texas A&M University.

2 An Algorithm for Stochastic Convex-concave Fractional Programs with Applications to Production Efficiency and Equitable Resource Allocation

Shibshankar Dey[1], Cheolmin Kim[2], Sanjay Mehrotra[1], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: shibshankardey2025@u.northwestern.edu

We propose an algorithm to solve convex and concave fractional programs and their stochastic counterparts in a common framework. Convergence of the Sample Average Approximation for the stochastic problem is proved under mild conditions. The convergence analysis provides a bound on the optimality gap as a function of approximation errors. We prove that the proposed branch-and-bound algorithm terminates in a finite number of iterations and the worst-case bound to obtain an -optimal solution reciprocally depends on the square root of the desired accuracy. Numerical experiments on Cob-Douglas production efficiency and equitable resource allocation problems support that the algorithm efficiently finds a highly accurate solution.

3 Markov Chain-based Policies for Multi-stage Stochastic Integer Linear Programming

Margarita Paz Castro[1], Merve Bodur[2], Yongjia Song[3], [1]Pontificia Universidad Católica de Chile, Santiago, Chile; [2]University of Toronto, Toronto, ON, Canada; [3]Clemson University, Clemson, SC, Contact: margarita.castro@ing.puc.cl

We introduce a novel aggregation framework for multi-stage stochastic programs with mixed-integer state variables and continuous local variables (MSILPs). The framework imposes additional structure to the integer state variables by leveraging the information of the underlying stochastic process given by a Markov chain (MC). We present a novel branch-and-cut algorithm integrated with SDDP as an exact solution method to the aggregated MSILP. We also apply two-stage linear decision rule approximations and propose MC-based variants to get high-quality solutions with significantly reduced computational effort. We test our methodologies in an MSILP hurricane disaster relief problem. Our experiments compare the proposed approaches' effectiveness and analyze the trade-offs between policy flexibility, solution quality, and computational effort.

Tuesday, 2 PM–3:15 PM

TD45

CC - Room 207

AI4OPT: End-to-end Learning and Optimzation

General Session

Session Chair

Pascal Van Hentenryck, 1</sup

1 Online Contextual Decision Making with a Smart Predict-then-Optimize Method

Heyuan Liu, UC Berkeley, Berkeley, CA

We study an online contextual decision-making problem with resource constraints. At each time period, the decision-maker first predicts a reward vector and resource consumption matrix based on a given context vector and then makes a decision. The final goal is to maximize the summation of the reward and the utility from resource consumption, while satisfying the resource constraints. We propose an algorithm that mixes a prediction step based on the "Smart Predict-then-Optimize (SPO)" method with a dual update. The regret bound is sublinear and depends on the risk bounds of the surrogate loss used to learn the prediction model. Our algorithm and regret bounds apply to a general convex feasible region for the resource constraints, including both hard and soft constraints, and they apply to a wide class of prediction models in contrast to linear context or finite policy spaces.

2 Learning Optimization Proxies for Large-Scale Security-Constrained Economic Dispatch

Wenbo Chen, Georgia Institute of Technology, Atlanta, GA

The Security-Constrained Economic Dispatch (SCED) is a fundamental optimization model in real-time energy markets to ensure reliable operations of power grids. With growing operational uncertainty, operators must continuously monitor risk in real-time. Unfortunately, systematically solving an optimization problem for each such scenario is not practical in real-time operations. Motivated by this, this paper proposes to learn an optimization proxy for SCED. The paper proposes a novel ML pipeline that addresses the variabilities of SCED solutions. A novel Classification-Then-Regression architecture is also proposed to further capture the behavior of SCED solutions. Numerical results are reported on the French transmission system and demonstrate the approach's ability to produce accurate optimization proxies that produce relative errors below 0.6%.

3 Discrete Optimization via the Constraint Composite Graph

T. K. Satish Kumar, University of Southern California, Marina Del Rey, CA

The weighted constraint satisfaction problem (WCSP) is a fundamental discrete optimization problem that arises in such diverse areas as artificial intelligence, statistical physics, computer vision, and information theory. In this talk, I will present new methods for efficiently solving the WCSP. Central to these methods is the idea of the constraint composite graph (CCG). The CCG provides a unifying computational framework for simultaneously exploiting the structure of the variable-interactions in a given WCSP as well as the structure of the weighted constraints in it. I will present some important applications of the idea of the CCG in kernelization of combinatorial problems, the revival of message passing algorithms, and in quantum computing, among others.

Tuesday, 2 PM–3:15 PM

TD46

CC - Room 208

Going Beyond Efficiency: Exploring Equity in Decision-making for Transit

General Session

Session Chair

Juan Carlos Carlos Martinez Mori, Cornell University, Ithaca, NY

Session Chair

Ayan Mukhopadhyay, 1</sup

1 When Efficiency Meets Equity in Congestion Pricing and Revenue Refunding Schemes

Devansh Jalota[1], Kiril Solovey[2], Karthik Gopalakrishnan[1], Stephen Zoepf[3], Hamsa Balakrishnan[4], Marco Pavone[1], [1]Stanford University, Stanford, CA, [2]Technion - Israel Institute of Technology, Haifa, Israel; [3]Lacuna AI, Palo Alto, CA, [4]Massachusetts Institute of Technology, Cambridge, MA, Contact: djalota@stanford.edu

While congestion pricing helps alleviate traffic congestion, its limited practical adoption stems from social inequity issues. In response to these inequity concerns, we study congestion pricing and revenue refunding (CPRR) schemes in non-atomic congestion games and demonstrate that appropriately refunding the collected toll revenues can help achieve both system efficiency and reduced inequality. Further, in doing so, we ensure that our schemes are user-favorable by guaranteeing that each user is no worse off than before the introduction of the CPRR scheme. Most notably, we characterize the set of optimal user-favorable CPRR schemes that simultaneously maximize system efficiency and minimize wealth inequality. Overall, our work emphasizes the importance of toll revenue distribution in the operation of congestion pricing policies to best preserve equity.

2 Urban Ridesharing: Improving Tradeoffs Between Geographic Fairness and Efficiency

Ashwin Kumar, Yevgeniy Vorobeychik, William Yeoh, Washington University in St Louis, St Louis, MO, Contact: ashwinkumar@wustl.edu

State-of-the-art order dispatching algorithms for ridesharing use deep reinforcement learning techniques along with ILP-based optimization to achieve high efficiency in terms of service rates (proportion of passenger requests accepted). However, in pursuit of efficiency, such approaches might lead to disparity in service rates based on geographic locations, leading to some passenger groups being under-served. In this talk, I will present some methods that allow us to improve group-level geographic fairness in such ridesharing systems. We propose an online method that leverages the ILP-based structure of the problem to incorporate fairness into existing matching algorithms without any retraining. Interestingly, we find that it is possible to significantly improve geographic fairness with minimal loss of overall service rate when using our methods.

3 Planning for Equity when Funding Depends on Ridership

Lhassa Mignot, Cornell University, Ithaca, NY, Contact: llm227@cornell.edu

Well designed mass-transit can help reduce congestion and lower emissions, while increasing affordable access to personal mobility. However, the planning of mass-transit systems involves many complex tradeoffs. For example, given a fixed budget should a transit agency maximize ridership or focus on some notion of fairness ? In many cases the budget itself is not fixed and might be a function of ridership and other factors related to the service provided (e.g., farebox recovery + taxes). We consider a multi-period network design problem in which an agency is assigned a budget based on the network design in the previous time period, and explore the dynamics of the systems. In particular, we study the setting in which the agency aims to maximize fairness while the budget depends on ridership.

4 Public Transport, Fair Division, and Social Justice

Juan Carlos Martinez Mori, Cornell University, Ithaca, NY,

Contact: jm2638@cornell.edu
Public goods, and in particular public transport, can be enjoyed by multiple people simultaneously. However, the value any particular person gets from public transport depends on its design: some might experience better service than others. In this work, we explore the design of public transport from the perspective of fair division. We pose the problem as a budgeted (public) resource allocation problem with self-interested agents and study its properties regarding fairness criteria, stability, and tractability. We moreover study the interplay between fairness and stability with the goal of advancing social justice--- ensuring sufficient access for those who rely on public transport the most.

Tuesday, 2 PM–3:15 PM

TD47

CC - Room 209
Modeling Traffic and Transportation
Contributed Session

Session Chair
Zhuo Han, University of Massachusetts Amherst, Amherst, MA

1 Optimal Sensor Placement Considering The Observability of Dynamic Traffic Systems Under Various Traffic Conditions
Xinyue Hu[1], Yueyue Fan[2], [1]UC Davis, Davis, CA, [2]University of California, Davis, CA
Traffic sensors serve a crucial role in traffic operation and management. To obtain more information under a limited budget, the strategic placement of traffic sensors has been a popular research topic. Most traffic sensor placement literature focuses on aggregated flow counts and thus does not incorporate the rich information from traffic dynamics. In some recent work where traffic dynamics is incorporated, a systematic and scalable sensor placement strategy that accounts for various traffic conditions is lacking. This research aims to fill this gap and develop a systematic sensor placement strategy to maximize the observability of link density in a highway network. Algebraic and graphical properties of highway network dynamical observability are explored and various traffic conditions are considered under a stochastic programming framework.

2 Real-time Vehicle Re-routing Under Disruption in Cross-dock Network with Time Constraints
Fahim Ahmed[1], Nathan Huynh[2], William G. Ferrell[3], Vishal Badyal[4], Bhavya Padmanabhan[5], [1]University of South Carolina, Columbia, SC, [2]University of South Carolina, Columbia, SC, [3]Clemson University, Greenville, SC, [4]Clemson University, Clemson, SC, [5] Contact: ahmedf@email.sc.edu
This study extends the vehicle routing problem with cross-dock (VRPCD) by incorporating disruption to enroute pickup trucks (e.g., traffic accident or mechanical failure) which becomes unavailable to complete its scheduled pickup of shipments from suppliers and deliver them to the cross dock. A mixed-integer linear program is developed to model the VRPCD under disruption for rerouting the trucks to maintain the flow of goods in the network. To solve the model in real-time, this paper proposes a modified Golden Ball algorithm (mGB). Experiments were performed on a hypothetical network with a cross-dock for varying disruption time and number of vehicles. The results show a significant reduction in computation time using the proposed algorithm compared to exact methods.

3 A Machine Learning-Based Traffic Signal Control Scheme Considering Vehicle Equality
Liang Zhang, Wei-Hua Lin, University of Arizona, Tucson, AZ, Contact: liangzhang@email.arizona.edu
Traffic signal control using vehicle-based data has improved the efficiency of the real-time traffic network. Equality, however, was not considered much for vehicles in the past. This research provides an equitable signal control scheme at signalized intersections using machine learning approaches. The control scheme collects vehicle-based data (speeds, locations and delay times) as the input, several constraints are given to the unsupervised learning approach to get the optimal control scheme while considering the vehicle equality at the same time. Based on the learning results, control schemes under stochastic traffic arrivals with respect to different market penetration levels are also considered. Results suggest that the proposed control schemes can help balance efficiency and equality and reduce the maximum delays at a significant level.

4 Framework for Line-specific Urban Rail Transit Energy Prediction and Inference
Zhuo Han, Jimi Oke, Eric Gonzales, Eleni Christofa, University of Massachusetts Amherst, Amherst, MA, Contact: zhuohan@umass.edu
Urban rail transit systems are critical for sustainable mobility, but their energy use can be costly. Current modeling efforts require detailed data or are too high-level to facilitate energy savings assessments. Thus, we develop a framework for predicting system energy with line-level explanations. Our case study is Boston's rail system which used 379.8 GWh

costing $15.05 million in 2020. We computed line-specific speed and acceleration variables from train trajectories, aggregated hourly, and other indicators. We used Random Forests to extract the relevant ones. Then, we fitted a ridge regression (Rsq. = .85) to predict energy from train movement, ridership, and weather, showing that Red, Blue, Orange and Green line trains contributed 6%, 4%, 5% and 5% of energy use in 2020, respectively. This framework can be used for decision-making toward energy savings.

Tuesday, 2 PM–3:15 PM

TD49

CC - Room 211

Optimal and Equitable Delivery of Goods

Contributed Session

Session Chair

Christina Stradwick, Kennesaw State University, Kennesaw, GA

1 An Agent-based Model for Fair and Efficient Delivery Area Allocations

HanByul Ryu, Daisik Nam, Inha University, Incheon, Korea, Republic of. Contact: z91221035@inha.edu

Fair allocation of parcels to delivery drivers is of critical importance in parcel transportation management systems. Delivery volume is a significant factor affecting the income of drivers; then, drivers might prefer denser regions where a driver can benefit from shorter working hours. The failure of fair allocation might induce envy among drivers. Setting a reasonable delivery area is necessary while considering the entire system's efficiency. Although existing research proposes the allocation of delivery loads based on the region or routing of each driver, there is a lack of considering the fairness of allocations. This paper utilizes the well-known "fair cake-cutting problem" to the delivery area allocation to each driver by extending it to efficiency and fairness. Efficiency is measured by the total delivery time, and the agent's level of envy evaluates fairness.

2 Volunteer Assignment and Route Design for Non-profit Food Banks Under Uncertain Volunteer Availability and Equity Constraints

Maria Cabarcas[1], Faisal Alkaabneh[2], Leila Hajibabai[1], Ali Hajbabaie[1], [1]North Carolina State University, Raleigh, NC, [2]North Carolina Agricultural and Technical State University, Greensboro, NC, Contact: mcabarc@ncsu.edu

This study analyzes the volunteer assignment-routing problem in a non-profit food network including the food bank, volunteers, and service locations. Routes consist of picking up volunteers, dropping them off at service locations, where they serve food-insecure households, and returning them home. Volunteers can be assigned to different vehicles, which may wait for volunteers to complete their service or transport other volunteers to other service locations. The problem is formulated as a customized network flow model considering volunteers with unique location and availability states. The objective is to maximize the number of volunteers assigned to service locations. A decomposition technique is developed to solve the problem. Numerical experiments confirm the quality of the solutions.

3 Scheduling Optimization and Routing Problem of Disinfection Robots

Ziwei Liu, Mingzhou Jin, University of Tennessee-Knoxville, Knoxville, TN, Contact: zliu72@vols.utk.edu

This paper aims to schedule disinfecting robots for a set of rooms that have a usage schedule. Based on the team orienteering problem and vehicle routing problem with time windows, we built a mixed-integer programming model to mitigate risk, which is evaluated based on an empirical model in the literature. When there are fewer than 50 rooms, the mixed-integer program can be solved by the Gurobi solver. Moreover, heuristics are designed to solve large-sized problems with up to 200 rooms. The paper also explores the impacts of the room schedule, the number of robots, and the speed of robots on risk reduction.

4 Optimal Scheduling of Recreational Youth Soccer

Andrew Henshaw[1], Christina Stradwick[2], [1]Kennesaw State University / GTRI, Atlanta, GA, [2]Kennesaw State University, Kennesaw, GA

Scheduling for youth, inter-club, recreational soccer emphasizes minimization of travel distance while providing as many different opponents as possible. Developed voluntarily for the dominant youth soccer association in the state of Georgia, we present binary, linear-optimization models that provide optimal pairings and schedules for hundreds of teams twice yearly.

Tuesday, 2 PM–3:15 PM

TD50

CC - Room 212

The Future of Digital Platforms

General Session

Session Chair
Chen Liang, University of Connecticut, Storrs, CT

1 Can Algorithm Recommendations Substitute Social Networks? Social Media Channels and User Engagement

Xiaohui Zhang[1], Qinglai He[2], Zhongju Zhang[1], [1]Arizona State University, Tempe, AZ, [2]University of Wisconsin - Madison, Madison, WI, Contact: xzhan537@asu.edu

Social media platforms often distinguish content from social network- and algorithm-driven channels to form users' newsfeeds. Prior literature has investigated each channel's impact on users' content consumption. However, little is known about the relationship between these channels. In this research, we leverage a natural experiment to examine the impacts of limiting social network content display on the quantity and the diversity of users' content consumption across channels. We show that users consume less content from the platform when the platform stops displaying their friends' likes. The users shift more attention proportionally to the algorithm-recommended content. Content consumption on the platform become less diverse. Longer-tenured/social-oriented users are less/more affected and they are more/less receptive to algorithmic recommendations.

2 1+1>2? Information, Humans, and Machines

Tian Lu[1], Yingjie Zhang[2], [1]Arizona State University, Pheonix, AZ, [2]Peking University, Beijing, China. Contact: yingjiezhang@gsm.pku.edu.cn

Inspired by the information processing literature, we introduce information volume and identify its roles in determining collaboration performance. We conduct a two-stage field experiment. First, we show that humans, especially experienced ones, might resist alternative information sources but make decisions via a traditional process with small information volumes. Second, machines perform better on larger information scales and better than humans but would unintentionally incur decision biases. Third, in the human-machine collaboration mode, the presence of machine interpretations could reduce humans' potential resistance to machines' recommendations. More importantly, the co-existence of large-scale information and machine interpretations can invoke humans' systematic rethinking, which in turn, shrinks biases and increases prediction accuracy.

3 Evaluating The Effectiveness of Group Buying

Huiyan Chen[1], Jing Peng[1], MengCheng Guan[2], Jianbin Li[3], [1]University of Connecticut, Storrs, CT, [2]Huazhong University of Science and Technology, Wuhan, China; [3]Huazhong University of Science & Technology, Wuhan, China. Contact: huiyan.chen@uconn.edu

Group buying allows customers to buy products with deep discounts if a minimum number of customers commits to purchase. Online stores often offer group buying for selective products to acquire new customers. In this study, we examine the impact of offering group buying on the sales of stores and brands using a dataset from an e-commerce platform. We find that offering group buying has a positive effect on the overall demand for stores, but the effect varies across different types of stores. Specifically, the positive effect is larger for smaller stores and stores selling cheaper products. Moreover, offering group buying has a negative spillover effect on other products from the same brands, especially for popular brands. This finding suggests that stores may gain from group buying at the expense of brands. We discuss the implications of our findings for stores and brands

4 Ai Assistant in Online Pharmacy

Tong Shen[1], Chen Liang[2], Jing Peng[2], Mengchen Guan[3], Jianbin Li[3], [1]University of Connecticut, Storrs, CT, [2]University of Connecticut, Storrs, CT, [3]Huazhong University of Science & Technology, Wuhan, China. Contact: tong-shen@uconn.edu

Artificial intelligence (AI) is increasingly popular in diagnosing diseases and recommending medicines. Leveraging an exogenous introduction of an AI-powered medical assistant to one product category in an online pharmacy, we investigate whether and how the AI assistant affects users' medicine purchases using a difference-in-differences design. We find that the AI assistant significantly increases users' medicine purchases not only in the focal product category but also in other categories without the AI assistant. Furthermore, we find that the positive effect of the AI assistant is stronger for early technology adopters and goal-directed shoppers. Moreover, we reveal that the AI assistant increases users' purchases by increasing their engagements on the platform. Our results have important implications for the design and evaluation of AI assistants.

Tuesday, 2 PM–3:15 PM

TD51

M - Santa Fe
Risk, Uncertainty, and Investment Equilibria in Electricity Markets
General Session

Session Chair
Farhad Billimoria, University of Oxford

1 Beyond Capacity: Contractual Form in Electricity Reliability Obligations

Han Shu, Jacob Mays, Cornell University, Ithaca, NY, Contact: hs2226@cornell.edu

Many liberalized electricity markets include some kind of explicit and implicit mandate that load serving entities (LSEs) contract with generation resources. However, different contractual form can adapt to different risk profiles of generation technologies and will have great impact on the resource mix. We construct a stochastic equilibrium model describing the competitive market with incomplete risk trading to investigates how the design of different contractual forms can lead to different investment equilibria. Results show that mandatory contracting can achieve a near optimal solution when generators are less risk averse and other contracts are available. When limited to one single instrument, standard fixed price forward contract and allowing generations to pool their risk of non-performance leads to the best near-optimal results.

2 Insuring The Tails in Decarbonising Electricity Markets

Farhad Billimoria, University of Oxford, Oxford, United Kingdom.

Driven by the imperative for decarbonisation of economies, the rapid deployment of variable renewable energy (VRE) is being observed in electricity markets around the world. Some markets expected to be VRE-dominated by the end of the decade. Such shifts in supply have dramatic impacts upon electricity pricing dynamics with higher proportions of very low and very high prices. The National Electricity Market is a case in point with negative prices being seen in 20-40% of dispatch intervals in many regions. While a range of contracts have developed to hedge high prices, the design of risk trading contracts for low prices have received limited attention to date. Using a risk-averse contracting model we identify resource biases in emerging ‘shape-based’ contracts which are increasingly used to hedge low-price risk today. Alternative designs are explored as potential solutions.

3 Affordability Options: A Regulatory Measure to Protect Consumers Against Periods of Sustained High Electricity Prices

Tim Schittekatte[1], Carlos Batlle[1], Christopher Knittel[2], [1]MIT, Cambridge, MA, [2]MIT, Cambridge, Contact: schtim@mit.edu

Since the Fall of 2021, the European Union has been confronted with sustained high electricity prices which has led to affordability and competition issues for a significant share of end users and has induced politicians to introduce often detrimental market interventions. In this research, we develop a long-term hedging product called “affordability options”. The objective of affordability options is not to turn future prices for end users into a stable signal which a contract-for-difference would do. Instead, the objective is to guarantee that the monthly bill remains under a certain threshold, to avoid affordability issues and avoid future political turmoil, while keeping end users exposed to hour-to-hour and even monthly price fluctuations.

4 Heterogenous Investments in Energy Models with Convex Optimization

Christoph Weber, University Duisburg-Essen, Essen, Germany.

With decarbonization, numerous and heterogenous new generation units are installed. Decisions on such investments depend on multiple, partly not observable factors. Many long-term energy models are yet formulated as linear programs and are therefore prone to abrupt changes in primal variables (“penny-switching”). Discrete choice models deal with heterogeneity in individual decisions and avoid penny-switching. Here an approach is presented to incorporate such decision modelling in a non-linear, convex optimization problem, along with technological and system constraints.

A first application investigates wind energy investments across Germany based on the novel approach and compares the outcomes to the results of standard LP formulations. It is shown that the regional spread of investments increases when unobserved heterogeneity is taken into account.

Tuesday, 2 PM–3:15 PM

TD52

M - Lincoln
Scheduling and Project Management Flash Session
Flash Session

Session Chair
Xiao Alison Chen, University of New Hampshire, Durham, NH

1 Using Quantile Forest for Robust Scheduling of Astronomic Images Processing

Luis Aburto, Rodrigo A. Carrasco, Gianfranco Speroni, Universidad Adolfo Ibañez, Santiago, Chile. Contact: luis.aburto@uai.cl

This project recommends job scheduling to minimize the total flow time to process astronomic images at the ALMA observatory. To do that, we calibrate machine learning models to estimate not only the expected processing time but also, the confidence intervals or uncertainty of the prediction. We rely on Quantile Forest to obtain the interquartile distance of the predicted processing time. We use the expected value and confidence intervals of the processing times as parameters for the MIP optimization problem to minimize total flow time. Preliminary results reduced the average gap by 4% improving the scheduling solution compared with the optimization model based only on expected values.

2 Distributionally Robust Group Testing with Correlation Information

Daniel Zhuoyu Long[1], Jin Qi[2], Yu Sun[1], Aiqi Zhang[3], [1]The Chinese University of Hong Kong, Shatin, Hong Kong; [2]Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [3]University of Toronto, Toronto, ON, Canada. Contact: zylong@se.cuhk.edu.hk

In this work, we consider a group testing problem where the infection of subjects has a correlation. In such a setting, the joint distribution cannot be exactly characterized; hence, we use a distributionally robust framework. Specifically, given the marginal distribution and the correlation information, we evaluate the performance under the worst-case distribution and minimize the expected number of tests and misclassifications (false positive and false negative). We investigate the optimal group size in such a setting, and by numerical studies, we show that the consideration of correlation information is significant.

3 Algorithmic Big Data Solutions for The Scheduling Problems

Yumei Huo, City University of New York, College of Staten Island & The Graduate Center, Staten Island, NY

We study the algorithmic big data solutions for the scheduling problems and aim at efficient algorithm design principles in two directions: sub-linear space algorithms and sub-linear time algorithms. The sub-linear space algorithm design targets at developing streaming algorithms to approximate the optimal solution in a few passes (typically just one) over the data and using limited space. The sub-linear time algorithm design targets at developing the sampling algorithm to approximate the optimal solution using a small portion of input data and using sub-liner time.

4 Goal Programming Approach for Bi Objective Optimization for a Single Batch Processing Machine

Dheeban Kumar Srinivasan Sampathi[1], Purushothaman Damodaran[2], [1]Northern Illinois University, DeKalb, IL, [2]Northern Illinois University, DeKalb, IL

This research considers a real-time problem where jobs need to be batched and scheduled to a single batch processing machine to minimize makespan and maximum tardiness. Jobs must be placed in batches such that the machine capacity is not violated. The jobs considered have unequal ready times, unequal processing times, and unequal sizes. This research aims to develop an effective solution approach for the proposed problem. The problem under study can be denoted as 1lp-batch, sj, rjl Cmax, Tmax. The problem under study is NP-Hard. A new Mixed Integer Linear Programming (MILP) formulation using Goal programming (MILP-G) and Column Generation (MILP-CG) are proposed as enhancements of formulations proposed in the literature and solved using the commercial solver. All MILPs are solved using IBM ILOG CPLEX.

5 Minimizing Number of Breaks in Scheduling Professional Football Leagues

Ali Hassanzadeh[1], Nasser Salmasi[2], [1]The University of Manchester, Manchester, United Kingdom; [2]Corning Incorporated, Wilmington, NC, Contact: ali.h@manchester.ac.uk

A widely used objective function in sports timetabling in symmetrical round robin tournaments is minimizing the number of breaks, i.e., two consecutive matches held both either at home or on the road. We study the break minimization problem in single and double round robin tournaments, and we introduce several valid inequalities which help the mixed-integer linear programming formulation to obtain the exact solution for real-size football leagues (e.g., league with 20 teams). We extend our results to a novel weighted break minimization problem. We highlight the effectiveness of our solution methodologies by performing computational experiments on English Premier League fixtures.

6 Smart Workforce Planning and Scheduling for Call Centers

Giulia Burchi, Kiat Shi Tan, DecisionBrain, Paris, France.

In this presentation, DecisionBrain will talk about a Smart Workforce Planning and Scheduling optimization solution for a call center company. The solution is able to compute an optimal plan and schedule in minutes and the results led to a +20% demand coverage, improving service levels and customer satisfaction while reducing staff burnout.

The solution covers three levels of optimization:1. and 2. Strategic and Tactical planning, for activities, skill design, hiring needs, leaves of absence3. Operational scheduling, for detailed scheduling of activities and shift design.
The solution was built on top of DB Gene, DecisionBrain's optimization platform, which allowed for a fast and effective implementation, from design to deployment, delivering significant ROI.

7 A Mathematical Approach to Paint Production Process Optimization

Wilkistar Otieno[1], Dah-Chuan Gong[2], Chuang Ching Ya[1], [1]University of Wisconsin-Milwaukee, Milwaukee, WI, [2]Chang-Gung University, Taoyuan, Taiwan.

This research project proposes a mixed-integer linear programming model to explore two production environments commonly used by paint manufacturers: the build-to-order, BTO and a variation of the configuration-to-order, also called the group production, GP. The objective is to determine the optimal batch size and batch sequence to minimize the makespan. Results show that the BTO mode appears more suitable for a situation of low mix of product types. As the demand and product diversity increase, the GP mode is preferable. It means that the GP mode is beneficial for producing highly differentiated products that require long setup times.

8 Smart Supply Chain Planning and Production Scheduling for Recyclable Packaging

Issam Mazhoud, DecisionBrain, Paris, France. Contact: issam.mazhoud@decisionbrain.com

In this presentation, DecisionBrain will talk about a Smart Supply Chain Planning and Production Scheduling optimization solution for a leading provider in the recyclable disposable packaging, and construction sectors. The solution consists of two major components: the production master planning engine and the scheduling engine. It considers all work centers at the same time to define the optimal solution while respecting the manufacturing capabilities and constraints.
The solution was built on top of DB Gene, DecisionBrain's optimization platform, which allowed for a fast and effective implementation, from design to deployment, delivering significant ROI.

9 Manufacturing Rescheduling After Crisis or Disaster-caused Supply Chain Disruption

Hongguang Bo[1], Xiao Alison Chen[2], [1]Dalian University of Technology, Dalian, China; [2]University of New Hampshire, Durham, NH, Contact: alison.chen@unh.edu

We study the rescheduling problem of a two-tier supply chain after major supply disruptions. In our model, a service provider provides maintenance requests to its customers. Replacement parts are provided by a designated manufacturer. After a major production disruption, service provider needs to reschedule all jobs to minimize costs. We formulate the rescheduling problem as an integer program to minimize tardiness and the channel's total inventory cost. A two-stage genetic algorithm is proposed to solve this program. Numerical results show that our model generates solutions that outperforms the original schedule. In addition, the proposed algorithm has better performance compared with other genetic algorithms.

10 Managing The Hyflex Scheduling Activity Usingexcel Dynamic Arrays

Larry J. LeBlanc[1], Thomas A. Grossman[2], Michael Bartolacci[3], [1]Vanderbilt University, Nashville, TN, [2]University of San Francisco, San Francisco, CA, [3]Penn State Berks, Bethlehem, PA

"Hyflex" classes involve students attending some class sessions in person and other classes online. Managing a hyflex course requires faculty to quickly generate various reports and to update them rapidly when students add/drop or other changes occur. Traditional Excel programming approaches (worksheet functions) alone are not efficient for this purpose. We show how to use Excel's new "dynamic array" capabilities to automate the creation and updating of the reports needed to manage the hyflex course. We provide a tutorial on these dynamic arrays, especially SEQUENCE, FILTER, and XLOOKUP

Tuesday, 2 PM–3:15 PM

TD54

M - Marriott 1
Experimental Design
General Session

Session Chair
Hannah Li, 1</sup

Session Chair
Hongseok Namkoong, Columbia University, New York, NY

1 Bipartite Experiments for Causal Inference in Marketplaces

Jean Pouget-Abadie, Google, NEW YORK, NY, Contact: jeanpa@google.com

When the treatment assignment of one unit affects the outcome of another, we say there is interference. Interference is especially prevalent in marketplaces, where buyer and seller interactions lead to complex dependence structures. As a violation of the stable unit treatment value assumption (SUTVA), the presence of interference can lead to bias of standard estimators under naive randomized designs. In this talk, we will cover a set of design and estimation paradigms to conduct causal inference research in a bipartite graph setting, inspired from (but not limited to) marketplace experiments, with specific attention to clustered randomized designs under different randomization constraints and bias corrections to standard estimators.

2 Marketplace Experiments: Inference and Interference

Ramesh Johari[1], Hannah Li[2], Gabriel Weintraub[3], [1]Stanford University, Stanford, CA, [2]Stanford University, Menlo Park, CA, [3]Stanford Graduate School of Business, Stanford, CA

Online marketplace platforms rely on experiments to aid decision-making. Due to interference effects, however, common estimators may be biased in these market settings. Prior work has focused on the biases that arise in the treatment effect estimates, but there is also bias in the typical standard error estimates, which can cause the platform to be under or over-confident in its estimates. In this work we study the standard error bias and its impact on the resulting platform decisions. We utilize a dynamic market model which captures the marketplace interference effects. We show that commonly used standard error estimators are biased in market settings. We explore practical methods to reduce the standard error bias. Finally, using calibrations to real marketplace data, we assess the quality of the ultimate decisions made using these biased estimates.

3 Policy Design in Experiments with Unknown Interference

Davide Viviano, University of California San Diego, San Diego, CA, Contact: dav.viviano@gmail.com

In this talk, I discuss the problem of experimental design for estimation and inference of welfare-maximizing policies in the presence of spillover effects. First, I introduce a single-wave experiment that estimates the marginal effect of a change in treatment probabilities, taking spillover effects into account. Using the marginal effect, I propose a practical test for policy optimality. Here, the marginal effect indicates the direction for a welfare improvement, and the test provides evidence on whether it is worth conducting additional experiments. Second, I design a multiple-wave experiment to estimate treatment assignment rules and maximize welfare. I derive strong theoretical guarantees and illustrate the method's advantages in simulations calibrated to experiments on information diffusion and cash-transfer programs.

4 Designing Adaptive Experiments for Policy Learning and Inference

Molly Offer-Westort, University of Chicago, Chicago, IL, Contact: mollyow@uchicago.edu

Compared to conventional static experimental designs, adaptive experimental designs allow researchers to more quickly identify the best policy, to reduce assignment to ineffective policies, and to collect the most data under the most effective policies. For adaptive designs to best serve inferential objectives, however, most adaptive algorithms should not be used out of the box, and researchers must also carefully consider design parameters. Structured simulations and careful design documents can ensure that experiments using adaptive designs will appropriately serve the inferential objectives of policymakers and researchers.

Tuesday, 2 PM–3:15 PM

TD55

M - Marriott 2

Advances in Decision-making Under Uncertainty

General Session

Session Chair

Rui Gao, University of Texas at Austin, Austin, TX

Session Chair

Zhi Wang, Austin, TX

1 Lp-based Approximations for Disjoint Bilinear and Two-stage Adjustable Robust Optimization

Ayoub Foussoul[1], Omar El Housni[2], Vineet Goyal[1], [1]Columbia University, New york, NY, [2]Cornell Tech, New York, NY, Contact: af3209@columbia.edu

We consider the class of disjoint bilinear programs max{x^Ty l x \in X, y \in Y} where X and Y are packing polytopes. We present an O(\frac{\log \log m_1}{\log m_1} \frac{\log \log m_2}{\log m_2})-approximation algorithm for this problem where m_1 and m_2 are the number of packing constraints in X and Y respectively. We give an LP relaxation of this problem from which we obtain a near-optimal solution via randomized rounding. As an application of our techniques, we present a tight approximation for the two-stage adjustable robust problem. In particular, based on the ideas above, we give an

LP restriction of the two-stage problem that is an O(\frac{\log n}{\log \log n} \frac{\log L}{\log \log L})-approximation where L is the number of constraints in the uncertainty set. This significantly improves over state-of-the-art approximation bounds known for this problem.

2 Asymptotically Exact Formulations in Optimization Under Uncertainty

Louis L. Chen, Johannes Royset, Naval Postgraduate School, Monterey, CA, Contact: louischenusa@gmail.com

Robust formulations lend to “conservative” decision-making. We develop, in contrast, an “optimistic” framework devoid of convexity and smoothness assumptions, as well as continuity of objective functions. More precisely, optimization is conducted not only over the original decision space but also jointly with a choice of model perturbation. We illustrate application to distributionally robust problems like two-stage stochastic optimization without relatively complete recourse, expectation constraints, and outlier analysis. Central to this are the concepts of exact and asymptotically exact Rockafellians, with interpretations of “negative” regularization emerging in certain settings. We illustrate the role of Phi-divergence, examine rates of convergence under changing distributions, and explore extensions to first-order optimality conditions.

3 Newsvendor with Advice

Lin An, Andrew A. Li, Benjamin Moseley, R. Ravi, Carnegie Mellon University, Pittsburgh, PA, Contact: linan@andrew.cmu.edu

A recent line of work seeks to incorporate generic `advice’ (e.g. machine learned predictions) into decision making problems in a manner that is robust to the (unknown) quality of the advice. We apply this lens to a repeated newsvendor game with nonstationary demand, where the advice is presumably on each period’s demand. Our main contributions include a generic model of a nonstationary newsvendor game with an algorithm solving the game itself, and an algorithm with advice which, without a priori knowledge of the accuracy of the advice, achieves the same minimax optimal regret had the accuracy been known.

4 Data-driven Decision Making Augmented by Human Knowledge

Wenhao Li[1], Ningyuan Chen[2], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada. Contact: wenhaoli6-c@my.cityu.edu.hk

In this paper, we investigate how to use human knowledge to help artificial intelligence (AI) to make decisions. The decisions made by AI are usually accurate but unstable. The decisions made by a human are rough but robust to outliers. We first build a model to describe the decision-making process of AI and human. We next give several examples to show the cases when human decisions are helpful to AI even though the AI system has a large amount of data.

Tuesday, 2 PM–3:15 PM

TD56

M - Marriott 3

Markets and Learning

General Session

Session Chair

Vijay Kamble, University of Illinois at Chicago, Chicago, IL

1 Dynamic Learning in Large Matching Markets

Anand Kalvit, Assaf Zeevi, Columbia University, New York, NY

We consider the archetypal problem of sequentially matching “jobs” to “workers” at a large centralized matching platform. On the demand side, an arriving job may have one among several possible “types” (from a finite universe) observable upon arrival. On the supply side, there exist *latent* clusters in the population of available workers reflecting a low-dimensional discretization of their skill levels w.r.t. job-types; a fixed distribution governs the relative sizes of said clusters. Subject to worker labels (w.r.t. clusters), their distribution as well as mean payoffs being unobservable attributes, the platform’s goal is to sequentially match incoming jobs to workers in a way that maximizes its cumulative payoffs over the planning horizon. Our work resolves several foundational questions pertaining to complexity and achievable performance in this problem setting.

2 Interactive Recommendations for Optimal Allocations in Markets with Constraints

Soham Phade[1], Efe Yigit[2], Kannan Ramchandran[2], [1]Salesforce Research, Palo Alto, CA, [2]University of California, Berkeley, Berkeley, CA, Contact: soham_phade@berkeley.edu

Despite the prevalence of capacity constraints in many real-world recommendation settings, a principled way of incorporating them in the design of these systems has been lacking. Motivated by this, we propose an interactive framework where the system provider can enhance the quality of recommendations to users by opportunistically exploring allocations that maximize user rewards and respect the capacity constraints using appropriate pricing mechanisms. We employ an integrated approach using techniques from collaborative filtering, combinatorial bandits, and optimal resource allocation to provide an algorithm that provably achieves low regret. Empirical studies on synthetic and real-world data also demonstrate the effectiveness and performance of our proposed approach.

3 Understanding How Fast Akerlof's Market for Lemons Unravels: A Multi-agent Learning Perspective

Jibang Wu, Haifeng Xu, Fan Yao, University of Virginia, Charlottesville, VA

A famous example of adverse selection is the market for lemons due to Akerlof. He shows that information asymmetry may gradually drive sellers with high-quality products out of the market, leading to market unraveling. This talk will study how fast such unraveling happens when sellers must learn to make decisions about participating the market. Underlying the market for lemons is a basic game structure called iterative dominance elimination. We show how standard no regret learning algorithms may provably take exponentially many rounds to iteratively eliminate dominated actions. This implies that if sellers use no regret learning algorithms, market unravelling may make take a long time to happen, and this is also supported by our empirical results. However, there are learning algorithms that can iteratively eliminate all dominated actions within polynomially many rounds

4 Exploration at Equilibrium

Vijay Kamble, Eren Ozbay, University of Illinois Chicago, Chicago, IL

The role of markets in aggregating diverse information held by market participants is well-understood in the literature, while the extent to which natural market mechanisms actively drive learning and exploration amongst *myopic* market participants is understood to a lesser degree. We consider local congestion-based pricing mechanisms and observe that while it may internalize the congestion externality induced by the matchings, it is not clear if it internalizes their exploration externality. We define a new concept of a local market equilibrium (LME) to investigate this. A matching rule is an LME if it is (1) a utility-maximizing response to the price-adjusted payoffs, and (2) self-sustaining. We prove that (a) an LME always exists, (b) it is polynomial-time computable, (c) the set of LME is convex and compact, and (d) the LME is always unique in non-degenerate settings.

Tuesday, 2 PM–3:15 PM

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M - Marriott 4

Journal of Intelligent Manufacturing Sponsored Session

General Session

Session Chair

Xiaowei Yue, Virginia Tech, Blacksburg, VA

Session Chair

Andrew Kusiak, University of Iowa, Iowa City, IA

1 Wave-picking Warehouse Management for E-commerceCompanies: An Estimation Distribution Algorithm

Zhi-Hai Zhang, Jingran Liang, Tsinghua University, Beijing, China.

Recently, warehouses are supposed to handle unique characteristics of customer orders in the era of E-commerce which consists of small order scales, large items count, unexpected irregular order arrival patterns, seasonality demand peaks, and high service level expectations. Warehouses are adopting wave-picking as an effective policy composed of item-batching, load-assignment, and picker-routing problems. In this research, a mixed-integer mathematical model is established based on features of a wave-picking warehouse. To improve the computational efficiency, we develop modified Estimation Distribution Algorithms. The set of proposed algorithms is proved to have stable gaps and can be solved on larger scales within a quite short time.

2 Mathematical Modeling and a Hybrid Evolutionary Algorithm for Process Planning

Qihao Liu, Xinyu Li, Liang Gao, Huazhong University of Science and Technology, Wuhan, China.

The reported process planning models are too simple to describe all characteristics because of the complexity of process planning. Therefore, a new MILP mathematical model is established based on OR-node of the network graph. The linear expression of the OR-node controlling function as well as three types of changing costs are first established. Beside, considering the OR-node selection state in the encoding and decoding method, HEA is designed to combine a genetic algorithm with a simulated annealing algorithm. The tournament selection method is adopted in the proposed HEA, and the discussion on the tournament size is conducted on the open problems to make the algorithm designing more reasonable and scientific. The HEA and the new MILP model are both tested on series of numerical experiments which are carried on the existing benchmarks as well as some randomly generated cases.

3 Machine Learning Integrated Design for Additive Manufacturing

David Rosen, Georgia Institute of Technology, Atlanta, GA, Contact: david.rosen@me.gatech.edu

For improving manufacturing efficiency and minimizing costs, design for additive manufacturing (AM) has been proposed. Due to the increasingly available data, machine learning (ML) has many applications in diagnosis, prediction, classification, etc. In this paper, a ML integrated design for AM framework is proposed, which takes advantage of ML that can learn the complex relationships between the design and performance spaces. Furthermore, the primary advantage of ML over other surrogate modelling methods is the capability to model input-output relationships in both directions. That is, a deep neural network can model property-structure relationships, given structure-property input-output data. A case study demonstrated the effectiveness of using ML to design a customized ankle brace that has a tunable mechanical performance with tailored stiffness.

Tuesday, 2 PM–3:15 PM

TD58

M - Marriott 5

Advancements in Spatial-temporal Analytics - II

General Session

Session Chair

fenglian Pan, 1</sup

Session Chair

Jian Liu, University of Arizona, Tucson, AZ

1 Modularized Bias-corrected Parameter Calibration

Cheoljoon Jeong, Eunshin Byon, University of Michigan, Ann Arbor, MI

Computer model calibration has received much attention to perform accurate prediction from a computer model by estimating its unknown parameters. Even with the correctly calibrated parameters computer models often exhibit systematic discrepancy, including spatiotemporal discrepancy. For example, a well-calibrated building energy model that simulates electricity consumption in a designated building may show temporal discrepancy patterns between observational and simulated energy consumption data. In this study, we present a new calibration methodology in a modularized way by successively conducting Bayesian optimization to estimate calibration parameters and modeling the discrepancy with nonparametric regression.

2 Aircraft Density Distribution Prediction Using a Spatial-temporal Neural Network

Qihang Xu, Yongming Liu, Arizona State University, Tempe, AZ

Predicting aircraft density distribution is of great importance to improving air traffic management and public safety. This paper proposes a framework based on Convolutional Neural Network (CNN) and Long Short-Term Memory (LSTM) to predict the aircraft density distribution near the main airports of USA. Spatial-temporal aircraft data is derived from Sherlock Database. Weather features are obtained from Visual Crossing database including temperature, wind, cloud cover, etc. In our framework, CNN is used extract spatial features and LSTM is adopted to learn temporal dependencies of data. Experiments show our model can make accurate prediction efficiently and outperforms 6 baseline methods.

3 Adaptive Sampling for Monitoring Multi-profile

Jinwei Yao[1], Chao Wang[2], [1]University of Iowa, Iowa City, IA, [2]University of Iowa, Iowa City, IA

Multi-profile data can provide self-and-cross profile information for efficiently modeling and monitoring system status. In practice, however, acquisition of such data requires a large number of sensors, which raises various concerns and difficulties, e.g., cost, energy, and data transmission bandwidth, in accessing the full data from each sensor. In this talk, we propose an adaptive sampling strategy for multi-profile monitoring by using a limited portion of data. The proposed sampling and monitoring scheme incorporates multivariate functional principal analysis (MFPCA) to capture the self-and-cross profile correlation and features the balance between random search and greedy search in identifying the most informative profiles. Numerical and case studies are conducted under various scenarios to demonstrate the effectiveness of the method.

4 Spatially Correlated Time-to-event Model for Titan GPU Failures Data Under Competing Risks

Jie Min, Yili Hong, Virginia Tech, Blacksburg, VA, Contact: yilihong@vt.edu

Graphics processing units (GPUs) are widely used in high-performance computing (HPC). In this paper, we conduct in-depth statistical modeling of the effect of positions on GPU failures under competing risks with covariates and spatial correlated random effects. In particular, two major failure types of GPUs in Titan are considered, the positions of GPUs inside each cabinet are modeled as covariates, and the positions of cabinets are modeled as spatially correlated random effects. We use the powered-exponential covariance function to construct the spatial random effects' covariance matrix and estimate the correlation of random effects between two failure modes. The proposed model combines competing risks and spatial random effects in modeling the Titan GPU failures data and our results interesting insights in GPU failures in HPC systems.

Tuesday, 2 PM–3:15 PM

TD59

M - Marriott 6

High-dimensional Data Analytics for Modeling, Monitoring, and Control

General Session

Session Chair

Ziyue Li, The Hong Kong University of Science and Technology, NT, Hong Kong.

Session Chair

Hao Yan, Arizona State University, Tempe, AZ

1 Temporal Control for Partially Observed High-dimensional Data

Zihan Zhang, Shancong Mou, Kamran Paynabar, Jianjun Shi, ISyE Georgia Tech, Atlanta, GA

The advanced and complex manufacturing process produces prodigious high-dimensional data for the process modelling and control; however, incomplete data is a common issue due to insufficient sensing resources, limited data transmission bandwidth, and degraded sensor performance. To achieve the optimal control, we propose a novel tensor-based control method for partially observed response. The model parameters are learned from restored responses offline. For the online employment, we complete missing entries of incomplete online observations using one-step-ahead estimations from the trained model. Once model inputs get completed, the control action is conducted to mitigate the process deviation from targets. Finally, we validate the superiority of the proposed method using simulation studies and a case study of the semiconductor photolithography process.

2 Stochastic Low-rank Tensor Bandits for Multi-dimensional Online Decision Making

Wei Sun, Purdue University

We introduce stochastic low-rank tensor bandits, a class of bandits whose mean rewards can be represented as a low-rank tensor, for multi-dimensional online decision making. We consider two settings, tensor bandits without context and tensor bandits with context. In the first setting, the platform aims to find the optimal decision with the highest expected reward. In the second setting, some modes of the tensor are contexts and the rest modes are decisions, and the goal is to find the optimal decision given the contextual information. We propose two learning algorithms tensor elimination and tensor epoch-greedy for tensor bandits without context, and derive finite-time regret bounds for them. Furthermore, we develop a practically effective Bayesian algorithm called tensor ensemble sampling for tensor bandits with context.

3 A Dimension-agnostic Change Point Testing Via Sample Splitting and Self-normalization

Hanjia Gao[1], Runmin Wang[2], Xiaofeng Shao[1], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]Texas A&M University, College Station, TX, Contact: hanjiag2@illinois.edu

The detection and estimation of change-point(s) have applications in many areas, whereas most methods in the literature are applicable only under a specific dimensional setting. Motived by this limitation, we propose a dimension-agnostic procedure of single change-point testing for time series by incorporating the idea of sample splitting and self-normalization. We propose test statistics against both dense and sparse change in mean and derive the limit when the sample size diverges, regardless of the dimensionality. The asymptotic power against the local alternative is also investigated. Additionally, our method can be generalized to multiple change-points estimation via the wild binary segmentation. The encouraging numerical results demonstrate the effectiveness of our method in detecting and estimating the change point(s) for a broad range of dimensions.

4 Self-supervised Prototype Representation Learning for Event-based Corporate Profiling

Zixuan Yuan[1], Denghui Zhang[2], Hui Xiong[1], [1]Rutgers University, Newark, NJ, [2]Rutgers Business School, Newark, NJ, Contact: yuanzx33033@gmail.com

Event-based corporate profiling aims to assess the evolving operational status of corresponding corporate from event sequence. Existing studies have partially addressed the problem via (i) case-by-case empirical analysis by leveraging traditional financial methods, or (ii) automatic profile inference by reformulating the problem into supervised learning task. However, they heavily rely on domain knowledge and are labor-intensive. To this end, we propose a Self-Supervised Prototype Representation Learning (SePaL) framework for dynamic corporate profiling. By exploiting topological information of event graph and exploring self-supervised learning, SePaL can obtain unified corporate representation that are robust to event noises. Experiments on two real-world datasets (stock spike prediction, corporate risk evaluation) demonstrate its effectiveness.

Tuesday, 2 PM–3:15 PM

TD60

M - Marriott 7

The Role of Battery Storage in Power System Decarbonization

General Session

Session Chair

Todd Levin, Argonne National Laboratory, Lemont, IL

1 **Presenter**

W. Neal Mann, Argonne National Laboratory

2 **Reducing Transmission Expansion by Co-optimizing Sizing of Wind, Solar, Storage, and Grid Connection Capacity**

Aneesha Manocha, Neha Patankar, Jesse D. Jenkins, Princeton University, Princeton, NJ, Contact: manocha@princeton.edu

Due to the necessary deployment of transmission to connect wind and solar photovoltaics (PV) projects to urban areas, we evaluate the effects of optimizing variable renewable energy (VRE) to interconnection sizing and co-locating VRE and battery resources on inter-regional transmission networks, shorter site-to-metro transmission, and VRE capacity deployment in 2030 low-carbon scenarios. Our findings indicate that inter-regional transmission expansion can be reduced by 12-31% depending on battery penetration with the ability to co-locate VREs and batteries in the American West. Grid connection capacity can decline by 21-32% with the ability to co-locate VREs and batteries. Lastly, current modeling does not incorporate resource trade-offs: co-location abilities favor PV and battery deployment, while only modeling oversized VREs builds more wind energy.

3 **Drivers for Storage Adoption in Decarbonized Electric Power Systems -insights from Systems Modeling**

Dharik Sanchan Mallapragada[1], Paul L. Joskow[2], Richard Schmalensee[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Massachusetts Institute of Technology, Cambridge, MA, Contact: dharik@mit.edu

We use a capacity expansion modeling framework to assess drivers of energy storage adoption in decarbonized grids under various technology and policy scenarios. Our analysis focuses on three US regions, Northeast, Southeast and Texas, under mostly-greenfield conditions and mid-century technology assumptions. We find that near-complete decarbonization of all three systems using variable renewable energy (VRE) generation and sparing use of natural gas, along with Li-ion storage, can be achieved without reduced reliability or large increases in system cost. Availability of storage technologies with lower energy capital costs than Li-ion can reduce system cost of decarbonization by displacing gas capacity and reducing VRE curtailment. Substantial demand for hydrogen outside the power sector would make its use as storage in the power system more attractive.

4 **The Impacts of Solar-battery Hybrids in a Decarbonized Electricity Supply**

Caitlin Murphy, Patrick Brown, Vincent Carag, National Renewable Energy Laboratory, Golden, CO, Contact: Caitlin.Murphy@nrel.gov

We explore the potential impacts of growing industry interest in hybrid systems comprising PV and battery technologies on the results and findings of the *Solar Futures Study (2021).* Through comparison of *Solar Futures Study* scenarios with and without PV-battery hybrid configurations enabled (in the same grid planning model), we find that the highest net-value hybrid configuration depends strongly on power sector carbon policy, which increases the value of more forward-looking designs. While the availability of PV-battery hybrid configurations primarily displaces standalone PV and battery capacity, we find that it (a) increases solar's share of total capacity and generation and (b) reduces required transmission expansion and associated costs under scenarios that combine aggressive cost reductions and power sector decarbonization policy.

Tuesday, 2 PM–3:15 PM

TD61

M - Marriott 8

Power Systems Optimization and Resilient Design
General Session

Session Chair
Amir Mousavian, 1</sup

Session Chair
Beheshteh Raouf, Clarkson University, Potsdam, NY

1 Infrastructuremodels: Composable Multi-infrastructure Optimization in Julia
Russell Bent[1], Carleton Coffrin[2], Byron Tasseff[1], [1]Los Alamos National Laboratory, Los Alamos, NM, [2]Los Alamos National Laboratory, los Alamos, NM
There is increasing need to understand the complex interdependencies between critical infrastructure systems, e.g., electric power, natural gas and potable water. While independent modeling of these systems has decades of research, co-modeling is more difficult-- a major challenge being the hidden combinatorics that arise when connecting infrastructure system models together. This work presents InfrastructureModels, an extensible, open-source mathematical programming framework for co-optimizing multiple interdependent infrastructures. It provides new insights into methods and programming abstractions that make state-of-the-art independent infrastructure models composable with minimal additional effort and demonstrate its effectiveness on canonical co-optimization resilience applications arising in interdependent infrastructure systems.

2 Equilibria in Interdependent Natural-gas and Electric Power Markets: An Analytical Approach
Amir Mousavian[1], Beheshteh Raouf[1], Antonio J. Conejo[2], [1]Clarkson University, Potsdam, NY, [2]The Ohio State University, Columbus, OH
This paper provides analytical Nash-Cournot equilibrium models to represent the joint operation of natural-gas and electric power markets with the assumption that the market participants in each market make their own decisions independently seeking the maximum profits, as often is the case in the real world. We develop an analytical equilibrium model and apply the Karush- Kuhn-Tucker (KKT) approach to obtain Nash-Cournot equilibria for the interdependent natural-gas and electric power markets. We use a double-duopoly case to study the interaction of both markets and to derive insightful analytical results.

3 False Data Injection Attacks on Data Markets for Electric Vehicle Charging Stations
Samrat Acharya[1], Robert Mieth[1], Ramesh Karri[1], Yury Dvorkin[2], [1]New York University, New York, NY, [2]New York University, Brooklyn, NY
Modern societies use machine learning techniques to make their decisions. Data fuels such techniques, so the quality of the data fed into them determines the accuracy of the results. While the amount of data is increasing with the adoption of internet-of-things, most of it is still private. Availability of data limits the application of machine learning. Scientists and industry pioneers are proposing a model that relies on the economics of data markets, where private data can be traded for a price. Cybersecurity analysis of such markets is lacking. This presentation examines the feasibility of false data injection attacks in the data market and proposes a defense mechanism against such attacks using a data market designed for electric vehicle charging stations. The results are illustrated using data from electric vehicle charging stations in Manhattan, New York.

Tuesday, 2 PM–3:15 PM

TD62

M - Marriott 9
Climate-friendly Energy Generation
General Session

Session Chair
Alexandra M. Newman, Colorado School of Mines, Golden, CO

1 Regression-based Machine Learning Models for Renewable Power Production Prediction
Ebisa Wollega[1], Ahmed Ferdous Antor[2], [1]Colorado State University Pueblo, Pueblo, CO, [2]Colorado School of Mines, Golden, CO, Contact: ebisa.wollega@csupueblo.edu
We present the application of ridge regression, polynomial regression, and random forest machine learning models for predicting solar irradiance and wind speed. The experimental results show that the random forest and the polynomial regression models perform better than the ridge regression at predicting a half-hour-ahead solar irradiance and wind speed. However, the predictive accuracy of the models for wind speed appears to be better than that of solar irradiance.

2 Optimizing Community Resilience Through Microgrid Deployment
James Grymes, Colorado School of Mines, Golden, CO, Contact: jgrymes@mines.edu

The ability to (re)establish basic community infrastructure and governmental functions such as medical and communication systems post-disaster rests on a continuous supply of electricity. Traditional energy generation systems are less capable given the increasing magnitude and frequency of climate-relatednatural disasters. We investigate the role that fuel cells play in post-disaster recovery efforts. We devise an optimization model that takes as inputs load and power technology data, determines a cost-minimizing design and dispatch strategy, and considers operational constraints by which the system is bound.

Tuesday, 2 PM–3:15 PM

TD63

M - Marriott 10

Energy, Health and Equity

General Session

Session Chair

Rodrigo Mercado Fernandez, VA

1 Comfort or Cash? The Covid-19 Pandemic's Impact on Energy Limiting Behavior in Households

Shuchen Cong[1], Arthur Lin Ku[2], Destenie Nock[1], Charlotte Ng[1], Lucy Yueming Qiu[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of Maryland College Park, College Park, MD, Contact: scong@andrew.cmu.edu

We present an energy justice study on the extent of energy limiting behavior displayed across income groups before and during the pandemic. We find lower-income households are 26% more likely to report worsened energy burden during the pandemic, as well as a disconnect between change in perceived energy limiting behavior and energy burden. In the <$15,000 group, 38% reported more difficulty paying energy bills during the pandemic, but only 32% reported further limiting energy use, and 23% reported more difficulty cooling their homes. We also find that lower-income households are willing to pay less than half ($2.1/F cooled) for a comfortable indoor environment compared to high-income households ($4.6/F cooled), potentially putting themselves at risk for heat-related illnesses. Reported energy limiting behavior correlates with a lower willingness to pay for cooling.

2 Regional Impacts on Health and Employment in The Decarbonization of China's Electricity Sector

Haozhe Yang[1], Ranjit Deshmukh[2], Jiang Lin[3], Qian Luo[4], Gang He[5], Jeremiah Johnson[4], Fernando Garcia Menendez[4], [1]University of California Santa Barbara, Santa Barbara, CA, [2]University of California, Santa Barbara, Santa Barbara, CA, [3]Lawrence Berkeley National Lab, Berkeley, CA, [4]North Carolina State University, Raleigh, NC, [5]Stony Brook University, Suffolk, NC, Contact: haozheyang@bren.ucsb.edu

The rapid decrease in the cost of renewable energy is expected to accelerate the decarbonization of China's power system. However, few studies have examined how the health and employment outcomes of this low-carbon transition will be distributed across China's regions and provinces. We integrate an electricity system planning model, a health impact model and a multiregional input-output model to quantify the impacts of decarbonization on health, employment and wage compensation at the provincial level, to meet GHG targets compatible with 2°C and 1.5°C pathways. We find that eastern China enjoys the largest reduction in premature deaths. Western and Northeast China experiences a minor increase in jobs. The wage compensation in Northeast and Southwest China remains the lowest. Our findings suggest that policies are likely needed to reduce disparities in employment.

3 Is Nuclear Energy a Solution to Climate Change? a Discussion of The Debate'smain Claims and Evidence

Becky D. Rafter, Georgia Institute of Technology, Atlanta, GA, Contact: brafter3@gatech.edu

Join in a discussion about the main claims and evidence in the debate over nuclear energy being a solution to climate change. Advocates for nuclear energy suggest that nuclear power offers 24/7 baseload energy, is a critical component of the decarbonization necessary to limit global warming to 1.5°C, and can be competitive in the marketplace. On the other hand, advocates for carbon-free, nuclear-free energy generation make several claims about how nuclear energy is too costly, unsafe, wasteful, unhealthy for local communities, and closely linked to nuclear weapons. Both sides have evidence to support their arguments, and advise that if policy prescriptions are not followed, many lives will be affected. How do we create supply-and demand-side engineering and policy solutions for nuclear energy that include social, economic, climate, and environmental impacts?

4 Distributed Energy Resources for Rural Resilience: The Nexus of Energy and Health

Rodrigo Mercado Fernandez, Appalachian State University, Richmond, VA

While photovoltaic (PV)+storage systems can provide many direct benefits to households in helping to reduce energy consumption, their economic viability is still limited, depending on local incentives, rate structures and available financing. The objective of this project is to determine the value of increased rural resiliency for households with medical dependencies through solar and storage systems. We will highlight the direct financial benefits that these systems can bring to households, by reducing energy consumption, as well as quantify the value of increased resiliency to the households, local counties and healthcare providers. We estimate the avoided cost, for a household with electricity-dependent durable medical equipment (DME) having the ability to maintain critical loads during a power outage and not having to travel to healthcare facilities.

Tuesday, 2 PM–3:15 PM

TD64

M - Indiana A

Presenting Mechanisms to Participants

General Session

Session Chair

Yannai A. Gonczarowski, Harvard, Brookline, MA

1 Self-Explanatory Strategyproof Mechanisms

Yannai A. Gonczarowski[1], Ori Heffetz[2], Clayton Thomas[3], [1]Harvard, Brookline, MA, [2]Cornell University and HUJI, Ithica, NY, [3]Princeton, Princeton, NJ, Contact: claytont@princeton.edu

We study *menu descriptions* of mechanisms, a class of descriptions which make strategyproofness self-explanatory. Perhaps our most striking results hold for the deferred acceptance (DA) matching rule. We propose a new, simple menu description of DA, which makes strategyproofness apparent by deviating from traditional descriptions in crucial ways. Specifically, this new description explains the match of one (and only one) student in the student-optimal outcome using a school-proposing algorithm. We also give an impossibility result, namely, a formal sense in which no menu description of DA can be found "within" traditional descriptions.

To ground our study in reality, we conducted a laboratory experiment on a set of very simple mechanisms, and find significant evidence that menu descriptions can better convey strategyproofness in some environments.

2 Zero-Knowledge Mechanisms

Ran Canetti[1], Amos Fiat[2], Yannai A. Gonczarowski[3], [1]Boston University, Boston, MA, [2]Tel Aviv University, Tel Aviv, Israel; [3]Harvard University, Cambridge, MA, Contact: yannai@gonch.name

Using cryptographic tools such as zero-knowledge proofs, we present a general technique for a mechanism designer to endogenously commit to an undisclosed mechanism, while still proving its properties of interest, eg, incentive compatibility and individual rationality, to agents, and at the end of the day proving the mechanism was run as planned, including that any random draws were fair. In a precise sense, agents learn nothing more about the mechanism than its realized outcome. Preliminary applications include bargaining, negotiations, ad auctions, and more. Finally, using ideas from prior literature on cryptographic hiding of bids in auctions, we also present an extension allowing both the mechanism and the bids to remain private, in the form of a general *un*revelation principle, opening the door for a new layer of mechanism customization we call "revelation design."

3 Contextually Private Mechanisms

Zoë Hitzig[1], Andreas Haupt[2], [1]Harvard, Cambridge, MA, [2]MIT, Cambridge, MA, Contact: zhitzig@gmail.com

Consider a mechanism design environment in which a designer sequentially queries agents' private information to determine the outcome of a choice rule. The designer's social and technological environment constrains the set of access *protocols* that it can use. A protocol is *contextually private* for a choice rule if each piece of information learned about each participant is needed to determine the outcome. We characterize choice rules that can be implemented with a contextually private protocol under different assumptions about the class of admissible protocols. In what we call *low-tech environments*, few common mechanisms are contextually private, with the exception of serial dictatorships and the first-price auction. In what we call *medium-tech environments*, contextual privacy can be preserved in many common mechanisms with a tatonnement-like implementation.

4 Incorporating Reference-dependence Considerations in Deferred Acceptance

Bnaya Dreyfuss[1], Ofer Glicksohn[2], Ori Heffetz[2], Assaf Romm[3], [1]Harvard University, Cambridge, MA, [2]Hebrew University of Jerusalem, Jerusalem, Israel; [3]Hebrew University of Jerusalem, Jerusalem, Israel. Contact: bdreyfuss@g.harvard.edu

Can incorporating expectations-based-loss-aversion (EBLA) considerations reduce deviations from straightforward behavior in Deferred Acceptance (DA)? We run an experiment (N = 500) that randomly assigns participants into one of four different DA variants—{static, dynamic} × {student proposing, student receiving}—and play 10 different problems, each simulating a large matching market. While the classical model always predicts straightforward behavior, our EBLA model predicts stark differences in behavior across variants and problems. We find, as predicted by our model, that (1) across problems, deviations from straightforward behavior increase with the competitiveness of the setting; (2) across variants, *dynamic student receiving* leads to fewer deviations; and (3) differences in *payoff-relevant* deviations are small (often non-detectable in our data).

Tuesday, 2 PM–3:15 PM

TD65

M - Indiana B

Economics and Computation IV

Award Session

Session Chair

Maxwell Allman, Stanford, CA

1 EC2022 Lotteries for Shared Experiences

Carlos Bonet[1], Nicholas A. Arnosti[2], [1]Columbia University, New York, NY, [2]Columbia Business School, Saint Paul, MN, Contact: cbonet23@gsb.columbia.edu

We study a setting where tickets for an experience are allocated by lottery. Each agent belongs to a group, and a group is *successful* if and only if its members receive enough tickets for everyone to participate. A lottery is *efficient* if it maximizes the number of agents in successful groups, and *fair* if it gives every group the same chance of success.
If agents must identify the members of their group, a natural mechanism --*the Group Lottery*-- is approximately fair and approximately efficient.
If agents may request multiple tickets without identifying members of their group, the most common mechanism --the *Individual Lottery*-- leads to arbitrarily unfair and inefficient outcomes. As an alternative, we propose the Weighted Individual Lottery, which is approximately fair and approximately efficient, and similar to the Group Lottery when there are many more agents than tickets.

2 EC2022 Fair Allocations for Smoothed Utilities

Paul Gölz, Carnegie Mellon University, Pittsburgh, PA

When allocating indivisible items across agents, it is desirable for the allocation to be *envy-free*, which means that each agent prefers their own bundle over every other bundle. Even though envy-free allocations are not guaranteed to exist for worst-case utilities, they frequently exist in practice. To explain this phenomenon, prior work has shown that, if utilities are drawn from certain probability distributions, then envy-free allocations exist with high probability.
We study a more general *semi-random* setting, in which utility profiles are mainly worst-case, but are slightly perturbed at random to avoid brittle counter-examples. If the probability of such perturbations is sufficiently large relative to the number of agents and items, we show that envy-free allocations exist with high probability and can be found efficiently.

3 [EC2022] Designing School Choice for Diversity in the San Francisco Unified School District

Maxwell Allman[1], Kaleigh Mentzer[2], [1]Stanford, CA, [2]Stanford University, Stanford, CA

Many cities have adopted school-choice policies with the goal of reducing school segregation resulting from residential segregation. We worked with the San Francisco Unified School District (SFUSD) to design a new policy for student assignment system that optimizes for the district's goals of diversity, predictability, and proximity. To develop potential policies, we used optimization techniques to design and evaluate the drawing of zones, student priority rules, and reserved seats. Our work informed the design and approval of a zone-based policy for use starting the 2025-26 school year.

Tuesday, 2 PM–3:15 PM

TD66

M - Indiana C

Data-driven modeling and algorithmic methods for a clean energy transition

General Session

Session Chair

Vivienne Liu, 1</sup

1 Reinforcement Learning for Selective Key Applications in Power Systems: Recent Advances and Future Challenges

Xin Chen[1], Guannan Qu[2], Yujie Tang[1], Steven Low[3], Na Li[4], [1]Harvard University, Allston, MA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]California Institute of Technology, Pasadena, CA, [4]Harvard University, Cambridge, MA, Contact: chenxin2336@gmail.com

With large-scale integration of renewable generation and distributed energy resources, power systems are confronted with new operational challenges. Meanwhile, more and more data are becoming available due to the widespread deployment of smart meters, smart sensors, and upgraded communication networks. Thus data-driven control techniques, especially reinforcement learning (RL), have attracted surging attention in recent years. This talk provides a comprehensive review of various RL techniques and how to apply them to power systems. We select three key applications, i.e., frequency regulation, voltage control, and energy management, as examples to illustrate RL-based models and solutions. We then present the critical issues in the application of RL, i.e., safety, robustness, scalability, and data. Several potential future directions are discussed as well.

2 A Multi-objective Adaptive Policy Search Approach for Microgrid Energy Management

Vivienne Liu[1], Patrick M. Reed[2], Garret Quist[3], David Gold[2], Lindsay Anderson[4], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, [3]Cornell University, Ithaca, NY, [4]Cornell University, Ithaca, NY, Contact: ml2589@cornell.edu

A challenge of managing microgrids is to identify energy dispatch strategies that accommodate multiple conflicting objectives from diverse stakeholders under uncertainties. Our study proposes a multi-objective evolutionary algorithm reinforcement learning framework to handle the daily energy management problem. We use the Cornell Microgrid as a test case and demonstrate that the non-dominated alternative policies provide better control strategies than the current operation with adaptive performance to exogenous information. We further open the black box to interpret the high dimensional parameterized control policies. This a-posteriori analysis provides an appropriate representation of stakeholder and climate priorities in the design and operation of microgrids, fostering positive outcomes for climate and society in general.

3 Synthetic Data to Advance Data Driven Modeling and Algorithms for The Future Electric Grid

Anna Scaglione[1,2], [1]Cornell University, New York City, NY, [2]Cornell University, New York, NY, Contact: as337@cornell.edu

To manage the clean energy transition stakeholders in the electricity delivery infrastructure are amassing data about their system demand, use and operations. However, they are reluctant to share them due to privacy concerns. In addition, data acquired today reflect the present, not the future grid. In this talk we discuss how to create databases that allow to study data driven algorithms with realistic data, projecting their performance in future scenarios that reflect a cleaner energy system. To capture the future, we introduce models for high resolution geo-embedded solar production data, realistic load patterns for EV charging geo-embedded synthetic feeders that can be augmented to reflect future clean electrified urban areas and user consumption data that that are differentially private while emulating real data.

4 Long-term Impacts of Energy Storage Providing Regulation on Power Plant Retirements and System Emissions

Jing Peng[1], Johanna Mathieu[2], Catherine Hausman[3], Jesse Buchsbaum[4], [1]University of Michigan, Ann Arbor, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, [3]University of Michigan, Ann Arbor, Ann Arbor, MI, [4]University of California, Berkeley, Berkeley, CA

Energy storage can provide a variety of economic and reliability benefits to the grid; however, the overall environmental impacts of storage are not always positive. In this talk, we explore the long-term impacts of using storage to provide frequency regulation. Specifically, using an optimization model that co-optimizes unit commitment, energy, and regulation capacity, we explore the effect of increasing penetrations of regulation-providing storage on dispatch, prices, profit, retirements, and CO_2 emissions. We find that storage can lead to increases or decreases in emissions, depending on system parameters. Additionally, we find that long-term impacts can be in different directions than short-term impacts. This points to the need for new mechanisms to ensure desired environmental outcomes are achieved when using so-called "green" technologies.

Tuesday, 2 PM–3:15 PM

TD67

M - Indiana D

RM Models for Sequential and Multiple Choices

General Session

Session Chair

Ningyuan Chen, University of Toronto, Mississauga, ON, Canada.

1 Assortment Decisions with All-at-once Returns and Heterogeneous Customers

Sahika Sahan, Jacob Feldman, Olin Business School, Saint Louis, MO, Contact: sahans@wustl.edu

In this paper, we study the assortment problem in a setting where heterogeneous customers can return the products that they ordered. We first fully characterize the dynamics of the model and show that the assortment problem is NP-hard. We then provide polynomial-time approximation scheme for the retailer's assortment problem

2 Privacy-preserving Personalized Recommender Systems

Pin Gao[1], Xingyu Fu[2], Ningyuan Chen[3], Yang Li[4], [1]The Chinese University of Hong Kong, Shen Zhen, Shenzhen, China; [2]The Hong Kong University of Science and Technology, Hong Kong, China; [3]Rotman School of Management, University of Toronto, Toronto, ON, Canada; [4]Chinese University of Hong Kong, Hong Kong, Hong Kong.

We study the optimal design of a personalized recommender system under the local differential privacy constraint. The recommender recommends a product to a consumer based on her preference ranking of products. We show the optimal policy is a coarse-grained threshold policy: it randomly selects a product to recommend with a subset having higher recommendation probabilities than the rest, where the subset is determined by a threshold on the consumer's preference ranking. We analyze the property of the threshold in the asymptotic regime. Our analysis suggests that pursuing privacy may come at a substantial economic loss due to the resulting inaccurate recommendation, although it may benefit consumers monetarily via the induced lower product price associated with the less relevant recommendation.

3 Customer-driven Bundle Promotion Optimization at Scale

Ozge Sahin[1], Ali Fattahi[1], Yuexing Li[2], [1]Johns Hopkins University, Baltimore, MD, [2]Duke University, Fuqua School of Business, Durham, NC, Contact: ozge.sahin@jhu.edu

Bundle promotions have become increasingly popular among online retailers due to their potential in increasing revenue and profit. They take various forms depending on how retailers offer them to customers (e.g., after a purchase incidence, as advertised deals, or as personalized promotions) and how they are structured (e.g., buy one get one free, spend $100 get 25% off, or buy 3 get $20 off). Understanding how customers respond to these promotions and designing optimal bundle promotions at scale are relevant but challenging problems due to the non-linearity of these promotions. We study a new class of bundle promotions that are not advertised but are offered after customers make their first purchases on a retailer's website. We develop scalable algorithms, and derive managerial insights.

4 Multi-product Dynamic Pricing with Limited Inventories under Cascade Click Model

Sajjad Najafi, HEC Paris, VERSAILLES, France.

The Cascade Click model is one of the most popular click models used in practice and has also been intensively studied in the CS literature. Incorporating this into a capacitated dynamic pricing problem, we provide an upper-bound by an approximate deterministic pricing problem, and develop asymptotically optimal heuristics.

Tuesday, 2 PM–3:15 PM

TD68

M - Indiana E

Empirical Revenue Management and Marketplace Analytics

General Session

Session Chair

Jun Li, Ross School of Business, University of Michigan, Ann Arbor, MI

Session Chair

Zoey Jiang, 1</sup

1 Design of Contingent Free Shipping Policy: The Role of Return Environment

Ashish Kabra[1], Wedad Elmaghraby[1], Sahar Hemmati[1], Nitish Jain[2], [1]University of Maryland-College Park, College Park, MD, [2]London Business School, London, United Kingdom. Contact: akabra@umd.edu

A contingent free shipping (CFS) policy offers free shipment of an order only if it satisfies a pre-specified threshold amount. Such a policy may induce customers to pad below-threshold orders to meet the threshold. On the one hand, such padded orders economize the retailer's logistics cost; on the other hand, it exposes the retailer to enhanced return costs as customers may engage in bubble purchases. Using an empirical approach, we show that these behaviors are strongly moderated by moderated by the retailer's returns policy and associated customers' ease-of-return experience.

2 Uncovering Customer Life-Changing Events from Financial Transactional Data

Yanhan (Savannah) Tang, Alan Montgomery, Carnegie Mellon University, Pittsburgh, PA, Contact: yanhanta@andrew.cmu.edu

A common hypothesis in the financial service sector is that life-changing events are times in which a customer is likely to be more receptive to new financial services. For a financial institution, being able to predict these life-changing events is helpful in choosing the appropriate offers to make. Information about life-changing events may be encoded, latently, within the customer's transaction history. For example, the replacement of salary from one employer by another is an indicator of a new job, and the addition of new account holders may reveal a new marriage. We develop data-driven techniques to detect changes in financial health and infer life-changing events from transaction-level data provided by a collaborating bank.

3 Why so Many Scooters? a Policy Analysis

Hale Erkan[1], Ioannis Stamatopoulos[2], Ashish Agarwal[3], Kumar Muthuraman[4], [1]University of Texas at Austin, Austin, TX, [2]The University of Texas at Austin, McCombs School of Business, Austin, TX, [3]University of Texas at Austin, Austin, TX, [4]University of Texas-Austin, Austin, TX, Contact: hale.erkan@mccombs.utexas.edu

We present analytical and empirical evidence that competition forces e-scooter firms to over-supply scooters. Estimating a game-theoretic econometric structural model and running counterfactual simulations, we conclude that policymakers should be frugal with the number of firms they permit to operate in each city, and should incentivize mergers in the e-scooter market.

Tuesday, 2 PM–3:15 PM

TD69

M - Indiana F

Personalization, Targeting, and Experimentation in Revenue Management and Healthcare

General Session

Session Chair

Spyros Zoumpoulis, INSEAD, Fontainebleau, France.

1 Diamonds in The Rough: Leveraging Click Data to Spotlight Underrated Products

Seyed Emadi[1], Sajad Modaresi[1], Vinayak V. Deshpande[2], [1]UNC-Chapel Hill, Chapel Hill, NC, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC, Contact: seyed_emadi@kenan-flagler.unc.edu

Inspired by a real data set from the Chinese retailer JD.com, we study the click and purchase behavior of customers in an online retail setting by employing a structural estimation approach. In particular, we aim to understand what characteristics of products drive the click versus purchase decisions of customers.

2 Assortment Optimization Under The Decision Forest Model

Yi-Chun Chen, Velibor Misic, UCLA Anderson School of Management, Los Angeles, CA

The decision forest model is a recently proposed choice model that is capable of representing any discrete choice model and in particular, can be used to represent non-rational customer behavior. In this paper, we study the problem of finding the assortment that maximizes revenue under this choice model. This problem is of practical importance because it allows a firm to tailor its product offerings to profitably exploit deviations from rational customer behavior. We approach this problem from a mixed-integer optimization perspective and propose three different formulations. We also propose a large-scale method based on Benders decomposition. Using synthetically generated instances, we demonstrate the practical tractability of our formulations and our Benders decomposition approach, and their edge over heuristic approaches.

3 Managing Customer Search: Assortment Planning for a Subscription Box Service

Fernando Bernstein, Yuan Guo, Duke University, Durham, NC, Contact: fernando@duke.edu

We study a subscription box company's problem of selecting the optimal box contents to maximize expected revenue. Customers choose between engaging in active search and subscribing to a box delivery service. We apply a cross-nested logit framework that correlates the contents in the box with the products available at the stores. We find that the box should include a collection of popular subsets of store products for customers that experience a low or high search cost. For those with moderate search cost, it may be optimal to include a utility loss leader, i.e., a product with relatively low valuation, to induce customers to subscribe to the box. We also study box operational strategies, including offering exclusive products and the inclusion of products from a category not requested by the customer.

4 Quantifying The Benefits of Targeting for Pandemic Response

Sergio Camelo[1], Dragos Florin Ciocan[2], Dan Andrei Iancu[1], Xavier Warnes[3], Spyros Zoumpoulis[2], [1]Stanford University, Stanford, CA, [2]INSEAD, Fontainebleau, France; [3]Stanford University Graduate School of Business, Stanford, CA, Contact: daniancu@stanford.edu

We propose and implement a rigorous framework and algorithms to quantify the merits of targeted confinement interventions for pandemic response, and demonstrate them in a case study of COVID-19 in Île-de-France. We find that optimized interventions that differentiate based on both population groups and activities are interpretable, and achieve significantly better health and economic outcomes, while also reducing confinement time for each group, compared to less targeted interventions. Given that some amount of targeting of activities and age groups is already in place in real world pandemic responses, our framework highlights the significant benefits in explicitly and transparently modelling targeting and identifying the interventions that rigorously optimize overall societal welfare.

Tuesday, 2 PM–3:15 PM

TD70

M - Indiana G

Nonsmooth Optimization and Machine Learning

General Session

Session Chair

Zev Woodstock, [1</sup]

Session Chair

Sebastian Pokutta, Zuse Institute Berlin (ZIB), Berlin, Germany.

1 Stochastic Projective Splitting

Patrick Johnstone, Brookhaven National Laboratory, Upton, NY, Contact: patrick.r.johnstone@gmail.com

Projective splitting (PS) is a family of algorithms for solving nonsmooth convex optimization and saddlepoint problems. It is tailored to optimization problems featuring a sum of nonsmooth functions, or from a dual perspective, multi-block-separable problems with linear constraints. As an operator splitting scheme, it is similar to ADMM and other well-known algorithms, however it allows for full decomposition of any number of operators, including compositions with linear operators, and the basic calculations are proximal evaluations and gradient (forward) evaluations. We present a new variant of PS that is able to use stochastic (as opposed to deterministic) gradient oracles. The key idea is to replace the hyperplane projection performed at each iteration with a weighted step in the hyperplane direction using an appropriate decaying stepsize.

2 On The Frank Wolfe Approach for Abs-smooth Optimization

Zev Woodstock, Zuse Institute Berlin, Berlin, Germany.

Despite being nonsmooth, many objective functions in machine learning reside in the class of *abs-smooth* functions -- functions whose evaluation can be described by successive application of smooth functions along with absolute value, min, and max operations. Recent work has illuminated efficient methods for unconstrained optimization of abs-smooth functions, although the structured/constrained problem remains unresolved. We consider the task of minimizing abs-smooth functions subject to closed convex constraints. The constraints are enforced via linear minimization oracles, which are typically more efficient than projections.

Tuesday, 2 PM–3:15 PM

TD71

M - Arizona

Decision Diagrams for Optimization

General Session

Session Chair

Anthony Karahalios, [1</sup]

1 Minimum Recursive Mccormick Linearization of Multilinear Programs

Carlos Henrique Cardonha[1], Arvind Raghunathan[2], Carlos Nohra[3], David Bergman[1], [1]University of Connecticut, Storrs, CT, [2]Mitsubishi Electric Research Laboratories, Cambridge, MA, [3]Amadeus, Dallas, TX, Contact: carlos.cardonha@uconn.edu

Recursive McCormick Linearizations (RML) convexify Multilinear Programs (MLP) by adding variables and concave and convex envelopes to represent bilinear products. This work introduces the first exact algorithm for identifying minimum-size RMLs. Our algorithm relies on the representation of all RLMs of an MLP as linearization diagrams, which are data structures based on decision diagrams tailored for this problem. Our results show that minimum RMLs can be significantly smaller than the linearizations used by state-of-the-art global optimization solvers. Finally, we also show that identifying a minimum RML is NP-hard and fixed-parameter tractable if each monomial is composed of at most three variables.

2 Comparing Column Elimination with Column Generation

Anthony Karahalios, Carnegie Mellon University, Pittsburgh, PA, Contact: akarahal@andrew.cmu.edu

A method called Column Elimination was recently introduced to generate both lower bounds and optimal solutions for the graph coloring problem. Based on dynamic programming and decision diagrams, this exact method begins with a relaxed state space and refines this space at each iteration. Our work provides methodological and computational comparisons between Column Elimination and Column Generation; it uses the Capacitated Vehicle Routing Problem (CVRP) as a case study.

3 Decision Diagram Based Approach for a Class of Discrete Robust Optimization Problems

Leonardo Lozano[1], Andre Augusto Cire[2], David Bergman[3], [1]University of Cincinnati, Cincinnati, OH, [2]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada; [3]University of Connecticut, Storrs, CT, Contact: leolozano@uc.edu

Robust optimization seeks to optimize the worst-case performance of an objective function considering that some uncertain components of the problem belong to some given uncertainty set. Discrete robust optimization problems are particularly challenging as standard approaches often rely on properties like convexity. We proposed an exact solution methodology for a class of robust optimization problems based on decision diagrams, which can be seen as a decomposition approach in which the state variables of a dynamic program are iteratively expanded. Our proposed algorithms outperform standard approaches from the literature on a collection of test problems for a robust routing problem.

Tuesday, 2 PM–3:15 PM

TD72

M - California

Social Media and QSR Flash Session

Flash Session

Session Chair

Sandeep Khurana, Hyderabad, India.

1 Why Should Charities Offer to Publicize Their Prosocial Acts on SNSs? - An Experimental Study

Kara Li Liu[1], Koray Ozpolat[1], Gulver Karamemis[2], [1]University of Rhode Island, Kingston, RI, [2]Georgia Southern University, Statesboro, GA, Contact: karaliliu@uri.edu

This research examines factors leading to prosocial behaviors on social network sites. An online experimental design is utilized, in which subjects were randomly assigned to see a Facebook post (prosocial/non-prosocial condition), followed by a request to engage in prosocial behavior. Their engagement decisions would either be posted publicly or kept confidential. Our research findings show subjects respond more positively to the publicity of their own prosocial acts rather than seeing others' prosocial behaviors online. Further examination suggests the positive effect of publicity is stronger for males. Our study helps charity organizations promote prosocial behaviors online.

2 CoNeCo: Combining Negative Control Outcomes for Bias Correction in Causal Inference

Yuanyang Liu[1], Emre Demirkaya[2], wei zheng[3], [1]University of Tennessee, knoxville, TN, [2]University of Tennessee, knoxville, TN, [3]university of tennessee, knoxville, TN, Contact: yliu191@utk.edu

The unobserved confounding is a key challenge for causal inference with observational study. One way to detect bias from unobserved confounding is the use of negative control outcomes. We present an algorithm that utilize many available negative control outcomes to create a synthetic negative control outcome variable for bias correction. Simulation analysis show the effectiveness of our method in reducing bias in causal effect estimates due to unobserved confounding.

3 Predicting Pandemic Surges Using Social Media

Nina Grundlingh, Kennesaw State University, Kennesaw, GA, Contact: ninagrund@outlook.com

We investigate the effectiveness of monitoring social media in order to predict upcoming regional surges in hospitalization for COVID-19. By geographically filtering Twitter keyword searches, we have found that social media can be used to enhance our predictive models (a recurrent neural network).

4 Approximation Techniques for Probabilistic Cellular Automata on a large Heterogeneous Network

Juniper Cocomello, Providence, RI

From social networks to neural systems, many real-world networks exhibit heterogeneity in their connectivity. Existing techniques to analyze and simulate interacting stochastic processes, such as mean-field approximations, are reliable only when applied to sufficiently dense networks. Approaches to the study of large heterogenous networks are still largely unexplored. We introduce a heterogenous network model featuring a cluster of densely connected nodes and a cloud of sparsely connected nodes. We consider a class of discrete-time interacting processes on this network. With a combination of mean-field methods and local convergence techniques we obtain a limit theorem for the empirical measure of the processes, and derive an autonomous characterization of the limit — thus approximating the interacting processes with a great reduction in dimensionality.

5 DECOMPOSITION BASED ANOMALY DETECTIOn in a DATA-RICh but LABEL-RARE ENVIRONMENT

Shancong Mou[1], Jianjun Shi[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]ISyE Georgia Tech, Atlanta, GA, Contact: smou7@gatech.edu

Unsupervised pixel-wise anomaly detection is important in product cosmetic inspection, including aiding pixel-wise annotation, providing precise defect specifications (i.e. diameter, area) for product surface quality screening, and so on. Matrix decomposition algorithms are widely used in extracting anomaly regions from image data. To further enhance its performance in a data-rich but label-rare environment, the following studies are conducted in the past several years, including (i) Additive Tensor Decomposition (ATD). (ii) Compressed Smooth Sparse Decomposition (CSSD), and (iii) Deep Image Decomposition and Robust GAN-inversion (RGI).

6 Directed Graphical Models for Multimodal Systems Collecting Heterogeneous Data

Manni Zhang, Ana Maria Estrada Gomez, Purdue University, West Lafayette, IN, Contact: zhan3735@purdue.edu

Complex sensing systems collect heterogeneous data, including scalars, functional signals, images, and point clouds. We use direct graphical models to represent the relationships between the variables and learn the system's structure for root-cause analysis. In this article, we propose a universal tensor representation for data and assume linear interactions between the variables. When the structure is known, we learn the parameters of tensor regressions; when it is unknown, we minimize the sum of least squares, group lasso, and L2 penalties using a cyclic coordinate accelerated proximal gradient decent algorithm. The performance of our method on simulation experiments shows its advantages.

7 Defects Classification Via Hierarchical Graph Convolutional Network in L-PBF Additive Manufacturing

Anyi Li, Jia Liu, Auburn University, Auburn, AL, Contact: azl0082@auburn.edu

Defects innate in laser beam powder bed fusion (L-PBF) process deteriorate the mechanical performance like the fatigue life of L-PBF components. This work presents a novel hierarchical graph convolutional network (H-GCN) to classify different types of defects by a cascading GCN structure with a low-level features (defect features) layer and a high-level features (fabrication conditions) layer. H-GCN can leverage the information from different hierarchies to classify the defects and explore the impact of fabrication conditions on defect features. Simulation results indicate that H-GCN is highly robust to both balanced and unbalanced datasets and can achieve a classification accuracy of 100%.

8 Mvgcn: Multi-view Graph Convolutional Neural Network for Surface Defect Identification Using 3d Point Cloud

Yinan Wang[1], Wenbo Sun[2], Jionghua Jin[3], Zhenyu James Kong[1], Xiaowei Yue[1], [1]Virginia Tech, Blacksburg, VA, [2]University of Michigan Transportation Research Institute, Ann Arbor, MI, [3]University of Michigan, Ann Arbor, MI, Contact: yinanw@vt.edu

Given that three dimensional (3D) point cloud can precisely represent the multi-dimensional structure of surface defects, we aim to detect and classify surface defects using 3D point cloud. In this work, a two-step surface defect identification approach is developed to investigate the defects' patterns in 3D point cloud data. We prove that the proposed approach is invariant to different permutations and transformations. A case study is conducted for defect identification in the aircraft fuselage. The results show that our approach receives the best defect detection and classification accuracy compared with other benchmark methods.

Tuesday, 2 PM–3:15 PM

TD73

M - Colorado

Emerging Technologies in Healthcare

General Session

Session Chair

Qiang Li, Wilfrid Laurier University, ON, Canada.

Session Chair

Meng Li, University of Houston, TX

1 The Interactions of Crowding, Patient Severity, and The Queuing Discipline at a Hospital Emergency Department

Lu Wang[1], Suman Mallik[2], Mazhar Arikan[2], [1]Ball State University, Muncie, IN, [2]University of Kansas, Lawrence, KS, Contact: wang@bsu.edu

Utilizing the detailed patient visit data from the ED of a large urban teaching hospital, we characterize the impacts of the change in patient queue rank on patient LOS. We study how arrivals of higher/lower severity patients influence patient LOS, and how changes in queue rank, arrivals of patients with higher/lower severities, and crowding simultaneously affect LOS.

2 Value of Live-Streaming Healthcare

Zhi Cao[1], Jingbo Zhou[2], Meng Li[3], Qiang Li[4], Dou Dejing[2], [1]University of Electronic Science and technology of China, Chengdu, China; [2]Baidu Research, Beijing, China; [3]University of Houston, Houston, TX, [4]Wilfrid Laurier University, Waterloo, ON, Canada.

As a revolutionary video technology, live streaming has significantly reshaped various markets. However, there is little research on its impact on healthcare. Taking advantage of variations in the timing of the adoption of live streaming for physicians, we utilize the difference-in-differences identification with coarsened exact matching to identify the causal relationship between the adoption of live streaming by physicians and the volume of their follow-up online consultations. We find that the adoption significantly increases physicians' follow-up online consultations by approximately 40%. Our paper also provides guidance for physicians who aim to popularize medical and health knowledge among the public through live streaming and among healthcare platforms when deciding whether to introduce or promote a live-streaming service.

3 How Physicians Adopt AI Assistant: A Field Experiment

Ting Hou[1], Meng Li[2], Yinliang Tan[2], Huazhong Zhao[3], [1]University of Science and Technology of China, Hefei, China; [2]University of Houston, Houston, TX, [3]City University of Hong Kong, Hong Kong, China.

Artificial intelligence (AI) is increasingly being used in healthcare practices, but little is known about physicians' AI adoption behaviors. In this paper, we conduct a field experiment in collaboration with a leading healthcare platform in Asia to investigate how physicians' adoption rate and adoption timing of AI assistants are affected by two AI strategies, AI smartness and AI transparency. We find a positive effect of AI smartness strategy on AI adoption rate and adoption timing. That is, physicians are more willing to adopt the smart AI assistant equipped with an algorithm than the standard AI assistant that provides fixed recommendations. We also find that AI transparency strategy is crucial in driving physicians to adopt AI assistants earlier. Moreover, it can increase the adoption rate of standard AI assistants

4 The Impact of Air Pollution on Chinese Mental Health

Zhi Cao[1], Jingbo Zhou[2], Meng Li[3], Jizhou Huang[2], Dejing Dou[2], [1]University of Electronic Science and Technology of China, Chengdu, China; [2]Baidu, Inc., Beijing, China; [3]University of Houston, Houston, TX, Contact: zcao@std.uestc.edu.cn

The rising mental health difficulties of the urban population in developing countries may be attributed to the high levels of air pollution. However, large-scale nationwide empirical works that examine this claim are rare. We construct a daily city-level mental health metric based on the volume of mental health-related queries (MHQs) on the largest search engine in China, Baidu, to test this hypothesis. We first document the extent and duration of exposure to air pollution that leads to worsened mental health among urbanites. The impact of long-term exposure (60 days) to air pollution is over six times that of daily exposure. Heterogeneity analyses reveal that the effect of air pollution on mental health varies by different demographic and socioeconomic characteristics.

Tuesday, 2 PM–3:15 PM

TD74

M - Florida

Green Finance

General Session

Session Chair

Aparna Gupta, Rensselaer Polytechnic Institute, Troy, NY

1 Assessing and Attributing Climate Change Response of U.s. Insurance Firms

Abena Fosua Owusu[1], Aparna Gupta[2], Jue Wang[3], [1]Montclair State University, Montclair, NJ, [2]Rensselaer Polytechnic Institute, Troy, NY, [3]University of Massachusetts, Amherst, MA, Contact: owusua@montclair.edu

In this research, we assess and distinguish between insurance firms' response to climate change risks and examine how their exposures relate to their financial and governance characteristics. Using text mining, we build a climate change dictionary with three sub dictionaries - risk, impact and response, and apply a nested structure feature extraction approach to define insurance firms' adaptation levels to climate change risk exposures. We find that insurance firms with high exposure to climate change physical risks and long term shift in climate change patterns present a high level of adaptation response to the pecuniary impact of the risks. Relating the climate risk features to quantitative firm characteristics in a CART analysis, we find that reinsurance liabilities and reinsurance assets of insurance firms largely dictates climate related risks of insurance firms.

2 Presenter

Alberto Lamadrid, 1</sup

3 Protecting Coastal Cities Against Climate-change-induced Flooding

Donald John Jenkins[1], Foad Mahdavi Pajouh[2], Paul Kirshen[3], Mahyar Eftekhar[4], [1]University of Massachusetts Boston, Boston, MA, [2]Stevens Institute of Technology, Hoboken, NJ, [3]University of Massachusetts Boston, Boston, MA, [4]Arizona State University, Tempe, AZ, Contact: fmahdav1@stevens.edu

We propose a network optimization approach to find optimal cost-benefit strategies for infrastructure development and flood reduction over time and space. Expected flood costs are included using a loss function that samples a range of possible climate-change-induced sea level rise scenarios. Investment costs are modeled for overall infrastructure development with budgetary limitations on infrastructure investment. Using the City of Boston as a case for this study, our proposed methodology resulted in a greater than 90% cost reduction compared to a "do nothing" strategy.

4 Storage Enhanced Renewable Energy Bidding Strategies

Sai Palepu, Aparna Gupta, Rensselaer Polytechnic Institute, Troy, NY, Contact: paleps@rpi.edu

The paper presents a risk-mitigation framework to enhance the profitability of the renewable power contract bids by leveraging a co-located energy storage. We develop a storage utilization algorithm that transforms the generation time series of the renewable asset when paired with a battery. Renewable bidding strategies, developed using principles of asset securitization on the stochastic renewable generation, are modified to account for the storage utilization. We find the storage enhanced renewable bids yield increased levels of reliable generation and improved risk-return tradeoffs as compared to the standalone bids. Improved risk-return characteristics of the renewable energy bids present attractive prospects for green finance projects.

Tuesday, 2 PM–3:15 PM

TD75

M - Illinois

Machine Learning for Quantitative Finance II

General Session

Session Chair

Maxim Bichuch, Johns Hopkins University, Baltimore, MD

Session Chair

Nils-Christian Detering, University of California-Santa Barbara, Santa Barbara, CA

1 Pricing Options on Flow Forwards by Neural Networks in Hilbert Space

Nils-Christian Detering, University of California-Santa Barbara, Santa Barbara, CA

We propose a new methodology for pricing options on flow forwards by applying infinite-dimensional neural networks. We recast the pricing problem as an optimization problem in a Hilbert space of real-valued function on the positive real line, which is the state space for the term structure dynamics. This optimization problem is solved by facilitating a novel feedforward neural network architecture designed for approximating continuous functions on the state space. The proposed neural net is built upon the basis of the Hilbert space. We provide an extensive case study that shows excellent numerical efficiency, with superior performance over that of a classical neural net trained on sampling the term structure curves.

2 High-Frequency Optimal Execution

Laura Leal[1], Mathieu Lauriere[2], Rene A. Carmona[3], Charles-Albert Lehalle[4], [1]Goldman Sachs, New York, NY, [2]NYU Shanghai, Shanghai, China; [3]Princeton University, Princeton, NJ, [4]ADIA, Abu Dhabi, United Arab Emirates. Contact: lleal@princeton.edu

We look at the optimal execution problem from two different perspectives. First we argue for the presence of a Brownian component in the inventory and wealth processes of individual traders, and extend the theoretical analysis of the optimal execution problem to include this result and compare to the optimal behavior of a trader. The second is to provide a solution to the stochastic optimization problem using an explainable neural optimizer, able to learn from intraday seasonality and adapt to risk preferences.

3 Mixed-Integer Programming Formulations for Systemic Risk Measures

Cagin Ararat[1], Nurtai Meimanjan[2], [1]Bilkent University, Ankara, Turkey; [2]Mazars, Bishkek, Kyrgyzstan. Contact: cararat@bilkent.edu.tr

Systemic risk is concerned with the instability of an interconnected financial system. In the literature, several systemic risk measures have been proposed to determine capital requirements for the members subject to joint risk considerations. We address the problem of computing systemic risk measures for networks with sophisticated clearing mechanisms. Specifically, we consider an extension of the Rogers-Veraart model where operating cash flows are unrestricted in sign. We propose novel mixed-integer programming problems for calculating clearing vectors. The corresponding set-valued systemic risk measure has nonconvex values in general. We provide theoretical results for the weighted-sum and Pascoletti-Serafini scalarizations of the systemic risk measure, and assess its sensitivity with respect to structural parameters via computational experiments.

Tuesday, 2 PM–3:15 PM

TD76

M - Michigan

Emerging Issues in Sustainable Supply Chains

General Session

Session Chair

Olga Perdikaki, University of South Carolina, Columbia, SC

Session Chair

Eda Kemahlioglu Ziya, North Carolina State, Raleigh, NC

1 Acquisition of Used Products for Remanufacturing

Akshay Mutha[1], Saurabh Bansal[2], [1]University of Vermont, Burlington, VT, [2]Penn State University, State College, PA, Contact: akshay.mutha@uvm.edu

Normal 0 false false false EN-US X-NONE X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:10.0pt; font-family:"Times New Roman",serif;} We develop models to analyze the process of acquiring used products for remanufacturing. We perform numerical analyses to show the applicability of our models.

2 Vehicle Routing Problem Using a Mixed Fleet of Traditional and Clean Trucks

Siqiang Guo[1], Shadi Goodarzi[2], Erhan Kutanoglu[3], [1]University of Texas at Austin, Austin, TX, [2]University of Texas Austin, Austin, TX, [3]University of Texas-Austin, Austin, TX, Contact: siqianggeorgeguo@gmail.com

This project researches the vehicle routing problem using a mixed fleet of traditional and clean trucks. Factors like carbon emissions and refueling of hydrogen/electric trucks are considered.

3 Cooperating with Third-party Collector or Not: Optimal Trade-in Strategy Considering Market Segmentation

Bin Zheng[1], Sijie Li[1], Wenli Xiao[2], [1]Southeast University, Nanjing, China; [2]University of San Diego, San Diego, CA, Contact: bzheng@seu.edu.cn

To retain existing customers and promote sales, firms offer trade-in services by either themselves (strategy NC) or cooperating with a third-party collector (strategy C). Strategy NC is limited to the firm's self-branded products, while strategy C has no restriction on brands. To this end, we explore the optimal trade-in strategy considering the brand and collection cost differences. We find that firm with high (low) collection cost prefers strategy C (NC). In addition, strategy C (NC) is always the better choice for the firm with a sufficiently low (high) market share.

Tuesday, 2 PM–3:15 PM

TD78

M - Utah

Social Media and Platform Efficacy

General Session

Session Chair

Tongxin Zhou, Arizona State University, Tempe, AZ

1 Afraid of Niche, Tired of Mass: Atypical Idea Combination on Crowdfunding Platform

Yu Kan[1], Yifan Yu[1], Yang Jiang[2], Yong Tan[1], [1]University of Washington, Seattle, WA, [2]Nanjing University, Nanjing, China. Contact: yifanyu@uw.edu

A new idea usually follows a stream of similar ideas yet simultaneously combines atypical elements from ideas outside this stream. A successful business idea usually balances well between familiarity and atypicality. To investigate the relationship between atypicality innovation and crowdfunding project performance, we collected data from one of the largest crowdfunding platforms in China. We build a similarity network of crowdfunding projects to measure the degree of atypicality innovation for these projects. Using a double machine learning model, we find that the atypical combination of mainstream and niche ideas has a significant positive effect on the individual project's funding. Our results further indicate that donors are more conservative due to the high risk of niche projects and driven away by the monotonous repetition of mainstream projects.

2 Promise or Peril? when Human Efficacy Meets with AI Efficacy Augmentation

Tian Lu[1], Yiyu Huang[2], Xianghua Lu[2], [1]Arizona State University, Tempe, AZ, [2]Fudan University, Shanghai, China. Contact: lxhua@fudan.edu.cn

Literature has amply disclosed that humans high in efficacy tend to resist AI advice despite AI's great value derived from its strong capacities, and suggests that humans should generally follow AI to realize the optimal results. However, when considering a dynamic setting wherein AI capacities are boosted, with the conflicting cues of perceived benefits from AI efficacy augmentation and high confidence in self-judgment, however, how people high in human efficacy would react to AI advice remains unpredictable. Focusing on a typical complementary human-AI collaboration setting of on-demand food delivery service, our study empirically investigates this question with a natural experiment of AI capacity augmentation. Our study offers nontrivial theoretical and practical implications.

3 Killing Not Just Weeds: Unexpected Consequences of Combating Misinformation

Yuchen Liu[1], Elina Hwang[2], Stephanie Lee[1], [1]University of Washington, Seattle, WA, [2]University of Washington-Foster School of Business, Seattle, WA, Contact: elina7@uw.edu

Social platforms employ interventions to combat the rapid spread of misinformation. This study focuses on one such intervention by Twitter that aims to suppress misinformation by helping users find accurate information. In particular, this study aims to provide a holistic view of the intervention's effectiveness by investigating its impact on false as well as true information diffusion. To this end, we employ a difference-in-differences model. Surprisingly, we find that the intervention suppresses not only the spread of false news but also true information. Further analysis reveals that true information is also suppressed because people have difficulty discerning the truthfulness of the information. We provide insights into the tweet characteristics that tend to mislead people's perceptions.

4 How You Play Matters: An Empirical Study of User Engagement in Online Multiplayer Video Games

Tongxin Zhou[1], Yong Tan[2], [1]Arizona State University, Tempe, AZ, [2]University of Washington, Seattle, WA

Despite the complex game features and mechanics of massive multiplayer online games (MMOGs), how users' gaming experiences affect their engagement behaviors remain underexplored. In this study, we are motivated to investigate the effect of players' in-game activities on their subsequent engagement decisions regarding the propensity to play and online engagement time contingent on play. Using clickstream data collected from a popular MMOG, we find that self-oriented activities tend to increase both the propensity to play and online engagement time contingent on play, whereas social-oriented activities increase users' play propensity while decreasing their online engagement time contingent on play. Action-oriented and environment-oriented activities are found to increase users' propensity to play but have insignificant effect on online play time.

Tuesday, 2 PM–3:15 PM

TD79

JWM - Room 201

Product and Process Innovation

General Session

Session Chair

Zhili Tian, Florida International University, Weston, FL

1 How Do Robots Affect Firms' Innovation Performance? Evidence from Spanish Manufacturers

Yiyao Zhou, Bilal Gokpinar, UCL School of Management, London, United Kingdom. Contact: uceihog@ucl.ac.uk

This paper examines the impact brought by robot use on manufacturing firms' innovation performance. The analysis uses a rich panel dataset of Spanish manufacturing firms over 27 years (1990-2016). Our findings suggest that robot use has a negative effect on firms' process innovation. However, we do not observe a similar effect on firms' product innovation. We also explore mechanisms by which robots use may affect process innovation. Our analysis finds no evidence supporting the hypothesis that robot use can impede firms' innovation performance through changing employee composition. However, we find that the negative effect of robot use on process innovation is only salient for complex manufacturing, rather than light manufacturing or heavy manufacturing. In addition, we find that the negative effects brought by robots on process innovation are smaller for older firms.

2 When The Crowd Grows Restless: Managing Interventions on Crowdfunding Platforms

Philipp Benjamin Cornelius[1], Bilal Gokpinar[2], Sergei Savin[3], [1]Rotterdam School of Management, Rotterdam, Netherlands; [2]UCL School of Management, London, United Kingdom; [3]Wharton School, Philadelphia, PA, Contact: cornelius@rsm.nl

Crowdfunding has become a cornerstone of entrepreneurial finance, but it also exposes companies to significant reputational risk from crowds that quickly turn hostile if they feel ignored or if the campaign does not progress as expected. Companies have several options to intervene in such cases, however certain interventions can aggravate the situation while others are costly. We empirically study the efficacy of different intervention strategies.

3 Adaptive Investment in New Product Development Project with Learning Product Quality

zhili Tian, CCU, Conway, SC, Contact: zhili.a.tian@gmail.com

Clinical trials represent the largest cost in drug development. The research requires modeling the physical process of enrolling patients and belief about the efficacy of a new drug and a placebo, and the modeling of the decision process. We develop dynamic program considering learning of drug efficacy. We develop an optimal policy for determining when to cancel, continue, or stop and go to market, for new drugs. Our model considers uncertainty in the performance of a new drug and a placebo, and characterizes the enrollment process. Our model captures the benefits of making decisions early to extend the time to market a drug under patent.

Tuesday, 2 PM–3:15 PM

TD80

JWM - Room 202

DEI

Contributed Session

Session Chair

Alison Murphy, University of Minnesota-Twin Cities, Minneapolis, MN

1 Reducing Racial Disparities in Newborn Screening for Cystic Fibrosis

Seyedehsaloumeh Sadeghzadeh, Binghamton University, Vestal, NY, Contact: ssadeghz@binghamton.edu

Cystic fibrosis is a life-threatening genetic disease that is currently included in the newborn screening panel of all fifty states. Although all states begin the screening process with a blood test, the screening methods and classification policies may significantly differ among the states. Current screening policies for cystic fibrosis mainly consider Caucasian populations, and there is no national guideline that offers equitable screening for all racial groups. It is crucial to design a screening policy that is both accurate and equitable for all races.

2 Evaluating Medicare Dental Coverage Expansion Alternatives

Justin Rist, The Pennsylvania State University, State College, PA, Contact: jsr5605@psu.edu

The Federal government is considering expanding dental coverage to Medicare beneficiaries; however, this expansion could increase demand for public-insurance dental appointments with a minimal increase in supply. Although the objective of Medicare dental coverage expansion is to increase access to care, these policy changes could negatively impact Medicaid enrollees (in states with Medicaid dental coverage) in access to dental appointments. We evaluate multiple Medicare dental coverage expansion plans and their impact on both Medicare and Medicaid beneficiary access to care.

3 Workload and Racial Bias in Healthcare

Alison Murphy, Rachna Shah, University of Minnesota, Minneapolis, MN, Contact: murp1888@umn.edu

Several studies have demonstrated the impact of workload and occupancy on clinician decision making and the impacts on operational outcomes and patient health in healthcare contexts. This study investigates the moderating role of patient race on the relationship between workload and health outcomes. Drawing on implicit bias research in psychology and medical fields, we hypothesize that under higher workload, clinicians are more susceptible to biased decision making, which would contribute to worse health outcomes for disadvantaged groups. We empirically examine this in the context of maternal health using a longitudinal data set and plan a confirmatory laboratory experiment to demonstrate the mechanism.

Tuesday, 2 PM–3:15 PM

TD81

JWM - Room 203

Business Applications

Contributed Session

Session Chair

Hee Youn Kwon, Northwestern University, Evanston, IL

1 **Resolve The Missing Data Problem of Recommendation System with Mixture Models**

Yuting Ye, SUSTech, China, China.

The issue of missing data has been a significant obstacle to recommendation systems (recsys). There are primarily two sources of missingness that have not received adequate attention: Customers' interests or preferences, and the influence of recommenders on customers (i.e., interventions of recsys determine what can be exposed to the customers). In the literature, the first form of missingness is under-represented by activities like clicks, views, and purchases, whereas the second is hardly discussed. To address the missing issue, we propose a mixture model to characterize various counterfactuals, and naturally, characterize the two aforementioned missing mechanisms as hidden variables. On two real datasets, our approach outperforms rival methods and gives light on the understanding of recommendation systems from a causal perspective.

2 **The Role of Engineering Changes on Plant, Quality and Market Performance**

Bilal Gokpinar[1], Sriram Narayanan[2], Bhavjot Singh[3], Mesut Tastan[4], [1]UCL School of Management, London, United Kingdom; [2]Michigan State University, East Lansing, MI, [3]Michigan State University, East Lansing, MI, [4]London School of Economics, London, United Kingdom. Contact: singhbh4@msu.edu

We study the effects of engineering changes in complex product development on plant productivity, product quality, and sales performance. We use proprietary data from the automotive industry merged with other secondary datasets to investigate our research questions. We also discuss potential mechanisms for the findings.

3 **Occupational Mobility and Wages from a Perspective of Worker Skills**

Hee Youn Kwon, Northwestern University, Evanston, IL, Contact: heeyoun.kwon@u.northwestern.edu

Mobility between occupations is in part determined by workers' skill sets. This paper observes a relationship between a worker's wage and sum of "skill potential" among occupations as well as worker mobility. Workers need to acquire large skill potential from it to other jobs when there is a large amount of non-negative differences in skill levels that are needed to switch jobs. This value takes into account of directional difficulty of moving from one job to another. This asymmetric measure and other measures which are symmetric in that they consider distance between occupations are discussed along with variances related to them.

4 **Trust-and-evaluate: A Dynamic Non-monetary Mechanism for Internal Capital Allocation**

Shivam Gupta[1], Saurabh Bansal[2], Milind Dawande[3], Ganesh Janakiraman[4], [1]University of Nebraska Lincoln, Lincoln, NE, [2]Penn State University, State College, PA, [3]The University of Texas at Dallas, Richardson, TX, [4]University of Texas-Dallas, Richardson, TX, Contact: sgupta7@unl.edu

To stay competitive, firms regularly invest in innovation by supporting internal capital projects (funded and executed in-house) that explore new products and operational improvements. Each year managers from different functional units submit proposals for such projects. Managers, due to their domain knowledge and expertise, are naturally better informed about the costs and benefits of their projects, and can use this information strategically to secure funding. An example of such behavior is the under-reporting of the cost estimate of a project and subsequently requesting additional funding during the execution phase. Such strategic behavior not only affects the firm's ability to fund the best projects but is also costly. We propose a dynamic non-monetary mechanism that is both provably near-optimal and guarantees truthful reporting from managers.

Tuesday, 2 PM–3:15 PM

TD82

JWM - Room 204

Supply Chain Networks of Critical Items

General Session

Session Chair

Deniz Besik, 1</sup

1 Food Distribution PODs Planning for Post-disaster Response

Diana Ramirez-Rios[1], Johanna Amaya Leal[2], Trilce Encarnacion[3], Jose Holguin-Veras[4], [1]University at Buffalo, Buffalo, NY, [2]Penn State University, State College, PA, [3]University of Missouri- St. Louis, Saint Louis, MO, [4]Rensselaer Polytechnic Institute, Troy, NY, Contact: dgramire@buffalo.edu

This research studies the location of Points of Distribution (PODs) in a region to serve the population impacted by disasters, especially in the case of food distribution. We propose a model that minimizes the social costs of human suffering in the form of deprivation costs for post-disaster response. We present the results from a Food Bank.

2 A Two-Stage Stochastic Programming Model to Plan for The Central Texas Food Bank Inventory and Delivery After Covid-19

Adaora Anagbogu, Cross Mitchell, Leo Montoya, Clara Novoa, Texas State University, San Marcos, TX, Contact: cn17@txstate.edu

During the last couple of years, the Central Texas Food Bank (CTFB) has experienced a decline in inventory to effectively meet the monthly demands of its partner agencies and ultimately those from the community. We present a two-stage stochastic model that identifies the product categories and amounts of food necessary to supplement inventory losses from canceled donations while considering the current CTFB budget and warehouse space constraints. Deterministic and two-stage stochastic models are compared over a one-year horizon. The model results are used to develop a cost-efficient plan for the daily routes of the fleet of trucks that also aligns with the region's predicted growth.

3 An Integrated Multitiered Supply Chain Network Model of Competing Agricultural Firms and Processing Firms: Case of Fresh Produce and Quality

Deniz Besik[1], Anna B. Nagurney[2], Pritha Dutta[3], [1]University of Richmond, Richmond, VA, [2]University of Massachusetts-Amherst, Amherst, MA, [3]Pace University, New York, NY, Contact: pdutta@pace.edu

We develop an integrated multitiered competitive agricultural supply chain network model in which agricultural firms and processing firms compete to sell their differentiated products. The focus here is on fresh produce and minimally processed agricultural products, with quality, also captured. The competition among agricultural firms and processing firms is studied through game theory, where the governing Cournot-Nash equilibrium conditions correspond to a variational inequality problem. A numerical study consisting of several supply chain disruption scenarios demonstrates the applicability of our modeling framework.

4 A Multicountry, Multicommodity Stochastic Game Theory Network Model of Competition for Medical Supplies Inspired by The COVID-19 Pandemic

Mojtaba Salarpour[1], Anna B. Nagurney[2], [1]Texas A&M University-Commerce, Amherst, TX, [2]University of Massachusetts-Amherst, Amherst, MA

In this paper, we construct the first stochastic Generalized Nash Equilibrium model for the study of competition among countries for limited supplies of medical items in the disaster preparedness and response phases in the COVID-19 pandemic. The government of each country is faced with a two-stage stochastic optimization problem. We provide the theoretical constructs, a qualitative analysis, and an algorithm, accompanied by convergence results. Both illustrative examples are presented as well as algorithmically solved numerical examples, inspired by the need for N95 masks and ventilators. The results reveal that, in addition to the preparedness of countries before the pandemic declaration, their ability to adapt to the conditions in different scenarios has a significant impact on their overall success in the management of the pandemic crisis.

Tuesday, 2 PM–3:15 PM

TD83

JWM - Room 205

Multi Criteria Decision Making and New Product Development Flash Session

Flash Session

Session Chair

Linqiu Li, Singapore Management University, Singapore, Singapore.

1 Big Data Enabled Supply Chains: Contributions from AHP/ANp and Extensions

Birsen Karpak[1], Y.Ilker Topcu[2], Füsun Ülengin[3], [1]Youngstown State University, Youngstown, OH, [2]Istanbul Technical University, Istanbul, Turkey; [3]Sabancı University, Istanbul, Turkey. Contact: bkarpak@ysu.edu

We assert that Big Data Business Analytics (BDBA) and Supply Chain Analytics (SCA) are the strategic assets of an enterprise. We review Analytic Hierarchy Process (AHP) /

Analytic Network Process (ANP) and extensions applied in big data enabled supply chain management (SCM). Big data enabled digital supply chains (DSC), big data adoption risks involved in sustainable supply chains are among the new research directions we are considering.

2 A New Approximation for Multi-Server Queues with Non-Poisson Arrivals

Carlos Chaves[1], Abhijit Gosavi[2], [1]Boeing Inc, Seattle, WA, [2]Missouri University of Science & Technology, Rolla, MO, Contact: gosavia@mst.edu

We present a simple approximation for multi-server queues under medium traffic with multiple identical servers in parallel under the first-come-first-served discipline. Our model breaks away from the literature that relies heavily on the *M/M/k* queue formula. We present numerical results, including a ventilator case study from the COVID-19 pandemic.

3 Project Selection in Strategic Alliance

Wenqi Lian, Lingnan University, Hong Kong SAR, Hong Kong.

Firms joining in strategic R&D alliances are desirous of bringing new projects to market and creating value by combining their complementary capabilities. The timing of the alliance formation matters: upfront contracting may achieve higher value creation if the partner commits to larger milestones. We show that profit-maximizing firms may not always choose to sign a flexible upfront contract; the partner firm captures more value under delayed contracting for high innovator bargaining power, whereas the innovator may prefer a fixed upfront contract over a flexible upfront contract for low self bargaining power.

4 Renegotiation in Collaborative Product Development

Sara Rezaee Vessal[1], Timofey Shalpegin[2], [1]ESSEC Business School, Cergy-Pontoise, France; [2]University of Auckland, Warkworth, New Zealand. Contact: rezaee@essec.edu

We model a collaborative development process in which a buyer and a suppler are collaborating in a product design project. Due to the uncertainty, some aspect of the project might not be cleared at the time of contract. After delivering the product, the buyer can accept an underperforming product after the first stage. This leads to renegotiation in the second stage of the product development. In this paper, we explore the effect of the bargaining power on the development efforts by the buyer and the supplier.

5 To Impose, to Incentivize, or to Subsume: How Solution and Solver Uncertainties Influence Problem Formulation Decisions in Crowdsourcing

Ademir-Paolo Vrolijk[1], Zoe Szajnfarber[2], [1]University of Toronto, Toronto, ON, Canada; [2]The George Washington University, Washington, DC

Despite the growing popularity of crowdsourcing, we do not understand how the solution-seeker translates their need into a problem statement, thus formulating their problem for outsider input. This work describes the formulation process of several complex innovation contests. Using detailed case narratives, we inductively captured three problem formulation actions to craft the problem statement: *impose*, *incentivize*, or *subsume*—each producing progressively less restrictive rules. These actions depended on the seeker's knowledge of the solution space and the solvers' technical capabilities. More knowledge of potential solutions produced more restrictive rules and lower performance constraints on solvers. These preliminary findings unpack the problem formulation process and provide practitioners with tools to formulate their future contest problems.

6 Sensing and Responding to Personalized Support Needs in Mental Healthcare Delivery Via Smartphone Mobile Applications

Adam Moen, Avalo, Minneapolis, MN, Contact: adam@reptech.io

In this study, we develop a machine learning algorithm that captures the risk level of mental health mobile application users by mining text-based user generated contents and provides them with real-time recommendations to care options which take into consideration of their socio-demographic backgrounds, core topic of concern, and other factors.

7 When Does Data Sharing Promote Innovation?

Zhi Chen, Jussi Keppo, National University of Singapore, Singapore, Singapore. Contact: keppo@nus.edu.sg

Many innovations today are data-driven such as self-driving cars. To improve the algorithms of these products, firms make substantial investments in data collection. However, the data is limited for an individual firm. This paper studies whether data collected by individual firms should be shared in order to promote innovation.

8 Role of Valuation Uncertainty and Operational Cost Structure on Product Line Design

Iva Rashkova[1], Lingxiu Dong[2], [1]Washington University-St Louis, St Louis, MO, [2]Washington University in St. Louis, Saint Louis, MO, Contact: dong@wustl.edu

We present a model of a monopolist developing and producing products with two key quality dimensions to serve a two-segment market where only one segment values the design feature of a product and their valuation is uncertain. We use a two-dimensional differentiation-contingency framework to depict the rich set of the firm's possible optimal strategy to segment the market. We explore how the market and the firm's operational environments affect the firm's choice of the optimal product strategy. Specifically, we consider the interplay between development and production costs to extend previous product line design results to the environment of uncertain market valuation.

9 **Asymmetric Information of Product Authenticity on C2C E-commerce Platforms: How Can Inspection Services Help?**

Linqiu Li, Xin Fang, Yun Fong Lim, Singapore Management University, Singapore, Singapore. Contact: linqiuli@smu.edu.sg

We consider a C2C platform that provides an inspection service. Uncertain about his product's authenticity, a seller sells his product through the platform. The platform's inspection service can detect a counterfeit with a probability. We develop a two-stage game-theoretical model. In the first stage, the platform designs a contract specifying the commission and penalty fees. In the second stage, the seller signals his product authenticity by setting a price. We find that the effect of inspection is beyond merely detecting counterfeits. The inspection, even an imperfect one, changes the signaling game's structure and incentivizes the seller who likely has an authentic product to sell.

Tuesday, 2 PM–3:15 PM

TD84

JWM - Room 206

Topics on Simulation, Optimization, and Analytics

General Session

Session Chair

Zeyu Zheng, University of California, Berkeley, Berkeley, CA

1 **Using Cache or Credit for Parallel Ranking and Selection**

Harun Avci[1], Barry L. Nelson[1], Eunhye Song[2], Andreas Waechter[1], [1]Northwestern University, Evanston, IL, [2]Penn State University, University Park, PA, Contact: harunavci2024@u.northwestern.edu

For ranking & selection problems with normally distributed output we introduce the gradient-based complete expected improvement (gCEI) replication-allocation procedure that converges to the probability-of-incorrect-selection rate-optimal allocation of Glynn and Juneja in the limit, but is aggressive in finite samples. For implementation in a parallel computing environment we develop two new gCEI-based procedures---greedy and caching---that also converge to the rate-optimal allocation while obtaining more than one replication in parallel either synchronously or asynchronously. Empirical performance comparisons are presented.

2 **Validating Stochastic Simulation Models Via Maximum Mean Discrepancy**

Haofeng Zhang, Ziyi Huang, Henry Lam, Columbia University, New York, NY, Contact: hz2553@columbia.edu

Simulation models aim to generate outputs from complex, analytically intractable stochastic systems for prediction and decision-making. The reliability of simulation models depends crucially on how well these models mimic reality, which points to model validation and calibration. A beginning tool required in the latter task is a measure on the difference between the simulation model and real data. We propose the use of maximum mean discrepancy, including a generalization that applies to conditional models, and study its statistical and computational properties pertinent to model validation. We demonstrate how it resolves some challenges faced by two-sample statistics used in the classical model validation literature, as well as more contemporary alternatives including GAN or the f-divergences, Wasserstein distance and their generalizations.

3 **Selection of The Most Probable Best**

Taeho Kim[1], Kyoung-Kuk Kim[2], Eunhye Song[3], [1]Pennsylvania State University, State College, PA, [2]Korea Advanced Institute of Science & Technology, Seoul, Korea, Republic of; [3]Georgia Institute of Technology, Atlanta, GA

This talk considers an expected-value ranking and selection (R&S) problem where all solutions' simulation outputs depend on a common uncertain parameter. Given that the uncertainty of the parameter is captured by a probability simplex on the finite support, we define the most probable best (MPB) to be the solution whose probability of being optimal is the largest. We propose an efficient sequential sampling algorithm to find the MPB by formulating and solving an optimal computing budget allocation (OCBA) problem. We devise a series of interpretable and computationally efficient sampling rules and prove their sampling ratios achieve the optimality conditions for the OCBA problem asymptotically. Application to a supply chain example will be demonstrated.

4 **Gradient-free Methods for Stochastic Nonsmooth Nonconvex Optimization**

Tianyi Lin[1], Zeyu Zheng[2], Michael Jordan[2], [1]University of California, Berkeley, Albany, CA, [2]University of California, Berkeley, Berkeley, CA, Contact: darren_lin@berkeley.edu

Nonsmooth nonconvex optimization problems broadly emerge in machine learning and business decision making, whereas two challenges impede the development of efficient solution methods with finite-time convergence guarantee: the lack of computationally tractable optimality criterion and the lack of computationally powerful oracles. First, we establish the relationship between the celebrated Goldstein subdifferential and uniform smoothing, thereby providing the basis and intuition for the design of gradient-free methods that guarantee the finite-time convergence to a set of Goldstein stationary points. Second, we propose the gradient-free method (GFM) and stochastic GFM for solving a class of stochastic nonsmooth nonconvex optimization problems. We prove theoretical guarantees for the proposed methods.

Tuesday, 2 PM–3:15 PM

TD86

JWM - Room 208

AAS Distinguished Speaker - American Airlines

Award Session

Session Chair

Jacquillat Alexandre, MIT Sloan School of Management, Cambridge, MA

1 **An Analytics-based Framework for Responding and Adapting to Changing Conditions Driven by Covid-19**

Timothy Niznik, American Airlines, Flower Mound, TX, Contact: tim.niznik@aa.com

COVID-19 affected the entire airline industry, but one area that was especially impacted was operations. Most of my career at American Airlines has involved building decision support solutions to manage weather disruptions, but COVID-19 caused arguably the biggest disruption in airline history, and it largely occurred under blue-sky conditions. This talk will describe not just how American Airlines responded to COVID-19 from an operational perspective, but also how it continues to respond to the post-COVID recovery given changing customer demand patterns, loss of airline and ATC operational experience, staffing challenges, supply-chain disruptions, and the continued presence of severe weather. These realities have motivated American Airlines to use and rely on data and data-driven analytics in new and innovative ways. That is the data story I would like to tell.

Tuesday, 3:30 PM–4:30 PM

TK01

CC - Sagamore 1

Keynote: Sports Analytics

Keynote Session

Session Chair

Enver Yucesan, INSEAD, Singapore, NA, Singapore.

1 **Sports Analytics**

Brian Macdonald, Florida Panthers, Sunrise, FL

Data has been meticulously collected in sports for decades. As technology has improved, so has the data, allowing for more appropriate statistical modeling and machine learning techniques to be used to answer interesting questions. Today, many leagues use computer vision, remote sensing, and machine learning techniques to collect player and ball location data multiple times per second throughout the duration of every game, and to automatically detect events of interest during a game, both of which allow for numerous new types of analyses. We will give a brief history of analytics in sports, the questions that teams, leagues, media organizations and fans try to answer using data, the current state of analytics in the sports industry, and how sports analytics is being used in education to inspire student interest in data science.

Tuesday, 3:30 PM–4:30 PM

TK02

CC - Sagamore 2

Keynote: Parallel Computing in Operations Research

Keynote Session

Session Chair

Yuan Zhou, University of Texas at Arlington, Arlington, TX

1 **Parallel Computing in Operations Research**

Jonathan Eckstein, Rutgers University, Piscataway, NJ

Parallel computing is currently a widespread tool in science and engineering. It is now common for large universities, large corporations, and government labs to use HPC (high-performance computing) systems with tens of thousands of processor cores for applications such as protein folding prediction, other kinds molecular simulations, fluid flow simulation, performance analysis of physical structures, fossil fuel reservoir analysis, weather prediction, and neural network training. By comparison, operations research as a whole makes minimal use of large-scale parallel computing technology. I will discuss why this is the case, and the potential for making better use of the technology in our field. I will describe the basics of parallel computing, and how the available hardware and software has evolved since the 1980s. Arguably, parallel programming tools have not matched the pace of hardware evolution and do not provide an ideal level of abstraction for software development. This situation has lead to uneven use of technology between various fields, depending on the availability of monolithic task-specific software applications and libraries. In operations research, a key obstacle is the challenge of adapting commonly used algorithms for continuous and mixed-integer optimization to the presently available parallel hardware and coding environments.
However, the potential for using parallel computing in operations research remains, and the benefits could be substantial. In particular, I will examine how numerical optimization solvers might more effectively take advantage of parallel computing, considering both altered approaches to continuous optimization and better parallel implementation of search methods for discrete and nonconvex optimization. Promising applications include difficult mixed-integer programming problems, control of large-scale power grids under uncertainty in both supply and demand, and mixed continuous-discrete data fitting problems.

Tuesday, 3:30 PM–4:30 PM

TK06

CC - Sagamore 6
Keynote: Modeling for COVID-19 College Reopening Decisions: Cornell, A Case Study
Keynote Session

Session Chair
Chun-Hung Chen, George Mason University, Centreville, VA

1 **Modeling for COVID-19 College Reopening Decisions: Cornell, a Case Study**
Peter Frazier[1], Shane Henderson[2], David Shmoys[3], [1]Cornell / Uber, Ithaca, NY, [2]Cornell University, Ithaca, NY, [3]Cornell University, Ithaca, NY
Like all universities, in the summer of 2020 Cornell faced the question of whether to go online-only in the fall or to bring students back for a residential semester. Like many universities, Cornell decided on a residential semester.
Like few universities who invited all students back, Cornell managed to keep COVID-19 at bay for the entire semester. Our modeling team played a major role in the decision to reopen, perhaps paradoxically showing that with appropriate interventions a residential semester was safer than an online-only one. Our team also helped design the major interventions deployed, including asymptomatic surveillance through pooled testing on-site, adaptive testing and a complete rebuild of the class schedule. The arrival of the Alpha variant in the spring of '21 and the Delta variant in fall of 2021 caused us to repeatedly strengthen our interventions, again only after modeling showed the potential benefits. The explosive arrival on campus of Omicron late in the fall 2021 semester led to a major change of strategy, again guided by the work of the modeling team. All of this work required great care in capturing uncertainty in key input parameters such as asymptomatic infection rates and, more recently, vaccine effectiveness. We'll share a perspective on this wild ride, emphasizing our modeling approaches, our close collaboration with Cornell leadership and some funny (in retrospect) stories.

Tuesday, 3:30 PM–4:30 PM

TK07

CC - Sagamore 7
Keynote: 2022 Daniel H. Wagner Prize Winner Reprise
Keynote Session

1 **2022 Daniel H. Wagner Prize Winner Reprise**
Margret V. Bjarnadottir, University of Maryland, College Park, MD
The Daniel H. Wagner Prize is awarded for a paper and presentation that describe a real-world, successful application of operations research or advanced analytics. The prize criteria emphasizes innovative, elegant mathematical modeling and clear exposition.

Tuesday, 5 PM–6:15 PM

TE01

CC - Room 101

Recent Advances in Modern Statistical Learning

General Session

Session Chair

Will Wei Sun, Purdue University

1 **Statistical Inference with Sparse Deep Learning**

Faming Liang, Purdue University, West Lafayette, IN

Deep learning has powered recent successes of artificial intelligence (AI). However, how to perform statistical inference with deep neural networks remains still an unresolved issue. We address this issue via spars deep learning. In particular, we lay down a theoretical foundation for sparse deep learning and propose some efficient algorithms for learning sparse neural networks. The former has successfully tamed the sparse deep neural network into the framework of statistical modeling, enabling relevant variables consistently identified and prediction uncertainty correctly quantified. The latter can be asymptotically guaranteed to converge to the global optimum, enabling the validity of the down-stream statistical inference. Numerical result indicates validity of the proposed methods. The presentation is based on joint works with Y. Sun, W. Xiong and Q. Song.

2 **High-dimensional Knockoffs Inference for Time Series Data**

Chien-Ming Chi[1], Yingying Fan[2], Ching-Kang Ing[1], Jinchi Lv[2], [1]National Tsing Hua University, Hsinchu, Taiwan; [2]University of Southern California, Los Angeles, CA

In this paper, we make some initial attempt to establish the theoretical and methodological foundation for the model-X knockoffs inference for time series data prevalent in applications. We suggest the method of time series knockoffs inference (TSKI) by exploiting the idea of subsampling to alleviate the difficulty caused by the serial dependence. We establish sufficient conditions under which the original model-X knockoffs inference combined with subsampling still achieves the asymptotic false discovery rate (FDR) control. To alleviate the practical concern on the power loss because of reduced sample size cause by subsampling, we exploit the idea of knockoffs with copies and multiple knockoffs. We further suggest the new backward elimination ranking (BE) knockoff statistic for improved power. This is a joint work with Chien-Ming Chi, Yingying Fan and Ching-Kang Ing.

3 **Statistical-computational Tradeoffs in Estimation of Orthogonally Decomposable Tensors**

Arnab Auddy, Columbia Univerisity

With the advent of more and more complex data generating mechanisms, it becomes necessary to model higher order interactions among the observed variables. Orthogonally decomposable tensors provide a unified framework for many such problems. While this is a natural extension of matrix SVD to tensors, they automatically provide much better identifiability properties. Moreover, a small perturbation affects each singular vector in isolation, and hence their recovery does not depend on the gap between consecutive singular values. In addition to the attractive statistical properties, these methods present us with intriguing computational considerations. To this end, we will discuss some statistical vs computational tradeoffs and describe methods of principal component estimation that have near optimal rates.

4 **Efficient Learning of Optimal Individualized Treatment Rules**

Weibin Mo, 1</sup

Recent development in data-driven decision science has seen great advances in individualized decision making. Existing methods typically require initial estimation of some nuisance models. To protect consistency from nuisance model misspecification, the double robustness property has been widely advocated, while the concern on estimation efficiency is rarely studied. To improve efficiency of the estimated ITR, we propose an Efficient Learning (E-Learning) framework for finding an optimal ITR in the multi-armed treatment setting. We show that the proposed E-Learning is optimal among a regular class of semiparametric estimates that can allow treatment-free effect misspecification and heteroscedasticity.

Tuesday, 5 PM–6:15 PM

TE02

CC - Room 102

Efficient Algorithms for Non-convex Low-rank Matrix Optimization Problems

General Session

Session Chair

Haixiang Zhang, Fremont, CA

Session Chair

Javad Lavaei, University of California, Berkeley, Berkeley, CA

1 Undesirable Properties of Burer-Monteiro Factorization and Unified Complexity Metric for Matrix Sensing Problems

Baturalp Yalcin, University of California, Berkeley, Berkeley, CA, Contact: baturalp_yalcin@berkeley.edu

Burer-Monteiro (B-M) factorization approach can efficiently solve low-rank matrix optimization problems under the Restricted Isometry Property (RIP) and incoherence conditions. A new complexity metric for an important class of low-rank matrix optimization problems is presented. This metric unifies the RIP and incoherence conditions. It aims to quantify the complexity of the nonconvex optimization landscape of each problem and the success of local search methods in solving the problem. A generalized rank-1 matrix completion problem is studied to present the properties of this complexity metric. It is shown that instances satisfying RIP condition or with small incoherence have small complexity metrics. In addition, necessary and sufficient conditions for the existence of spurious solutions are presented in terms of this proposed complexity metric.

2 Landscape of Noisy Low-rank Matrix Optimization

Ziye Ma, UC Berkeley, Berkeley, CA, Contact: ziyema@berkeley.edu

Low-rank matrix optimization in the special case of matrix sensing has been studied extensively through the notion of Restricted Isometry Property (RIP). In this talk, we will talk about some new results concerning this problem in a noisy setting. We prove that as long as the RIP constant of the noisy quadratic objective is less than $1/2$, and the RIP constant of the noisy general objective is less than $1/3$, any spurious local solution of the respective problem must be close to the ground truth solution. By working through the strict saddle property, we also show that an approximate solution can be found in polynomial time for both kind of objectives. We characterize the geometry of the spurious local minima of the problems in a local region around the ground truth in the case when the RIP constant is greater than $1/3$ or $1/2$ as well.

3 Certifying The Absence of Spurious Local Minima at Infinity

Cedric Josz[1], Xiaopeng Li[2], [1]Columbia University, Le Kremlin-Bicetre, France; [2]Columbia University, New York City, NY, Contact: xl3040@columbia.edu

When searching for global optima of non-convex unconstrained optimization problems, it is desirable that every local minimum be a global minimum. This property of having no spurious local minima is true in various problems of interest nowadays, including principal component analysis, matrix sensing, and linear neural networks. However, since these problems are non-coercive in general, they may yet have spurious local minima at infinity. The classical tools used to analyze the optimization landscape, namely the gradient and the Hessian, are incapable of detecting spurious local minima at infinity. In this talk, we identify conditions that certify the absence of spurious local at infinity and check that they hold in several applications of interest, in particular in low-rank matrix factorization.

4 Optimal Iteratively Reweighted Least Squares Algorithms for Low-rank Optimization

Christian Kümmerle[1,2], [1]University of North Carolina at Charlotte, Charlotte, NC, [2]Johns Hopkins University, Baltimore, MD, Contact: kuemmerle@uncc.edu

While it is well-understood that non-convex surrogates of the rank such as Schatten-p quasinorms are powerful tools in low-rank optimization, their optimization remains challenging. Improving on previous methods based on the idea of iteratively reweighted least squares (IRLS), we present a scalable IRLS algorithm minimizing such surrogates, and prove the optimality of its weight operator choice in the sense that its associated quadratic model would not retain a majorization property if chosen smaller, which is essential to ensure monotonicity of IRLS. We also present how optimal IRLS methods utilize second-order information, and illustrate the data efficiency of the methods in applications such as matrix completion and phase retrieval.

Tuesday, 5 PM–6:15 PM

TE04

CC - Room 104

The Use of Machine Learning in Facilitating Decision Making

General Session

Session Chair

Kwan-Yuet Ho, Leidos, Silver Spring, MD

1 A Mix-reality-based Interactive Training System Augmented with Artificial Intelligence

Kamelia Sepanloo[1], Yijie Chen[2], Young-Jun Son[1], [1]Purdue University, West Lafayette, IN, [2]University of Arizona,

Tucson, AZ, Contact: ksepanlo@purdue.edu

The mixed-reality (MR) technique provides a unique combination of real and virtual worlds, and has been widely practiced in the clinical and industrial applications. While most prior research focused on improving the visualization performance and system validation, our research aims to integrate artificial intelligence with the MR to develop a self-adaptive dynamic training system. Our training system evaluates users' learning efficiency, and provides both training guidance and post-training suggestions in a hierarchical manner. To this end, our system collects real-time data streams and conducts hierarchical analysis: 1) physical proficiency analysis, 2) visual attention and cognitive load, and 3) subjective report based analysis along with a decision-making framework.

2 Propaganda Analysis with Machine Learning: An Example of Human-machine Integration

Weifeng Zhong, Mercatus Center at George Mason University, Arlington, VA, Contact: weifeng.zhong@policychangeindex.org

Intelligence communities in the West have a long tradition of propaganda analysis, the study of competitors' and adversaries' propaganda for the purpose of making inferences. Meanwhile, recent advances in natural language processing have created impressive potentials for automating analyses of language data. How can these new technologies be applied to propaganda analysis to produce better intelligence? This presentation uses the Policy Change Index (PCI) as an example to illustrate how subject-matter expertise and machine algorithms can work together effectively in analyzing propaganda. The PCI has demonstrated the success of this approach in predicting major policy moves by the Chinese government, predicting the likelihood of a Chinese crackdown on pro-democracy protests in Hong Kong, and estimating the severity of the COVID-19 pandemic in China.

3 Presenter

Kwan-Yuet Ho, Leidos, Silver Spring, MD

In governments and institutions, there are a lot of decision making, with many administrative processes that involve handling text documents. It is natural to incorporate the natural language processing (NLP) techniques to facilitate such a process. In this talk, I will go through some examples. I will talk about the use case, the algorithms, and how to include human experts in the loop for the perfection of the processes.

Tuesday, 5 PM–6:15 PM

TE05

CC - Room 105

Data-driven Learning Models and Methods

General Session

Session Chair

N. Bora Keskin, Duke University, Durham, NC

Session Chair

Yuexing Li, Duke University, Durham, NC

1 Taylor Approximation of Inventory Policies for Distribution Systems with Demand Features

Jingkai Huang[1], Kevin Shang[2], Yi Yang[3], [1]Zhejiang University, Hangzhou, China; [2]Duke University, Durham, NC, [3]Zhejiang University, Zhejiang, China. Contact: khshang@duke.edu

We consider a distribution system in which retailers replenish perishable goods from a warehouse, which, in turn, replenishes from an outside ample supplier. Demand at each retailer depends on exogenous features and unfilled demand is lost. The objective is to minimize the average inventory cost per time period. We construct a data-driven inventory policy in two steps. The first step is to use Taylor expansion to obtain a simple heuristic, referred to as Taylor Approximation (TA), by assuming the demand distributions are known. The second step is to apply empirical risk minimization on the TA solution to obtain the data-driven (DDTA) policy. We show asymptotic and consistent properties on the TA and DDTA policies, and verify the effectiveness of the policies in numerical studies.

2 The Fragility of Optimized Bandit Algorithms

Lin Fan[1], Peter W. Glynn[2], [1]Stanford University, Stanford, CA, [2]Stanford University, Stanford, CA, Contact: linfan@stanford.edu

Much of the literature on optimal design of bandit algorithms is based on minimization of expected regret. It is well known that designs that are optimal over certain exponential families can achieve expected regret that grows logarithmically in the number of arm plays, at a rate governed by the Lai-Robbins lower bound. In this talk, we show that such optimized designs necessarily have the undesirable feature that the tail of the regret distribution behaves like that of a truncated Cauchy distribution. Furthermore, for $p>1$, the p'th moment of the regret distribution grows much faster than poly-logarithmically, in particular as a power of the number of sub-optimal arm plays. We show that optimized designs are also fragile, in the sense that when the problem is even slightly mis-specified, the regret can grow much faster than the conventional theory suggests.

3 Sample Complexity of Policy Learning for Inventory Control with Censored Demand

Xiaoyu Fan[1], Boxiao (Beryl) Chen[2], Zhengyuan Zhou[1], [1]Stern School of Business, New York University, New York, NY, [2]University of Illinois-Chicago, Chicago, IL, Contact: fx2087@stern.nyu.edu

We consider both single period and infinite horizon inventory models with unknown demand distribution and propose sampling-based approximation policies using censored demand data. We develop optimal upper bounds for the number of samples required to guarantee that the performance of our proposed policy is close to that of the true optimal policy at any given accuracy level.

4 UCB-C: An Efficient UCB Algorithm for Contextual-Bandit Learning with Continuous Actions

Zhi Wang, Rui Gao, University of Texas at Austin, Austin, TX, Contact: zhi.wang@mccombs.utexas.edu

In decision-making with contextual information, upper-confidence-bound (UCB) algorithms are a celebrated class of algorithms. Each iteration of the algorithm involves a subproblem optimizing over the action set and the parameter confidence set. When the action set is in a continuum, this sub-problem is generally computationally intractable. In this paper, we propose a conceptually simple UCB algorithm with efficient implementation and derive its performance guarantees for a variety of problems. In particular, for generalized linear bandits with continuous actions, our algorithm is the first computationally tractable algorithm with nearly optimal regret in terms of its dependence on the parameter dimension; and for feature-based dynamic pricing, our algorithm significantly improves the known regret bound in terms of its dependence on the number of products.

5 Information, Convexity and Measures of Statistical Association

Emanuele Borgonovo[1], Alessio Figalli[2], Elmar Plischke[3], Giuseppe Savare[1], [1]Bocconi University, Milano, Italy; [2]ETH, Zurich, Switzerland; [3]Technical University of Clausthal, Clausthal-Zellerfeld, Germany. Contact: emanuele.borgonovo@unibocconi.it

We study the link between convexity, information value and measures of statistical association. We start with the consideration that several measures of statistical associations can be represented within an information value rationale. We then derive several properties and study the conditions under which information has no value or has has its maximal value. We show also that for information whose quality is intermediate, the value of the measures of association is also intermediate.

Tuesday, 5 PM–6:15 PM

TE07

CC - Room 107

Optimization with Machine Learning: Exact and Approximation Algorithms

General Session

Session Chair

Yongchun Li, Virginia Tech, Blacksburg, VA

Session Chair

Weijun Xie, Virginia Tech, Blacksburg, VA

1 On The Convex Hull of Convex Quadratic Optimization Problems with Indicators with Applications in Statistical Learning

Linchuan Wei[1], Alper Atamturk[2], Andres Gomez[3], Simge Kucukyavuz[1], [1]Northwestern University, Evanston, IL, [2]University of California-Berkeley, Berkeley, CA, [3]University of Southern California, Los Angeles, CA, Contact: linchuanwei2022@u.northwestern.edu

We consider the convex quadratic optimization problem with indicator variables and constraints on the indicators. We show that a convex hull description in an extended space with a quadratic number of additional variables consists of a single positive semidefinite constraint and linear constraints. We also give descriptions in the original space of variables: we provide a description based on an infinite number of conic-quadratic inequalities, which are ``finitely generated.” In particular, it is possible to characterize whether a given inequality is necessary to describe the convex hull. The new theory unifies several previously established results, and paves the way toward utilizing polyhedral methods to analyze the convex hull of mixed-integer nonlinear sets with applications in statistical learning.

2 Explicit Convex Hull Description of Bivariate Quadratic Sets with Indicator Variables

Aida Khajavirad[1], Antonio De Rosa[2], [1]Lehigh University, Bethlehem, PA, [2]University of Maryland at College Park, College Park, MD

We obtain an explicit description for the convex hull of bivariate quadratic sets with indicator variables in the space of original variables.

3 Solving Cut-generating Linear Programs Via Machine Learning

Danial Davarnia, Atefeh Rajabalizadeh, Iowa State University, Ames, IA

Cut-generating linear programs (CGLPs) play a key role as a separation oracle to produce valid inequalities for the feasible region of mixed-integer programs. Running CGLPs at nodes of the branch-and-bound tree, however, is computationally cumbersome due to the large number of node candidates. In this paper, we propose a novel framework based on machine learning to approximate the optimal value of the CGLP. Translating the CGLP as an indicator function of the objective function vector, we show that it can be approximated through conventional data classification techniques. Computational results suggest that the outcome of the approximate CGLP obtained from classification achieves a high accuracy rate in a significantly smaller amount of time compared to modern LP solvers.

4 An Approach to Training Machine Learning Models for Optimization Tasks

Alexander Vinel, Saina Abolmaali, Auburn University, Auburn, AL

In the last decade, the forecasting models successfully improved the accuracy of predictions. However, not as much effort has been dedicated to translating these predictions into decisions. In this research, we are proposing a new data driven decision making algorithm for stochastic optimization given available predictive modeling. The approach is based on an intelligent selection of possible scenarios for classic SAA, based on the historical data, forecast and auxiliary parameters. Some preliminary results will be presented.

Tuesday, 5 PM–6:15 PM

TE08

CC - Room 108

Agricultutral Applications

Contributed Session

Session Chair

Sanchita Das, University of Washington, Seattle, WA

1 A Fuzzy AHP-DAMATEL MCDM Framework for Selecting Strategy for Agricultural Firms' IoT Adoption Based on Service Provider's Readiness Level

Atefeh Shoomal, Mohammad Jahanbakht, Paul Componation, University of Texas at Arlington, Arlington, TX

Although the Internet of Things (IoT) presents new opportunities for agriculture services, increasing efficiency in supply chain, reducing spoilage and increasing speed of operation, its adoption remains slow. This study proposes a Multiple Criteria Decision-Making (MCDM) approach with fuzzy Analytic Hierarchy Process (AHP) - Decision Making Trial and Evaluation Laboratory (DAMATEL) method to assess firm's readiness level in adoption using technological, market, acceptance, organizational, and regulatory factors. Accordingly, we rank four technology acquisition strategies, contracting, licensing, R&D consortia, and joint-venture. We propose an integrated framework of assessment and verify via a survey for an agricultural service provider.

2 Optimizing Land Usage for Crops and Livestock in Cattle Ranch Management

Alfonso Hinojosa[1], Joon-Yeoul Oh[2], [1]Texas A&M University-Kingsville, Kingsville, TX, [2]Texas A&M University-Kingsville, Kingsville, TX, Contact: alfonso.hinojosa@students.tamuk.edu

A well deployed irrigation system can utilize land usage to yield crops and raise livestock, so it will increase profits by minimizing land waste. This research, first of all, identifies the cost and profit factors in a cattle ranch management. Using the identified factors, various LP models are formulated to optimize the land usage, such as optimal number of livestock and amount of dry matter yield. Furthermore, a rotational grazing schedule was used to take advantage of the crop production yield that allowed cows and crops optimal portions of land in various situations. The proposed LP model can be applied for any cattle ranch management to determine a proper land usage for crops and livestock for producing the maximum profits.

3 Designing a Coordination Contract Between Government and Risk Averse Farmers in India

Sanchita Das, Masha Shunko, University of Washington, Seattle, WA, Contact: sanchd20@uw.edu

We study the role of government's production policy in farmers' decision of crop cultivation choices. We build on existing instruments of production policy to model an optimal contract that incentivizes farmers to diversify their cultivation towards nutritious alternatives. We model a two-level sequential game. The government is the leader and has multiple followers who are risk-averse small farmers. The government sets an agriculture production policy to maximize the net social value by specifying three policy instruments (i) Minimum Support Price at which it procures some selected crops from farmers and redistributes it to poor households across the country, (ii) Insurance Coverage for crop damage in case of unforeseen weather, and (iii) Technology Subsidy to improve yield of nutritious crops. Based on the policy, farmers decide the crop type and area to cultivate.

Tuesday, 5 PM–6:15 PM

TE09

CC - Room 109

Analytics by Graphs and Networks

Contributed Session

Session Chair

Sebin Gracy, Rice University, Houston, TX

1 Minimizing The Influence Spread over a Network Through Node Interception

Shunyu Yao, Neng Fan, University of Arizona, Tucson, AZ, Contact: shunyuyao@email.arizona.edu

Minimizing the spread of influence over a network is a significant and challenging problem, which has applications in various fields such as epidemiology, cyber-security, and rumor control. This problem is closely related to the critical node detection problem (CNDP), whose goal is to identify the most critical nodes for maintaining network properties (e.g. connectivity). In this presentation, we combine these two problems to investigate the node interception problem (NIP). Specifically, given a network G=(V,A), a set of seed nodes, and the linear threshold diffusion model, our work is to determine which nodes are most critical in the influence propagation process. We propose several integer linear optimization models and develop a delayed constraint generation algorithm to address this problem.

2 Exploration of Centrality Measures and Network Flows Using Simulation Studies

Chintan Amrit, University of Amsterdam, Amsterdam, Netherlands.

Networks are differentiated by the flow mechanism (i.e. Parallel replication, Serial replication or Transfer) and the flow trajectory (i.e. Geodesic, Paths, Trails or Walks). When metrics are used for an inappropriate flow process, the result of the metric can be misleading and often incorrect. The aim of this research is to therefore determine centrality measures that are applicable to varying network types and flows.
We conduct a simulation study to determine the impact of network properties (like size, power-law/linkage parameter, clustering coefficient) on all the proposed centrality measures. The results of different experiments showed that network cohesion is a key factor to consider. Furthermore, the network cohesion factor also showed that for certain networks the proposed centrality measures are appropriate only under certain network settings.

3 B - D Rates of Simplices for Persistent Homology of Point Cloud Data

Taekgeun Jung[1], Hong Seo Ryoo[2], [1]Korea University, Seoul, Korea, Republic of; [2]Korea University, Seoul, Korea, Republic of. Contact: xorrms78@korea.ac.kr

Persistent homology for topological data analysis studies *n*-holes in the combinatorial representations of the data over the entire range of parameter ⍰ for data triangulation. It is expensive analyzing *n*-holes; over Z_2 coefficients, it requires $O(m^3)$ time where *m* grows exponentially as ⍰ increases. We discovered that every *n*-hole is bounded by a set of *n*-simplices. Exploiting this 'simplex boundedness property', we develops a method for analyzing persistent homology via the B-D (birth-and-death) rates of simplices in triangulated representations of data. Toward this end, we exloit the property that, for each *n*-hole, every *n-1*-simplicial face along its boundary must constitute a facet of an even number of *n*-simplices in the bounding set. Practical utilities of our result are demonstrated with the analysis of well-studies datasets, in comparison with standard tools.

4 Modelling and Analysis of The Spread of Multiple Competitive Viruses

Sebin Gracy[1], Mengbin Ye[2], Cesar A. Uribe[3], [1]Rice University, Houston, TX, [2]Curtin University, Perth, Australia; [3]Rice University, Houston, TX

Motivated by the spread of competing viral strains, competing political ideas, adoption of competing products in a marketplace, etc., we consider the spread of 3-competitive viruses over a directed network of n agents. Each agent can be, at any point in time, either infected with one particular virus or none. We show that, unlike the 2-competitive case, the 3-competitve case is not monotone. We identify sufficient conditions for i) local exponential convergence to a boundary equilibrium, where two viruses are eradicated and one virus persists; and ii) existence of, and local exponential attractivity of, multiple lines of coexisting equilibria, i.e., two out of the three viruses persist, one gets eradicated.

Tuesday, 5 PM–6:15 PM

TE10

CC - Room 110
Retail Management II
Contributed Session

Session Chair
Saman Modiri, Syracuse University, Syracuse, NY

1 **Predictably Unpredictable: How Judgmental Forecasts and Machine Learning Predictions Complement Each Other**
Devadrita Nair[1], Arnd Huchzermeier[2], [1]WHU - Otto Beisheim School of Management, Vallendar, Germany; [2]WHU - Otto Beisheim School of Management, Vallendar, Germany. Contact: devadrita.nair@whu.edu
We present a seasonal demand forecast using machine learning algorithms in combination with expert forecasts and clickstream data. Judgmental forecasts prove to be instrumental as product innovation can be radical, and market information is withheld until the product launch. Hybrid models can further improve the forecasts.

2 **Effects of Minimum Purchase Amount Restrictions in Coupon Promotions**
Yordan Soelter[1], Arnd H. Huchzermeier[2], Christian Schlereth[2], [1]WHU - Otto Beisheim School of Management, Vallendar, Germany; [2]WHU - Otto Beisheim School of Management, Vallendar, Germany. Contact: yordan.soelter@whu.edu
A key question for retailers in running promotions is how to avoid granting discounts without generating (sufficient) incremental revenues. To add to the empirical couponing literature, we run a field experiment with >1.5 million customers in cooperation with a retailer. Based on a randomized allocation of coupons in the field experiment, we estimate the effects of different levels of minimum purchase amount restrictions for redeeming a coupon. Moreover, we explore optimal targeting policies based on prior transaction histories.

3 **Should You Charge a Delivery Fee? The Optimal Bundle of Delivery Time and Delivery Fee for Profit Maximization**
Saman Modiri, Scott A. Fay, Syracuse University, Syracuse, NY, Contact: smodiri@syr.edu
We identify the optimal shipping fees and delivery time of a multi-channel retailer that operates online and physical stores. Specifically, we use a stylized analytical model to study the conditions under which the firm offers free fast shipping (FF), charges for fast shipping (CF), offers free normal shipping (FN) or offers a menu that includes free normal shipping and a charge for fast shipping (FNCF). We find that, if the pain of paying (caused by decoupling retail price and shipping fees) is small, the firm should adopt either FF or FNCF. However, under greater pain of paying, FN can emerge as an optimal strategy. It is counterintuitive that FN can be optimal because, under this strategy, the firm chooses to offer standard shipping, essentially lowering the utility of online shopping, even though we have assumed fast shipping would not have been any more expensive for the firm.

Tuesday, 5 PM–6:15 PM

TE11

CC - Room 111
Machine Learning in Retail Business and Digital Commerce
General Session

Session Chair
Shenghao Wang, Jersey City

1 **Can Your Toothpaste Shopping Predict Mutual Funds Purchasing? Transferring Knowledge from Consumer Goods to Financial Products Via Machine Learning**
Shenghao Wang[1], Tong Wang[1], Cheng He[2], Yu Jeffrey Hu[3], [1]University of Iowa, Iowa City, IA, [2]University of Wisconsin, Madison, Madison, WI, [3]Georgia Institute of Technologuy, Atlanta, GA, Contact: shenghao-wang@uiowa.edu
With the rapid growth of e-commerce, financial products are being brought onto online platforms. However, due to the scarcity of data in this new product domain, online platforms face challenges in predicting users' purchase behavior. In this paper, we study whether we can "transfer" knowledge learned from the existing consumer goods domain to benefit the prediction in the domain of the financial products. With data provided by one of the largest online shopping platforms in China, we develop machine learning solutions to enable knowledge transfer. We show that users' prior browsing and shopping history in consumer goods can significantly improve the prediction accuracy of users' purchases of mutual funds for both the existing-user and the new-user scenarios.

2 **Flash Sales Versus Traditional Sales: Price Optimization for An Online Retailer**
Ruijie Zhang[1], Yun Fong Lim[2], Zhenzhen Yan[3], [1]Singapore Management University, Singapore, Singapore; [2]Singapore

Management University, Singapore, Singapore; [3]Nanyang Technological University, Singapore, Singapore.

This paper examines a new flash-sale model where consumers first pay the deposit and then wait several days to make the final payment. The deposit determines the discount strength that the customer can enjoy due to the *Double Deposit Inflation* and provides a signal to the retailer on potential demands, allowing the retailer to reduce the logistical cost incurred from bottlenecked demand surges. We propose a pricing optimization model and jointly decide the optimal deposit and the product's full price. The condition of when the retailer should introduce flash sales is provided. In the case study, we calibrated our model with the real data from an e-commerce company in China, and the results from a 5-fold cross-validation show that our model can predict the demand well. Besides, by applying the pricing strategy proposed in this paper, we can dramatically improve the profit.

3 THE ASYMMETRIC INFLUENCe of AI-AUGMENTED SYSTEMS

Saunak Basu[1], Aravinda Garimella[2], wencui han[3], Alan R. Dennis[4], [1]University of Illinois at Urbana-Champaign, Champaign, IL, [2]University Of Illinois - Urbana-Champaign, Seattle, WA, [3]University of Illinois at Urbana Champaign, Champaign, IL, [4]Indiana University, Bloomington, IN, Contact: saunakb2@illinois.edu

We investigated whether and how AI agents influence human experts' assessments in highly uncertain financial investment. We used panel data from a leading initial coin offering (ICO) assessment platform that uses AI to augment human experts. Our results show that the AI agent exerts an asymmetric influence: When the AI agent assigns an ICO project a low score (a more common outcome), the assessments of human experts follow it; when the AI agent assigns a high score (a less common outcome), the assessments of human experts do not follow it. Our results suggest that AI agents have an asymmetric influence in uncertain situations, with experienced users relying more on the AI agent when it suggests a more common outcome and less when it suggests a less common outcome. Thus, AI systems that erroneously produce assessments matching prior probabilities are far more dangerous.

Tuesday, 5 PM–6:15 PM

TE12

CC - Room 113

Military Logistics and Infrastructure

General Session

Session Chair

Nicholas Ulmer, United States Navy, Pacific Grove, CA

1 Optimizing Portfolio-level Army Modernization Investment: An Overview of The Aim Point Investment Model (apim)

Jeremy Eckhause[1], Katharina Ley Best[2], [1]RAND Corporation, Arlington, VA, [2]The RAND Corporation, Pittsburgh, PA, Contact: kbest@rand.org

This presentation introduces the Aim Point Investment Model (APIM), a mixed-integer programming model for portfolio-level investment allocation across Army technology acquisition programs based on those programs' utility, subject to constraints on the ability to employ the invested funds productively within the required timeframes. APIM allows decisionmakers to quickly understand the implications of changing operational prioritization and budget constraints in terms of real effects on actual program-level funding.

2 Airlift Planning in a Contested Environment

James Whitlow, Naval Post Graduate School, Monterey, CA

The United States Air Force Air Mobility Command (AMC) requires the ability to rapidly design new route structures that optimize airlift in contested environments. The emerging future state will require AMC to rapidly evaluate alternative basing, route, and aircraft utilization strategies to mitigate threats while still delivering vital cargo and personnel. This talk presents an Integer Linear Program (ILP) that prescribes daily what airfields to employ, the level of MOG (Maximum on Ground) capacity to establish at each airfield to include movement of capacity between airfields, and the use of aircraft to move materiel. The ILP permits analysis of the tradeoff between risk to force (expected attrition) and risk to mission (cargo and personnel not delivered). We present computational experience for up to 30 days, several airfield locations, and multiple aircraft types.

3 Emergency food distribution and logistics in Hawaii

Felicia Goodell, [1</sup]

The island of Oahu is susceptible to multiple types of natural disasters, such that an emergency distribution plan must be in place to get residents and service members vital supplies when ports and roadways are disrupted. This work determines optimal points of distribution (PODs) on Oahu for civilian and military emergency management needs, including prepositioning of food and water at distribution centers and in local communities (Pre-PODs), the resupply of food and water to local communities (Re-PODs), and the supply of fuel to critical assets and communities (F-PODs). Each POD type requires a different dataset and model to assess optimal locations, including traffic flows, queuing, and delivery mechanisms. Overall, this work supports an integrated distribution management plan for Oahu and determines future DoD needs and support for civil authorities.

4 Applying Approximate Dynamic Programming to the Inter-Theater Airlift Problem

Alexander Cooper, Jefferson Huang, Pete Nesbitt, Naval Postgraduate School, Monterey, CA, Contact: alexander.cooper@nps.edu

The US Air Force's Air Mobility Command (AMC) is tasked with ensuring the timely movement of personnel and materiel between active theaters of operation via airlift. While many decision support tools exist for airlift planning under stability operations, few explicitly consider the case where the underlying logistics network is contested. As it prepares for potential future conflicts with near-peer adversaries, AMC is particularly interested in the contested case. We consider the use of approximate dynamic programming (ADP) methods to provide guidance on routing decisions, as well as on how to assign pallets and passengers to aircraft. We describe our underlying model of airlift operations in a contested environment, summarize ADP approaches to this problem, and provide methodological recommendations based on numerical experiments.

5 Energy-Aware Unmanned Aerial Vehicle Routing for Logistic Support of Expeditionary Advanced Base Operations

Vladimir Dobrokhodov[1], Emily Craparo[2], David Won[1], [1]Naval Post Graduate School, Monterey, CA, Canada; [2]Naval Postgraduate School, Monterey, CA

Advancements in unmanned aerial vehicle (UAV) technology make these vehicles a promising option for last-mile distributed deliveries in austere and contested environments. Despite advances in flight efficiency, the energy needs of UAVs limit high-volume distribution. To address the complex distributed aerial logistics problem, we propose a two-layer approach for optimally assigning demands to UAVs while simultaneously routing the UAVs so as to minimize energy expenditure. In the first layer we solve a boundary value problem to determine energy-optimal routes in a time-varying wind field. In the second layer we solve a robust multi-vehicle routing problem to maximize prioritized deliveries, subject to UAV energy constraints for each member of an ensemble weather forecast. We illustrate our approach on scenarios inspired by Marine Corps expeditionary logistics.

Tuesday, 5 PM–6:15 PM

TE14

CC - Room 115
Worker Performance
Contributed Session

Session Chair
Zherui Yang, Erasmus University Rotterdam, Rotterdam, Netherlands.

1 Implications of Worker Classification in On-demand Economy

Zhoupeng (Jack) Zhang, Rotman School of Management, University of Toronto, Toronto, ON, Canada. Contact: zhoupeng.zhang@rotman.utoronto.ca

How should gig workers be classified? We study this policy question focusing on the welfare of long-term (LT) workers, who depend on gig jobs as primary income sources. We identify two issues with uniform classifications: when all workers previously treated as contractors are reclassified as employees, a profit-maximizing service company may undercut workers, and LT workers' average welfare can decrease; when all are reclassified as "contractors+", an intermediate status that provides incomplete employee benefits but allows workers to self-join, workers can overjoin such that LT workers' utilization rate will remain low and their welfare may not be enhanced. We show that discriminatory approaches such as to classify gig workers according to their needs or to operationally prioritize LT workers can Pareto improve over uniform classifications. Finally, we empirically calibrate the model and apply our insights to the ride-hailing market in California.

2 Data Scientist Productivity, Software Libraries, and Worker Skills: Evidence from a Field Experiment

Daniel N. Yue[1], Iavor Bojinov[2], Paul Hamilton[1], [1]Harvard Business School, Boston, MA, [2]Harvard Business School, Somerville, MA

Predictive algorithm development is understudied despite its increasing importance to modern businesses. In a field experiment leveraging a predictive data science contest, we find that teams restricted from using library ML functions perform 30% worse in log-loss error — a statistically and economically significant amount. Surprisingly, the amount of time spent working does not significantly predict log-loss error. Total skill level does not moderate the effect of restrictions; however, teams with high tool-specific skills are most severely affected by the restriction, whereas teams with high general data-analysis skills are less affected. This suggests that general skills are substituted for by ML libraries, but that library restrictions cause teams to take different problem-solving approaches where general skills become more relevant.

3 On The Estimation of Managerial Ability

Rajiv Banker[1], samah jradi[2], Han-Up Park[3], John Ruggiero[4], [1]Temple University, Philadelphia, PA, [2]Em normandie, paris, France; [3]University of Saskatchewan, Saskatoon, SK, Canada; [4]University of Dayton, Dayton, OH, Contact: sjradi@em-normandie.fr

In an important paper on measuring managerial ability, Demerjian et al. (2012) developed a multiple stage model that exploits the production frontier model of Data Envelopment Analysis (DEA). The first stage uses the nonparametric DEA model to capture residuals from the production frontier. In the second stage, regression analysis is used to control for contextual variables that influence production differences. The unexplained residual is then used to proxy managerial ability. In this paper, we consider the alternative Stochastic DEA (SDEA) model to measure managerial ability. The results indicate that the SDEA model outperforms DEA across all model situations, providing consistently higher correlations between estimated and true managerial ability.

4 Future of Work: How Does Augmented Reality (AR) Improve Workers' Performance

Zherui Yang[1], Ting Li[2], Xuewen Han[3], Zhitao Yin[4], Sean Xin Xu[3], [1]Erasmus University Rotterdam, Rotterdam, Netherlands; [2]Erasmus University Rotterdam, Rotterdam, Netherlands; [3]Tsinghua University, Beijing, China; [4]Hong Kong University of Science and Technology, Hongkong, China. Contact: yang@rsm.nl

Augmented Reality (AR) glasses are introduced in companies to improve business. However, current streams of literature rarely discuss the behavioral or managerial side of AR. Therefore, we bridge this gap and investigate the effect of AR on workers' performance and its underlying mechanism. In a field study, we demonstrate that there is an immediate gain in performance improvement after a short-term AR usage. Specifically, based on information processing theory and cognitive load theory, we propose that by improving how workers perceive and absorb information, AR enhances workers' efficiency in information processing and consequently improves performance effectiveness. Moreover, workers' perception of extraneous cognitive load towards how information is presented moderates AR's effect on the efficiency of information processing.

Tuesday, 5 PM–6:15 PM

TE15

CC - Room 120

Using Models to Improve Healthcare

General Session

Session Chair

Sze-chuan Suen, University of Southern California, Los Angeles, CA

1 Model Based Reinforcement Learning for Personalized Heparin Dosing

Qinyang He, Yonatan Mintz, University of Wisconsin Madison, Madison, WI

Miss-dosing patients with time sensitive drugs, such as heparin, can lead to adverse health effects. Correctly dosing a patient with heparin is challenging since its concentration cannot be measured directly and the rate at which it is metabolized varies greatly between individuals. In this talk we design a precision medicine framework for optimizing heparin doses in an ICU setting. We use a pharmacokinetic predictive model to infer the current concentration of heparin and predict future therapeutic effects. In addition, we show how this model can be used in a model based reinforcement learning framework to optimize heparin dosing. We validate the predictive and prescriptive capabilities of our model against existing machine learning and reinforcement learning techniques, and show that our methods can achieve better performance when compared to model free approaches.

2 Using a Microsimulation Approach to Understand Covid-19 Effects on The HIV Epidemic Among Men Who Have Sex with Men (MSM) in San Francisco County

Citina Liang[1], Sze-chuan Suen[1], Anthony Nguyen[1], Corrina Moucheraud[2], Ian Holloway[2], Edwin Charlebois[3], Wayne Steward[3], [1]University of Southern California, Los Angeles, CA, [2]University of California, Los Angeles, Los Angeles, CA, [3]University of California, San Francisco, San Francisco, CA, Contact: citinal@usc.edu

Limitations on nonessential social services and lockdowns due to Covid-19 decreased sexual partnerships and HIV testing, viral load suppression, and Pre-Exposure Prophylaxis (PrEP) uptake and retention. To quantify the impact of Covid-19 on the HIV epidemic, we used a microsimulation model to predict outcomes on HIV awareness, treatment, and prevention for MSM in San Francisco County over the next 15 years (2020-2035). We compared scenarios where

Covid-19 effects end in 2022 or in 2025 and scenarios where resources are prioritized to new or existing patients from the end of 2022-2025 before all services return to normalcy. We measured differences in level, cumulative burden, and impact to EHE goals due to Covid-19.

3 Towards Practical Implementation of Predictive Models: Cost-effectiveness Modeling of Risk Score Cutoffs

Yiwen Cao, Sze-chuan Suen, University of Southern California, Los Angeles, CA, Contact: ycao0253@usc.edu

While identifying predictive models with high area under the curve (AUC) values is important, identifying the best cut-off value for positive and negative labels is additionally needed for deploying predictive models in the field. Which threshold value is best can be evaluated within a cost-effectiveness framework, where the optimal sensitivity-specificity pair along the frontier receiver-operating characteristic (ROC) curve provides the highest incremental net monetary benefit when considering residual lifetime costs, quality adjusted life years (QALYs), and additional opportunities for prediction. We demonstrate this process for chronic kidney disease (CKD) prediction in non-diabetic and non-hypertensive patients using a microsimulation framework to evaluate cost-effectiveness outcomes.

4 Optimal Investments on HIV Intervention Portfolios when Future Budgets are Linked to past Performance

Peng Dai[1], Sze-chuan Suen[2], Joel Goh[3], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, [3]NUS Business School, Singapore, Singapore.

Funding agencies may identify public health programs for renewal or continued financing by reviewing performance over prior grant periods. Satisfactory progress towards stated goals may increase the likelihood of future funding. We study the impact of an environment where future budget may be linked to prior performance in infectious disease policy. Specifically, we examine how this may influence the public health program's choice of investments across time for HIV/AIDS epidemic control. We use a Markov decision process (MDP) model incorporating a dynamic compartmental model of infectious disease, and we compare outcomes with and without the presence of budgets linked to past performance.

Tuesday, 5 PM–6:15 PM

TE16

CC - Room 121

Policy Design in Healthcare

General Session

Session Chair

Saumya Sinha, Rice University, Houston, TX

1 Does Broader Sharing Improve Patient Outcomes?

SHUBHAM Akshat[1], Liye Ma[1], Subramanian Raghavan[2], [1]University of Maryland, College Park, MD, [2]University of Maryland-College Park, College Park, MD, Contact: sakshat@umd.edu

We study the deceased-donor liver allocation policies in the United States (U.S.). In the transplant community, broader organ sharing is believed to mitigate geographic inequity and recent policies are moving in that direction in principle. We develop a patient's dynamic choice model to analyze her strategic response to a policy change. We study the impact of various policies on behavioral change of patients at the transplant centers, geographic equity, and efficiency (transplant quality, offer refusals, organ travel distance, etc.). We illustrate that a policy that equalizes supply (deceased donors)-to-demand (waiting list patients) ratios across geographies is better than broader sharing in achieving geographic equity at the lowest trade-off on efficiency metrics. The key message to policymakers is that they should move away from "one-size-fits-all" approach.

2 Incentives in Outcome-based Regulation for Solid Organ Transplantation

David Mildebrath[1], Saumya Sinha[2], Andrew J. Schaefer[3], Taewoo Lee[4], Howard J. Huang[5], Ahmed O. Gaber[5], [1]Rice University, Houston, TX, [2]University of Minnesota, Minneapolis, MN, [3]Rice University, Houston, TX, [4]University of Pittsburgh, Pittsburgh, PA, [5]Houston Methodist Hospital, Houston, TX, Contact: saumya@umn.edu

Transplant programs in the US are subject to federal regulations that penalize programs whose patients have poorer-than-expected post-transplantation survival. We present a game-theoretic model of transplant programs to study the incentives created by these outcome-based regulations. We demonstrate that harsh penalization, more than other factors, incentivizes programs to engage in adverse patient selection. We then propose a pay-for-performance reimbursement scheme that penalizes underperforming programs, but also pays a bonus to programs with above-average outcomes. We demonstrate that our proposed scheme can incentivize programs to improve post-transplant outcomes, without inducing adverse patient selection.

3 Optimizing Multi-Modal Cancer Treatment Under 3D Spatio-Temporal Tumor Growth

Eyyub Yunus Kibis[1], Esra Buyuktahtakin Toy[2], [1]Montclair State University, Montclair, NJ, [2]New Jersey Institute of Technology, Newark, NJ, Contact: kibise@montclair.edu

In this talk we introduce a new mixed-integer linear programming (MIP) model that explicitly integrates the spread of cancer cells into a spatio-temporal reaction-diffusion (RD) model of cancer growth, while taking into account treatment effects. This linear but non-convex model appears to be the first of its kind by determining the optimal sequence of the typically prescribed cancer treatment methods—surgery (S), chemotherapy (C), and radiotherapy (R)—while minimizing the newly generated tumor cells for early-stage breast cancer in a unique three-dimensional (3D) spatio-temporal system. Our results provide the optimal dosages for chemotherapy and radiation treatments, while minimizing the growth of new cancer cells.

4 A Multi-stage Stochastic Game Investment Model for The Waiting List Crisis in Health Systems: A Chilean Case Study

Jorge A. Acuna[1], Daniela Cantarino[1], Rodrigo Martinez[2], Jose L. Zayas-Castro[3], [1]University of South Florida, Tampa, FL, [2]Universidad de Chile, Santiago, Chile; [3]University of South Florida, Tampa, FL, Contact: jorge@usf.edu

Universal Health Coverage is a goal that most countries aim for. Increasing quality of care, reducing the financial burden, and improving access to specialized health services are some of its expected benefits. Unfortunately, when requesting a visit to a specialized physician, patients are most likely to join a waiting list, extending anywhere from months to years. Such lengthy waiting times lead to worse quality of life, emotional trauma, political burden, and in some cases, to the patient's death prior to their appointment. This talk presents a stochastic modeling approach to estimate the investment needs to end the waiting lists. The mathematical framework implements time-series prediction models to optimally allocate resources through a defined planning horizon, considering demand, hospitals, and regional characteristics.

Tuesday, 5 PM–6:15 PM

TE17

CC - Room 122

Operations Research in Public Health: Recent Advances and Trends

General Session

Session Chair

Ebru Korular Bish, University of Alabama, Tuscaloosa, AL

Session Chair

Hrayer Aprahamian, Texas A&M University, College Station, TX

1 Disease Bundling or Specimen Bundling? Cost- and Capacity-efficient Strategies for Multi-disease Testing

Douglas R. Bish[1], Ebru Korular Bish[1], Hussein El Hajj[2], [1]University of Alabama, Tuscaloosa, AL, [2]University of Waterloo, Waterloo, ON, Canada. Contact: helhajj@uwaterloo.ca

When multiple diseases manifest with similar symptoms, an accurate diagnosis often requires lab-based testing, which is important when the diseases require different interventions. There are two strategies that the tester can use to reduce the testing cost or the capacity requirement: multiplex assays or pooled testing. However, if and how these two strategies should be combined in an optimal testing design is not clear. Towards this end, we develop novel models that determine optimal testing designs that integrate these two strategies; derive key insight on optimal testing designs; and develop an efficient solution procedure for important special cases. Our case study of respiratory diseases, including COVID-19, underscores the value of such an integrated approach to testing design, over current practices.

2 Prediction of Long-term Medication Adherence and Its Potential Benefits for Intervention

Daniel Felipe Otero-Leon, Mariel Sofia Lavieri, Brian T. Denton, University of Michigan, Ann Arbor, MI, Contact: dfotero@umich.edu

Long-term adherence to medication helps prevent chronic diseases. When patients adhere poorly, physicians intervene to increase this adherence. Therefore, knowing which patients will stop adhering would help distribute the available resources effectively. We study a long-term adherence prediction model using dynamic logistic regression that can inform clinicians about which patients are likely to stop adhering and when. We applied our model to longitudinal data for cardiovascular diseases in a large cohort of patients seen in the national Veterans Affairs health system. Additionally, we show the importance of including past

adherence to increase prediction accuracy. Finally, we assess the potential benefits of using the prediction model to allocate interventions to patients under budget constraints.

3 Optimal Time-Varying Scheduling Policies for Multi-Service Appointment Systems with Uncertain Demand

Sohom Chatterjee, Lewis Ntaimo, Hrayer Aprahamian, Youssef Hebaish, Texas A&M University, College Station, TX, Contact: sohom070994@tamu.edu

In this paper, we construct optimal dynamic (time-varying) scheduling policies for an appointment scheduling system with multiple service categories and uncertain demand. We consider a queuing-theory based formulation and construct two different optimization-based frameworks, which involve solving challenging MINLP problems. Our analytical results on the structural properties of these problems allow for two custom solution algorithms that lead to the global optimum in polynomial time. We illustrate the benefits of this methodology using a series of numerical experiments on a discrete-event simulation model based on the operations of the student mental-health counseling center at Texas A&M University. Our results highlight the major benefits of using this framework over the current scheduling policy as well as simpler time-invariant models.

4 A Comparative Communication Analysis of Two US Hospital Systems' Covid-19 Communications Using Topic Modeling

Annisa Marlin Rus[1], Maria Esther Mayorga[2], Julie Simmons Ivy[2], Joseph Kapena Agor[3], Osman Ozaltin[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC, [3]Oregon State University, Corvallis, OR, Contact: amasbar@ncsu.edu

Although understanding initial internal communication to manage the COVID-19 pandemic within healthcare systems is important for effective operational strategies, little is known regarding the themes within hospital-level communications. This study used Structural Topic Modeling (STM) to analyze the internal communications of two healthcare systems from 2/2020 to 5/2021. The analysis also captured the influence of the hospital systems on communication content. COVID-19 communication topics were characterized using STM and their cross-healthcare systems variation to be compared. Variation was found in the main topics discussed across the healthcare systems in the response to the pandemic throughout the specified timeline.

Tuesday, 5 PM–6:15 PM

TE18

CC - Room 123
Healthcare Operations
General Session

Session Chair
Mohammad Delasay, Stony Brook University, East Setauket, NY

Session Chair
Zhila Dehdari Ebrahimi, ND

1 Complexity Measure: An Index for Managing Patient Flow in Emergency Departments

Enayon Sunday Taiwo[1], Farzad Zaerpour[1], Mozart B. C. Menezes[2], Zhankun Sun[3], [1]Faculty of Business and Economics, The University of Winnipeg, Winnipeg, MB, Canada; [2]NEOMA Business School, Department of Information Systems, Supply Chain Management and Decision-Making, Paris, France; [3]Department of Management Sciences, College of Business, City University of Hong Kong, Hong Kong, Hong Kong. Contact: e.taiwo@uwinnipeg.ca

The challenge of overcrowding in the Emergency Department (ED) is a well-documented problem, cutting across nations of the World. This problem, alongside other attending issues like ambulance diversion, long waiting times, delayed access to treatment or consultation, increased length of stay, and the burden of workload on healthcare personnel affects the quality of care. Despite consensus on the effects of ED crowding, there is no commonly accepted definition or shared measure of crowding. This study proposes some complexity measures for managing patient flow in hospital emergency departments (EDs) and investigates the impact on operational efficiency. Our data analyses revealed that complexity measures, not the common crowding measures existing in practice, influence performance outcomes in the ED the most.

2 A Queueing-theoretic Framework for Evaluating Transmission Risks in Service Facilities During a Pandemic

Sherwin Doroudi[1], Kang Kang[2], Mohammad Delasay[3], Alexander Wickeham[2], [1]University of Minnesota, Minneapolis, MN, [2]University of Minnesota, Minneapolis, MN, [3]Stony Brook University, East Setauket, NY, Contact: sdoroudi@umn.edu

We propose a new modeling framework for evaluating the risk of disease transmission during a pandemic in small-scale settings driven by stochasticity in the arrival and service processes. We propose a novel metric, *system-specific basic reproduction rate*, inspired by the "basic reproduction rate," which measures the transmissibility of infectious diseases. We derive our metric for various queueing models of service facilities by leveraging a novel queueing-theoretic notion: sojourn time overlaps. We showcase how our metric can be used to explore the efficacy of a variety of interventions aimed at curbing the spread of disease inside service facilities. Specifically, we focus on some prevalent interventions employed during the COVID-19 pandemic such as occupancy limits and the prioritization of high-risk customers.

3 Effect of Workload on EMT Scene Time and Transport Decision

Kenneth Schultz[1], Maryam Hosseinabadi[2], Armann Ingolfsson[3], Mohammad Delasay[4], [1]Unaffiliated, Englewood, OH, [2]University of Alberta, Edmonton, AB, Canada; [3]University of Alberta, Edmonton, AB, Canada; [4]Stony Brook University, East Setauket, NY, Contact: bopschultz@gmail.com

We use multiple years data from EMT calls in two large Canadian cities. We analyzed the data to determine if EMT change the scene time duration based on system workload or EMT workload prior to the call. We also look at workload affects the decision to transport from the scene to a hospital. We use previous literature and discussions with EMT to hypothesize differentials for codes indicating Cardiac Arrest, Trauma, Influenza Like Illness (both before and after Covid) and Opioid Overdose. As of this submission, data arrived recently but testing has not yet begun.

4 Capacity Planning of Service Systems with Cyclic Arrivals and State-dependent Service Rates

Zhila Dehdari Ebrahimi[1], Mohammad Delasay[2], [1]North Dakota State University, Fargo, ND, [2]Stony Brook University, East Setauket, NY, Contact: zhila.dehdari@ndsu.edu

Many service systems, including emergency medical services, have non-stationary and cyclic customer demands. Determining the capacity requirements of such systems is essential to achieving the quality-of-service targets. We evaluate the reliability of the stationary independent period-by-period (SIPP) approach and its variants in systems with cyclic arrivals and state-dependent service rates. We also show how disregarding the state dependency of service rates might lead to erroneous required capacity estimates.

Tuesday, 5 PM–6:15 PM

TE19

CC - Room 124
Treating COVID-19 Patients Efficiently
Contributed Session

Session Chair
Doulotuzzaman Xames, Virginia Tech, Blacksburg, VA

1 A Data Driven Approach for Matching While Learning

Hamid Reza zarei[1], Ozlem Ergun[2], [1]Northeastern University, boston, MA, [2]Northeastern University, Boston, MA, Contact: zarei.h@northeastern.edu

In this study, we design a service platform that matches dynamically arriving workers to jobs inspired by the experience of matching workers to long-term care facilities during the COVID-19 outbreak in Massachusetts. Workers arrive randomly over time with different characteristics. A limited number of jobs exist on the platform at the initial time period and no new jobs arrive after the platform starts matching. The outcome of a match is not known before matching and by using data from outcomes of previous matches, the platform finds the probability of success for a match. By matching workers to jobs, the platform aims to maximize the total probability of success considering future expected outcomes subject to job availability. We examined the performance of the service platform using real-world data that we obtained from the COVID-19 matching framework in MA.

2 On an OT-ICU-SDu with overflow and COVID-19

Nico M. Van Dijk, [1</sup]

The availability of an intensive care (ICU) bed is of considerable interest, both with and without COVID patients. By integrating an ICU system with a flexible step down unit (SDU), the availability might be greatly enhanced. First analytic (un)solvability is studied to conclude product form expressions. This is of both theoretical and practical interest as it involves serial overflow, insensitivity as well as well as sensitivity, distinguishable patients and capacity contention. Next, it is shown by simulation that optimization becomes involved. Numerical support is provided based on realistic academic (Dutch) hospital data.

3 A Novel Fuzzy-DEA Approach to Assess Healthcare System Performance in Tackling Covid-19 Pandemic: Evidence from Asian Economies

Doulotuzzaman Xames[1], Jannatul Shefa[2], [1]Virginia Tech, Blacksburg, VA, [2]University of Arkansas, Fayetteville, AR, Contact: xames@vt.edu
The COVID-19 pandemic has posed unprecedented challenges to the healthcare system globally. Asian countries, with relatively low investment in the healthcare sector, have been struggling to cope with the uncertainties caused by the epidemic. In this paper, a novel principal component analysis-based fuzzy data envelopment analysis (PCA-FDEA) model is developed to evaluate the efficiency of the public healthcare systems in Asian countries. PCA is used for dimensionality reduction and FDEA is used for handling ambiguity and vagueness in the inputs and outputs of DMUs. A sensitivity analysis is also performed to assess the consistency of the efficiency scores. The combined use of PCA and FDEA improves the effectiveness of healthcare system performance measurement. The findings of this research can be used for improved healthcare decision-making in a pandemic setting.

Tuesday, 5 PM–6:15 PM

TE20

CC - Room 125
Military Decision Analysis for Smart Bases
General Session

Session Chair
Gregory S. Parnell, University of Arkansas, Fayetteville, AR

1 Predictive Analytics for Smart Installations Weather

Randy K. Buchanan, USACE - ERDC, Vicksburg, MS, Contact: randy.k.buchanan@erdc.dren.mil
The Smart Installations Predictive Analytic effort supports the modernization of installation decision-making processes by applying complex computational analytics and high performance computing assets to inform installation decision makers for making holistic weather-related decisions. Current decision processes are manual and require extensive human interactions in order to inform inclement weather-related decisions such as base closure. This research integrates weather and traffic data with real-time analytics in order to develop a decision dashboard that can more effectively communicate the impact of risk on weather and traffic safety advisories and closures.

2 Developing a near Real Time Weather Informed Traffic Safety Model Using Modern Traffic Data

Kyle Compton, US Ignite, DC
US Ignite has worked closely with Fort Carson Garrison leadership to apply an agile methodology to UI/UX development for a decision support tool for Army installation inclement weather decisions.
To meet the functional requirements of that tool, US Ignite is developing a spatial data science methodology for predicting future transportation safety based on forecasted inclement weather. US Ignite is developing this AI/ML model using connected vehicular data and publicly available weather data, and providing their results to a broader Bayesian network for decision support.
US Ignite proposes to share the lessons learned from this agile UI/UX development process, along with our spatial data science approach.

3 Developing Advanced Machine Learning Techniques to Predict Gate Closing Decisions Under Extreme Weather Situations

Mohammad Marufuzzaman[1], Randy K. Buchanan[2], John Richards[3], [1]Missipppi State University, Starkville, MS, [2]USACE - ERDC, Vicksburg, MS, [3]Engineer Research and Development Center, Vicksburg, MS, Contact: maruf@ise.msstate.edu
The objective of this research was to develop advanced machine learning techniques for determining installation operational closure under predicted extreme weather situations. Complex computational analytics and high performance computing techniques were applied to real-time data, collected and mined in the Gov Cloud, to provide informed risk assessment for decision makers. In this pilot study, Fort Carson CO was used for target data and as a testbed to visualize and verify prediction results.

4 Smart Bases

Natallie Myers, ERDC, Champaign, IL
The Army now views its installations as part of the battlespace. Installations are where the combat power initiates and as such necessitate the latest automation technologies to maintain competitive advantage. A variety of smart city technology demonstrations at installations test and evaluate smart base concepts. These demonstrations include sensor integration with artificial intelligence. This presentation will discuss the Army's drivers to modernization and how they are leveraging smart and connected technology to get there.

Tuesday, 5 PM–6:15 PM

TE21

CC - Room 126

Data Acquisition, Dynamic Learning, and Marketplace Platforms

General Session

Session Chair

N. Bora Keskin, Duke University, Durham, NC

Session Chair

Hongfan Chen, The Chinese University of Hong Kong, Hong Kong, China.

1 Selling Information in Competitive Environments

Thibaut Horel, Massachusetts Institute of Technology, Cambridge, MA

The design of data markets has gained importance as firms increasingly use externally acquired data to inform their business decisions. When the firms are in competition, the acquisition of data by a firm exerts a negative externality on its competitors, an aspect that has received limited consideration so far. We formulate the problem facing a monopolistic data seller in such an environment as a mechanism design problem. The firms preferences for data as well as the negative externalities can be modeled as either intrinsic to the firms or arising from the downstream competition. In both cases, we derive the welfare- and revenue-optimal mechanisms, showing that the presence of externalities couples firms' optimal allocations, despite the inherent free replicability of data, and increases the profitability of selling information to one of the firms exclusively.

2 On The Statistical Complexity of Reinforcement Learning with Function Approximation

Wenlong Mou, UC Berkeley, Berkeley, CA, Contact: wmou@eecs.berkeley.edu

Reinforcement learning (RL) provides a formalism for optimal sequential decision making. With the large state-action space arising in practice, function approximation play a crucial role. Given a function class that approximately contains the true value function or the optimal policy, RL can be made possible with a statistical complexity depending only on their intrinsic complexities. In this talk, we present recent advances of RL with two popular forms of function approximation. For value learning, we establish optimal and instance-dependent oracle inequalities for solving Bellman equations. For policy learning, we propose a new notion of eluder dimension that enables policy space generalization. Both results are independent of model-based assumptions on the underlying Markov decision process, featuring novel, optimal, and model-free measures of complexity.

3 Inventory Control and Learning for One-warehouse Multi-store System with Censored Demand

Recep Yusuf Bekci, Mehmet Gumus, Sentao Miao, McGill University, Montreal, QC, Canada. Contact: recep.bekci@mail.mcgill.ca

We study a two-echelon inventory control problem called the One-Warehouse Multi-Store (OWMS) system when the demand distribution is unknown. This system has a central warehouse that receives an initial replenishment and distributes its inventory to multiple stores in each time period during a finite horizon. In this work, we consider the OWMS problem when the demand distribution is unknown a priori. We propose a sophisticated algorithm based on a primal-dual learning and optimization approach. Results show that both algorithms have great theoretical and empirical performances.

4 To Interfere or Not to Interfere: Information Revelation and Price-setting Incentives in a Multiagent Learning Environment

Hongfan (Kevin) Chen[1], John R. Birge[2], N. Bora Keskin[3], Amy R. Ward[4], [1]The Chinese University of Hong Kong, Hong Kong, China; [2]University of Chicago, Chicago, IL, [3]Duke University, Durham, NC, [4]The University of Chicago Booth School of Business, Chicago, IL, Contact: kevinchen@cuhk.edu.hk

We consider a platform in which multiple sellers offer their products for sale over a time horizon of T periods. The platform provides price-setting incentives to the sellers to maximize its own revenue. Initially, neither the platform nor the sellers know the demand function, but they can learn about it through sales observations. Perhaps surprisingly, a simple "do-nothing" policy does not always exhibit poor revenue performance. With a more conservative policy that reveals information to make price-setting incentives more effective, the platform can always protect itself from large revenue losses caused by demand model uncertainty. We develop a strategic-reveal-and-incentivize policy that combines the benefits of the aforementioned policies and thereby achieves asymptotically optimal revenue performance as T grows large.

Tuesday, 5 PM–6:15 PM

TE22

CC - Room 127
Technology and Disaster Management
General Session

Session Chair
Eunae Yoo, Indiana University, Bloomington, IN

1 **Cause Marketing as a Strategic Tool for Firms & An Opportunity for NGOs**
Sebastian Villa[1], Vinit Tipnis[2], Alfonso J. Pedraza-Martinez[2], Fei Gao[3], [1]University of New Mexixo, Albuquerque, NM, [2]Indiana University, Bloomington, IN, [3]Indiana University Bloomington, Bloomington, IN, Contact: svillab@iu.edu
In cause marketing campaigns (CMCs), firms donate a percentage of their sales revenue to partnering non-governmental organizations (NGOs) as a strategy to increase sales. Using an online experiment, we investigate how and when earmarked (i.e., restricted) and flexible (i.e., unrestricted) donations in CMCs affect consumers' purchase intent and willingness to pay. Our study provides clear recommendations both to firms and NGOs.

2 **Leveraging The Digital Tracing Alert in Virus Fight: The Impact of COVID-19 Cell Broadcast on Population Movement**
Heeseung Andrew Lee, The University of Texas at Dallas, Dallas, TX, Contact: bsh01250@gmail.com
Digital tracing alerts have emerged as effective means to share information with agility in responding to disaster outbreaks. We examine the extent to which instant digital tracing alerts and the information included in the alerts affect people's actions toward disaster management in the context of South Korea. We leverage 4,029,696 district-hour level datasets including population movement and digital tracing alert transmission information. Our results provide policymakers and law enforcement with novel insights into whether and how the usage of information technology can facilitate disaster management and to what extent they should collect and expose private information to effectively safeguards public health and safety during a pandemic.

3 **Presenter**
Changseung Yoo, McGill University, Montreal, QC, Canada.
Using Twitter data collected in partnership with the Canadian Red Cross, we study the impact of the type and content of tweets on donations and user engagement during the 2016 Fort McMurray wildfire. We utilize a Vector Autoregression model to investigate the interactions between variables of interest and how those interactions evolve over time. Our study offers actionable guidelines for disaster relief organizations to better deliver information during disasters.

Tuesday, 5 PM–6:15 PM

TE23

CC - Room 128
Pharmaceutical Shortages Analytics and Modeling
General Session

Session Chair
Ozlem Ergun, Northeastern University, Boston, MA

Session Chair
Noah Chicoine, Chelmsford, MA

1 **The Impact of Drug Reimbursement Policy on Drug Shortages**
Xuejun Zhao[1], Justin Jia[2], Hui Zhao[3], [1]Purdue University, West Lafayette, IN, [2]University of Tennessee, Knoxville, TN, [3]The Pennsylvania State University, University Park, PA, Contact: justinjia@utk.edu
We address the long-term debate of whether the Medicare drug reimbursement policy change from an Average Wholesale Price (AWP) regime to an Average Sales Price (ASP) regime in 2005 was a major cause to drug shortages. Based on analytical models and numerical analysis of the drug supply chain, we find that two opposite effects exist under ASP and the ASP policy actually possesses resilience to the drug shortages due to the policy's unique structure.

2 **Time to Recover Market Share: Lasting Effects of Supply Chain Disruptions on Firm Performance**
Minje Park, Anita Carson, Rena Conti, Boston University, Boston, MA, Contact: parkmj@bu.edu
We study how long it takes to recover the market share after supply chain disruptions using a new metric we propose, *Time to Recover Market Share*. Focusing on pharmaceutical supply chains, we explore the differential effects of competition levels in the market and by durations of the supply disruption.

3 **Modeling Optimal Operations Policies of Hospital Pharmacies Subjected to Evolving Resupply Information During Drug Shortages**
Noah Chicoine[1], Jacqueline Griffin[2], [1]Northeastern

University, Boston, MA, [2]Northeastern University, Boston, MA, Contact: chicoine.n@northeastern.edu

Our previous work highlights the uncertain and evolving nature of estimated resupply dates (ERDs), point estimates of future product deliveries given to hospitals by disrupted pharmaceutical manufacturers and wholesalers during drug shortages. This unreliable information, however, is most often the only information hospital pharmacists have to work with when deciding how best to mitigate the effects of drug shortages. In this work, we develop specialized models that determine the optimal operations policy for a hospital pharmacy given ERD information that mimics the behavior observed in our previous study. We note the negative impacts uncertain ERD information has on hospital operation costs and compare the results with those from a system where time intervals of deliveries are communicated instead of point estimates.

4 Behavioral Models of Scarce Resources Management During Supply Chain Disruptions

Min Gong[1], Jacqueline Griffin[1], Ozlem Ergun[2], David Kaeli[3], Casper Harteveld[4], Stacy Marsella[5], [1]Northeastern University, Boston, MA, [2]Northeastern University, Boston, MA, [3]Northeastern University, Boston, MA, [4]Northeastern University, Boston, MA, [5]Northeastern University, Boston, MA, Contact: gong.mi@northeastern.edu

As highlighted in the COVID-19 pandemic, supply chain resiliency is both a function of the system features and structures as well as the behaviors of the stakeholders throughout the system. Following a previous study that investigates the resource allocation of a profit-maximizing distributor in a disrupted supply chain by adopting a simulation-based decision-making approach, we propose two new tractable models by applying a decision tree algorithm and a heuristic method, to approximate and explain the old approach so that to address its non-negligible limitations. This work contributes novel methods of constructing behavioral models in supply chain management and provides a potential direction to inform the policies and strategies to mitigate the lasting consequences of a disruption.

5 A Deep Reinforcement Learning Aided Inventory Control Approach for Managing Drug Shortages

Zohreh Raziei, Ozlem Ergun, Northeastern University, Boston, MA, Contact: raziei.z@northeastern.edu

The outbreak of COVID-19 caused significant disruptions in pharmaceutical supply chains (SCs), which resulted in new drug shortages and demonstrated the lack of resiliency in the pharmaceutical industry. We study drug supply chains and stakeholder behavior to create decision support systems to help make better decisions in the absence of reliable data and information sharing. This study proposes Deep Reinforcement Learning (DRL) framework for improving drug shortage management by adaptive decision-making involving RL agents in a disrupted multi-agent system.

Tuesday, 5 PM–6:15 PM

TE24

CC - Wabash 1
SpringerNature/
Technology Tutorial

1 The Researcher's Publishing Toolbox: Operations Research & Optimization with Springer Nature

Elizabeth Loew, Springer Nature, Stoughton, MA, Contact: elizabeth.loew@springer.com

Take your research to the next level and explore our trusted community of books and journals. In this session, Springer Nature's book and journal Publishers will share insights and tips for potential authors, presenting recent tools and platforms that have been implemented (or are in fast-track development) in order to improve and enhance the publication process. In addition to highlighting these recent advances, we will also showcase select publications that can be used to learn or apply innovative modeling and programming tools.
For a full list of our latest offerings and a 20% discount, visit Springer Nature at Booth #27!

Tuesday, 5 PM–6:15 PM

TE26

CC - Wabash 3
Facility Location Problems
General Session

Session Chair
Wei Qi, McGill University, Montreal, QC, Canada.

Session Chair
Yuli Zhang, Beijing Institute of Technology, Beijing, China.

Session Chair
Yan Zhang, Canada.

1 Continuous Approximation Formulas for Location Problems

Bo Jones[1], John Gunnar Carlsson[2], [1]Rice University, Houston, TX, [2]University of Southern California, Los Angeles, CA, Contact: bo.jones@rice.edu

The majority of research in the continuous approximation paradigm has emphasized routing problems, such as the traveling salesman problem and the vehicle routing problem. This work instead focuses on continuous approximation formulas for problems involving location, specifically the k-medians, k-dispersion, and generalized minimum spanning tree problems. We contribute bounds for constants that describe the growth rate of the cost of these problems as the number of demand points becomes large, and conduct computational experiments that verify that they provide a good approximation in practice.

2 Locating Electric Vehicles Charging Stations in a Continuous Convex Region

Mehdi Behroozi, Dinghao Ma, Northeastern University, Boston, MA

The efforts to reduce greenhouse gas emissions to combat climate change has led to the development and increasing adoption of electric vehicles (EVs) that are considered competitive and in many aspects, better than their internal combustion engine counterparts (ICEVs). However, they still have a long way to go to replace ICEVs. One of the main aspects that EVs still have the lower hand is the accessibility of charging stations, which makes the optimal location of EV charging stations a significant factor in fast and successful adoption of EVs. In this paper, we take a robust partitioning and assignment approach for finding efficient locations for these charging stations.

4 A Parsimonious Model for Electric Vehicle Sharing with Battery Degradation

Xin Wang, University of Wisconsin-Madison, Middleton, WI

Free-floating Electric Vehicle (EV) sharing is expected to be adopted on a tremendous scale due to its service flexibility and energy efficiency. However, the extensive driving and charging of these shared vehicles could significantly reduce the quality of batteries and incur an underestimation of cost. In this paper, we propose a continuous model to address the joint vehicle charging and moving problems for a large-scale EV sharing system. In particular, a Continuous Time Markov Chain is used to characterize the battery degradation process. This model can benefit a shared EV fleet by providing decision support on the problems of charging piles installation, vehicle relocation, and battery charging/replacing. Under reasonable approximations, we reduce the model to the continuous Kantorovich-Rubinstein Transshipment Problem by separating the battery-related issues from the vehicle moving problems. On this basis, we can obtain a near-optimal battery charging/replacing policy analytically through continuum approximation. We show the performance of our model and the solution method through a set of numerical studies.

Tuesday, 5 PM–6:15 PM

TE27

CC - Room 138

Managing Ride-Hailing Platforms

General Session

Session Chair

Ashish Kabra, University of Maryland-College Park, College Park, MD

Session Chair

Harish Guda, Arizona State University, Tempe, AZ

1 Matching and Competition in Ride-hailing Markets

Danko Turcic, University of California, Riverside, 900 University Ave., CA

We construct a grid city model in which operational frictions from matching passengers and cars are the primary drivers of competition between taxis and Uber for wait-sensitive passengers. We tune the model to match the current competitive equilibrium between Ubers and taxis in that city. We then utilize our model to study what happens when taxis switch to Uber-like centralized dispatch and show that though this strategy improves taxi efficiency, it may reduce taxi market share.

2 Operating Three-sided Marketplaces: Pricing and Spatial Staffing in Food Delivery Systems

Zhe Liu[1], Yiwen Shen[2], Yanwei Sun[1], [1]Imperial College Business School, London, United Kingdom; [2]HKUST Business School, Hong Kong, Hong Kong. Contact: yiwenshen@ust.hk

We study a food delivery platform's joint pricing and staffing problem under endogenous participation of three sides: restaurants, customers and deliverers. Using a state-dependent queueing model where service rates depend on the imbalance of all three sides due to spatial frictions, we study the system's equilibrium behavior in heavy traffic and show through asymptotic analysis how platform controls balance capacity utilization and service quality. We show the platform's value is threefold: (i) increased market output as the platform boosts demand for restaurants and offers faster delivery for customers; (ii) delivery resource pooling that saves the restaurants' logistic costs and increases deliverer utilization; (iii) efficient network routing that reduces cross-location pickups, hence customer waiting and deliverer idleness.

3 Minimum Wage Regulation in Ride-hailing Platforms: Unintended Spatial Equity Consequences

Harish Guda[1], Ashish Kabra[2], [1]Arizona State University, Tempe, AZ, [2]University of Maryland, College Park, MD, Contact: hguda@asu.edu

Ride-hailing platforms experienced tremendous growth in the recent past. As these platforms matured, a large population of drivers have reported dissatisfaction with their earnings. Motivated by their low wages, several large cities have proposed regulations to improve the effective driver pay, the most popular of which is a utilization-adjusted minimum wage. We analyze the implications of such a minimum wage in a spatially-dispersed market. Our model captures two key features. First, most large cities comprise a dense core zone, surrounded by peripheral zone. Second, the demand patterns between these zones exhibit large imbalances. Our analysis is instructive to policymakers about the ramifications of a minimum wage in spatially-dispersed markets.

4 A Hybrid Employment Model for a Freight Sharing Economy

Joon Moon[1], Nicholas G. Hall[2], Guangwen (Crystal) Kong[3], Parinaz Naghizadeh[1], [1]Ohio State University, Columbus, OH, [2]Ohio State University, Colubmus, OH, [3]Temple University, Wynnewood, PA, Contact: naghizadeh.1@osu.edu

We study a truck sharing platform operating in multiple locations. The platform adopts a hybrid employment model, in which it fulfills demand by employing both full-time and on-demand drivers. This hybrid model allows the platform to benefit from the lower cost of hiring on-demand workers, while also compensating for the uncertainty in their availability by utilizing full-time workers. The platform aims to allocate jobs in each location to available workers at that location, over time, with the goal of maximizing its long-run expected payoff. We identify optimal allocation policies using reinforcement learning. This analysis generates insights into the optimal hiring level of full-time workers, the platform's worker re-balancing decisions over time, and the platform's decisions to grow the pool of on-demand workers by providing increased opportunities to them.

Tuesday, 5 PM–6:15 PM

TE28

CC - Room 139

Managing Scarce Healthcare Capacity in the Context of COVID-19

General Session

Session Chair

Alex Mills, Baruch College, City University of New York, New York, NY

1 Capacity Planning for Effective Cohorting of Hemodialysis Patients During The Coronavirus Pandemic: A Case Study

Ali Kaan Kurbanzade[1], Cem Deniz Caglar Bozkir[2], Cagri Ozmemis[3], Burcu Balcik[2], Evrim D. Gunes[4], Serhan Tuglular[5], [1]Northwestern University, Evanston, IL, [2]Ozyegin University, Istanbul, Turkey; [3]Ozyegin University, Istanbul, Turkey; [4]Koc University, Sariyer, Turkey; [5]Marmara University, Istanbul, Turkey. Contact: alikurbanzade2026@u.northwestern.edu

Planning has become challenging in hemodialysis clinics during the pandemic. In this study, we address capacity planning decisions of a hemodialysis clinic in Istanbul, which serves both COVID-19 infected and uninfected patients with limited machines. The clinic currently applies a 3-unit cohorting strategy to treat uninfected, infected, and suspected patients in separate units and at different times to mitigate the spread risk. Due to the uncertainties in the number of different types of daily patients, it is difficult to determine which capacity configuration would minimize the overlapping treatment sessions of different cohorts. We present a stochastic programming approach to support capacity allocation decisions, based on real-world patient data. We also compare the performance of different cohorting strategies.

2 Rationing Scarce Healthcare Capacity: A Study of The Ventilator Allocation Guidelines During The Covid-19 Pandemic

David Anderson[1], Tolga Aydinliyim[2], Margret V. Bjarnadottir[3], Eren Basar Cil[4], Michaela Restivo Anderson[5], [1]Villanova University, Villanova, PA, [2]Baruch College, CUNY, New York, NY, [3]University of Maryland, College Park, MD, [4]University of Oregon, Eugene, OR, [5]Penn Medicine, Phialdelphia, PA, Contact: tolga.aydinliyim@baruch.cuny.edu

Using NYS as an example, we study the existing approaches to allocate scarce ventilator capacity and propose alternatives. We show that, by taking into account both mortality risk and resource use duration, triage teams can improve expected survival rates as well as allocate capacity more equitably across different racial demographics.

3 Optimal Asymptomatic Testing Under Limited Test Supply

Nikolai Lipscomb, UNC Chapel Hill

We examine the problem of a patient choosing when to use COVID tests when the supply of tests is limited. We consider a partially observable Markov decision process where the only observable states are whether symptoms are observed or not. Under various model assumptions, we are able to analytically derive optimal policies as we prove structural results of the model.

4 Optimal Vaccination Rollout Policies

Puyao Ge[1], Vidyadhar Kulkarni[1], Jayashankar M. Swaminathan[2], [1]University of North Carolina-Chapel Hill, Chapel Hill, NC, [2]University of North Carolina-Chapel Hill, Chapel Hill, NC, Contact: puyao@live.unc.edu

A limited supply of vaccines is available to a community consisting of several distinct groups. The groups differ in size, their readiness to be vaccinated, and the potential benefits to their members from the vaccine. We develop the optimal vaccine rollout schedule: the policy that dynamically opens and closes the access to the vaccines to each group so as to maximize the total benefit to the society. We find that the optimal vaccine roll-out schedules can be surprisingly complicated and counter-intuitive.

Tuesday, 5 PM–6:15 PM

TE29

CC - Room 140

Empirical Studies in Operations-Finance Interface

General Session

Session Chair

Vibhuti Dhingra, 1</sup

1 The Effect of Expedited Payments on Project Delays: Evidence from Quickpay Reform

Vibhuti Dhingra[1], Volodymyr O. Babich[2], Harish Krishnan[3], Jie Ning[4], [1]Schulich School of Business, York University, Toronto, ON, Canada; [2]Georgetown University, Washington, [3]University of British Columbia, Vancouver, BC, Canada; [4]Case Western Reserve University, Cleveland, OH, Contact: vibhutid@schulich.yorku.ca

Contractors are not paid instantaneously upon completing the project tasks and furnishing the invoice. We study the impact of payment timings on project delays. We develop theories that explain how payment duration affects project completion, and generate testable hypotheses. We empirically test these hypotheses using data on U.S. public projects. Our identification strategy uses a policy amendment that expedited payments to certain federal contractors as an exogenous shock.

2 Local Shocks, Fintech Lending, and Social Injustice Amplification

Raffi Garcia, Sen Li, Rensselaer Polytechnic Institute, Troy, NY, Contact: lis23@rpi.edu

Does Fintech lending amplify acute local social shocks? Using U.S. mass shooting data for causal identification, this paper investigates the reactionary effects of negative local shocks on peer-to-peer (P2P) platform lending behavior. Our difference-in-differences and event study results show that demand for credit drops immediately after an acute local shock. However, interest rates rise. Local business activities and collateral assets such as the flow of bank branch deposits and home values do not seem to get affected, supporting the evidence of Fintech lending markets' overreaction after acute social shocks. The increased public attention, the severity of the event, and the location type of the mass shooting exacerbate these impacts. These results highlight that the reactive nature of online credit marketplaces can amplify local social injustices.

3 Labor Coordination and Division: Human Capital Investment in Supply Chains

Ling Cen[1], Michael Hertzel[2], Zi'ang WANG[1], Jing Wu[1], [1]Chinese University of Hong Kong, Hong Kong, Hong Kong; [2]Arizona State University, Phoenix, AZ, Contact: jingwu@cuhk.edu.hk

Using a novel database of online job postings, we document labor coordination and division in recruiting activities of supply-chain partners. We find that recruitment by dependent suppliers caters to the needs of their major customers and that the coordination is enhanced when customers face greater switching costs, measured by either higher supplier market power, higher relationship R&D intensity, or greater supplier asset redeployability. To establish causality and demonstrate the real effects of human capital coordination, we use outcomes from H-1B lotteries as an exogenous shock to recruitment activities. In addition, we find that supply chain partners recruit positions that require labor-intensive and general skills together while pursuing labor division for positions that need technology-intensive and specialized skills.

Tuesday, 5 PM–6:15 PM

TE30

CC - Room 141

Optimizing Service Operations in a Pandemic

General Session

Session Chair

Shouqiang Wang, The University of Texas at Dallas, Richardson, TX

Session Chair

Andrew E. Frazelle, The University of Texas at Dallas, Dallas, TX

1 **No Panic in Pandemic: The Impact of Individual Choice on Public Health Policy and Vaccine Priority**

Miao Bai[1], YING CUI[2], Guangwen (Crystal) Kong[3], Zhenhuan Zhang[4], [1]University of Connecticut, Storrs, CT, [2]University of Minnesota, Minneapolis, MN, [3]Temple University, Philadephia, PA, [4]University of Minnesota, Bellevue, WA, Contact: guangwen.kong@temple.edu

Infectious disease outbreaks such as COVID-19 pose significant public health threats and challenges worldwide due to their high transmissibility and potentially severe symptoms and complications. Although public health interventions such as social distancing and lockdown can slow the disease spread, the disruption to regular economic and social activities caused by these interventions have caused significant financial losses. We consider public health interventions (social distancing and lockdown) for COVID-19 pandemic by incorporating human responses to these policies. We derive insightful structural properties and find its implications for vaccine priority.

2 **Service Density and Pricing for Dependent Price- and Crowd-sensitive Demand**

Toghrul Rasulov, Richardson, TX

We study a service provider's pricing and density decisions when customers differ in their valuation and in their sensitivity to crowds. Customers exhibit rigid preferences that they will purchase the service if and only if the price does not exceed their valuation and the density is bounded above by their tolerance of crowdedness. We use copulas to model such multidimensional heterogeneity and examine the effects of dependence structure on optimal decisions. For a wide range of parameters, we characterize the optimal policy in detail. The small remaining parameter range reflects the case where customers are extremely sensitive to density. We show that the optimal policy reflects one of four possible strategies corresponding to whether the provider chooses to serve a particular subpopulation and whether to regulate demand from another subpopulation via price or density.

3 **Service Staffing for Shared Resources**

Buyun Li[1], Vincent Slaugh[2], [1]Kelley School of Business; Indiana University, Bloomington, IN, [2]Cornell University, Ithaca, NY, Contact: vws8@cornell.edu

Many shared resources, such as hotel rooms or rental cars, require cleaning, charging, or some other form of servicing between successive customer usage intervals. We study capacity management decisions for workers or other resources needed to service shared resources. In particular, we focus on the number of workers to start their shift in each time period amid uncertainty about customer arrival and departure times. The objective of the combined staffing level and shift construction problem is to minimize the total cost of staffing and customer waiting. We show that the staffing vector representing the number of workers to start their shifts in each time period is M-convex. We also illustrate the value of our model for hotel housekeeping operations and use our model to provide guidance for pandemic-related changes in staffing strategies and guest policies.

Tuesday, 5 PM–6:15 PM

TE31

CC - Room 142

Collaboration and Coordination in Supply Chains

General Session

Session Chair

Abhishek Roy, Temple University, Fox School of Business, Philadelphia, PA

1 **When Research and Development is Bad for Patients: Strategic Price Control Under External Reference Pricing in The Presence of a Tactical Firm**

Shubham Gupta[1], Yingxin Zhang[2], Subodha Kumar[3], Xiangpei Hu[2], [1]Temple University, Philadelphia, PA, [2]Dalian University of Technology, Dalian, China; [3]Fox School of Business, Temple University, Philadelphia, PA, Contact:

gupta.shubham@temple.edu
Healthcare expenditures are increasing worldwide, and pharmaceutical spending is a major contributor to this trend. Countries are responding by implementing external reference pricing (ERP), a policy commonly used by many countries, to contain drug prices. ERP sets a price ceiling for drugs based on the prices firms charge in other countries. While studying its effects, past research on ERP has not studied the counter-strategies that can potentially undermine the effectiveness of ERP. We address this gap in the literature by developing a stylized game-theoretic model to incorporate firms' counter-strategies and capture the interactions among the parties involved. Our results can help governments to optimally plan and implement ERP policy in the country while accounting for counter-strategies by the pharmaceutical firms.

2 Co-creation in New Product Development: Collaborating with The Competitor in The Presence of a Shared Supplier

Abhishek Roy, Temple University, Fox School of Business, Philadelphia, PA
The increasing complexity of technology has resulted in the emergence of a few key suppliers, and new product development has become a complex endeavor. In many industries, such suppliers are shared by competing manufacturers, who may benefit from forming alliances and co-creating new products jointly with their shared suppliers. Using a game-theoretic model, I analyze the strategic interactions in such a collaborative alliance and examine the strategic trade-offs that arise when competing buyers decide to co-create a common component with the supplier, instead of relying on the supplier to independently develop the component. This research highlights that in an industry where the quality of the common component is critical to consumer demand, collaborative design processes may benefit all the firms involved.

3 The Impact of Best Seller Recommendation in Online Platforms

Farzad Fathi, Yi Xu, University of Maryland, College Park, MD, Contact: ffathi@umd.edu
We study the impact of the best seller recommender system on customers, sellers, and the platform on an online platform. We show that the best-seller recommender system intensifies competition among sellers, resulting in a lower equilibrium price. While the lower price attracts more customers, it reduces the incentive for the sellers to join the platform. Both the lower price and the lower seller participation hurt the platform's commission revenue. Our results suggest that a platform must carefully assess the effects of a recommender system on the whole ecosystem before adopting it.

4 To Join or Not to Join: How Market Conditions Affect The Participation of Competing Firms in Cooperative Ventures

Hao Jiang[1], Abhishek Roy[1], Joydeep Srivastava[2], Subodha Kumar[3], [1]Fox School of Business, Temple University, Philadelphia, PA, [2]Fox School of Business, Temple University, PHILADELPHIA, PA, [3]Fox School of Business, Temple University, Philadelphia, PA, Contact: hao.jiang0001@temple.edu
Although the participation of firms in horizontal cooperative ventures (HCVs) that benefit all firms, such as industry alliances and generic advertising campaigns, has been well-studied in the literature, prior studies have not explored how the firms decide their participation levels when the underlying market conditions change. In this paper, we investigate the impact of changing market conditions of the market on two competing firms' strategic decisions, when they face the prospect of cooperating with their competitor, and develop academic as well as managerial insights.
We study the firm's strategy of voluntary contribution and production in the context of collaboration and competition, considering various structures of the market, as well as a variety of environmental factors and intrinsic factors.

Tuesday, 5 PM–6:15 PM

TE32

CC - Room 143
Improving LIves and the Environment: Analytics for Smart(er) Agriculture and Smart(er) Cities
General Session

Session Chair
Xavier Warnes, Stanford University Graduate School of Business, Stanford, CA

Session Chair
Dan Andrei Iancu, Stanford University, Stanford, CA

Session Chair
Erica Plambeck, Stanford University, Stanford, CA

1 Improving Smallholder Welfare While Preserving Natural Forest: Optimal Mechanisms and Operational Implications

Xavier S. Warnes[1], Dan Andrei Iancu[1,2], Erica Plambeck[1], [1]Stanford University, Stanford, CA, [2]INSEAD, Fontainebleau, France. Contact: xwarnes@stanford.edu

Environmental science documents that agricultural production is the dominant driver of deforestation in developing countries. Complex land tenure systems coupled with costly enforcement of conservation laws enable farmers to convert rainforest into productive land in search of better income. In this paper, we model the incentives and specific decision-making processes of farmers who dynamically choose their land expansion in response to specific economic and value-chain circumstances. We analyze several interventions that balance preserving the natural forest and improving farmers' welfare.

2 Tip Your Farmer? Implications of Tipping in Agriculture on Sustainability and Financial Inclusion

Saed Alizamir[1], Foad Iravani[2], Basak Kalkanci[3], [1]Yale University, New Haven, CT, [2]Uber Freight, San Francisco, CA, [3]Georgia Institute of Technology, Atlanta, GA, Contact: basak.kalkanci@scheller.gatech.edu

An emerging financial innovation in agricultural supply chains is the capability to "tip the farmers." This innovation empowers socially-conscious customers to identify the individual farmers of their sustainably-sourced products and reward them by sending them direct payments. We examine the implications of this new capability on farmers' and consumers' welfare, and agricultural firm profits. We show that if tipping is implemented under the right conditions (e.g., when farmers' outside option is moderate and customers are relatively socially conscious about farmers' earnings), it can create a triple win for all supply chain members including every individual farmer. Conversely, when these conditions do not hold, farmers and/or consumers can be worse off with tipping.

3 Direct Trade and Specialty Coffee: Sourcing and Pricing Under Uncertainty

Burak Kazaz[1], Scott Webster[2], Shahryar Gheibi[3], [1]Syracuse University, Syracuse, NY, [2]Arizona State University, Tempe, AZ, [3]Siena College, Loudonville, NY, Contact: bkazaz@syr.edu

Leading specialty coffee roasters rely on *direct trade* to source premium coffee beans. We examine a roaster who sells two basic types of roasts: a single-origin roast is sourced from a specific locale and available for a limited time during the year and a blend roast is available year-round using a mix of beans from different sources. We study how characteristics of the operating and market environment affect the optimal sourcing strategy for single-origin beans. One of three distinct strategies emerges as optimal: specialized (no of downward substitution), diversified (consistent downward substitution), mixed (between these two extremes). Our findings also point to a simple signal that policymakers may use to identify coffee growing locales where targeted interventions can improve grower welfare.

To Err is Human: A Field Experiment in Nudging Doctors Away from Drug-to-Drug Interactions

Xiaodan Shao[1], Vivek Choudhary[1], Arnab Majumdar[2], Burhanuddin Pithawala[2], [1]NTU, Singapore, Singapore; [2]HealthPlix, Bengaluru, India.

Nearly 1% of hospitalizations in the US happen because of drug-to-drug interactions (DDIs), wherein a patient unknowingly follows the doctor's prescription containing drugs that interact, which then causes severe reactions. Systems that alert doctors when drug interactions are detected in prescriptions are either ignored or overridden by doctors when they are made mandatory. In this paper, we study an information nudge in a field experiment in collaboration with a large health-tech firm. The DDI nudge reduces the number of DDIs prescribed by doctors in the treatment group by ~8.7%. We find evidence that doctors learn from the nudge and become cautious in prescribing DDIs. Findings indicate that the nudge effect persists and does not vary across doctor gender but is significantly higher for general physicians than for specialists.

Tuesday, 5 PM–6:15 PM

TE33

CC - Room 144

Inventory Management II

Contributed Session

Session Chair

Fabio Castro, MIT CTL, Cambridge, MA

1 Modeling Repair Demand in Existence of a Nonstationary Installed Base

Deniz Karli[1], Mustafa Hekimoglu[2], [1]Işık University, Istanbul, Turkey; [2]Kadir Has University, Istanbul, Istanbul, Turkey.

Life cycles of products consist of growth, maturity and decline phases. Among the three main life cycle stages of products, modeling repair demand is particularly difficult in growth and decline stages due to nonstationarity. In this study, we suggest respective stochastic models to capture the dynamics of repair demand in growth and declining phases. We apply our theory to lifetime extension of aging capital products. We focus on investment decisions of Original Equipment Manufacturers (OEMs) to extend products' economic lifetimes with technology upgrades. We characterize the optimal investment policy for lifetime extension decisions from risk-neutral and risk-averse perspectives and discuss its profitability from managerial perspective. We find a critical level of investment cost and installed base size for the profitability of lifetime extension for OEMs.

2 Bullwhip Effect of Supply Networks: Joint Impact of Network Structure and Market Demand

Jinzhu Yu[1], Chencheng Cai[2], Jianxi Gao[1], [1]Rensselaer Polytechnic Institute (RPI), Troy, NY, [2]Temple University, Philadelphia, PA, Contact: yujinzhu88@gmail.com

The variance of demand can amplify upward along a supply network, i.e., the bullwhip effect (BWE). Here, we investigate how network structures impact variance amplification under different demand patterns. For supply networks without intra-layer links, the variance amplification is measured as tier-wise BWE. We first analytically characterize tier-wise BWE using a control-theoretic approach and show that: (i) Network structures do not affect the tier-wise BWE under stationary market demand. (ii) Wider supply networks have a lower average tier-wise BWE under non-stationary market demand. The impact of tier width on tier-wise BWE declines as the demand moves upstream. In addition, we analytically characterize the node-to-node variance amplification when supply networks have intra-layer links, in which case tier-wise amplification rate is not applicable.

3 Inventory Management and Assortment for Cash-constrained Micro and Small Firms

Fabio A. Castro, Josué C. Velázquez-Martínez, Massachusetts Institute of Technology (MIT), Cambridge, MA, Contact: facastro@mit.edu

Micro and Small Enterprises (MSEs) account for a major number of firms, source of employment, and GDP contribution in developing countries. They generally however suffer from limited working capital availability, limited access to financial markets, and limited human capital, restricting their logistics efficiency and threatening their survival. We apply an inventory, assortment and cash flow optimization model to real-world micro firms' transaction data to obtain insights about management decisions under cash constraints. These insights result in a supply chain management framework to guide the small firms' reordering policy, payment terms and products assortment according to their cash availability to increase their profitability and survival. Such insights may also guide their suppliers intending to increase market share.

Tuesday, 5 PM–6:15 PM

TE34

CC - Room 145

Energy and Natural Resource Distribution Systems

Contributed Session

Session Chair

Andrea Arriet, Texas Tech University, Lubbock, TX

1 Studying Potentials of Feedback Control in Fossil Fuel-minimal Power Systems

Muhammad Nadeem, Ahmad F. Taha, Vanderbilt University, Nashville, TN

Today's power systems are controlled based on fundamentals of physics-based properties of dispatchable, fuel-based generators. Future power grids however must cope with the increasing penetration of renewable energy resources (RERs) and require a much more sophisticated control architecture. This is because RERs are formed by uncertain solar- and wind-based resources and are connected to the grid using converter-based technologies. These are, in short, far more complex to control than traditional generators. Furthermore, RERs do not provide inertia to damp frequency oscillations, and thus the grid's operating point changes more unpredictably. To that end, the objective of this work is to investigate the potential of feedback control theory to perform real-time frequency/voltage regulation in power systems comprised mainly of RERs and a few fuel-based machines.

2 Distributing LNg to Isolated Communities in The Brazilian Amazon

Andre Bergsten Mendes[1], Paulo Cezar Azevedo Jr.[2], Nelson Kuwahara[3], [1]University of Sao Paulo, Sao Paulo, Brazil; [2]Institute for Research in Economics and Business Administration, Bergen, Norway; [3]Federal University of Amazonas, Manaus, Brazil. Contact: andbergs@usp.br

Currently, there are around 95 isolated communities in the State of Amazonas, Brazil, whose energy is not supplied by transmission lines. Instead, electricity is generated by local diesel thermal power stations. Besides the high diesel procurement costs, the consequences to human health and the environment are harmful. Among cleaner options, one could replace diesel with natural gas as a transition to a more environmental-friendly alternative. We propose a distribution network for liquefied natural gas (LNG) transported in cryogenic containers to the communities that are reachable by barges. A network design problem is modeled based on the period vehicle routing problem, with routes that can last

up to three weeks. We evaluate alternative supply points and design the fleet. We present a mathematical model, a heuristic, and results for a real case.

3 A Multiscale Integrative Framework for The Design of Cost-competitive Resilient and Sustainable Distributed Energy Systems

Natasha J. Chrisandina[1], Shivam Vedant[2,3], Eleftherios T. Iakovou[4], Efstratios Pistikopoulos[5], Mahmoud M. El-Halwagi[1], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, [3]Texas A&M University, College Station, TX, [4]Texas A&M Engineering Experiment Station, College Station, TX, [5]Texas A&M Energy Institute, College Station, TX, Contact: nchrisandina@tamu.edu

Distributed energy systems, which employ facilities located in geographically distributed areas, provide a more sustainable pathway for energy production. It is desired that these systems are able to adapt to and quickly recover from disruptions to ensure consistent service levels. To increase the cost-competitiveness of investing in resilience, implementing targeted small-scale changes are necessary. In this study, we develop an approach for integrating facility-level process synthesis and supply chain planning concepts through a mixed-integer programming model to generate resilient distributed energy system designs. A study on the Texas-Louisiana hydrogen grid is presented to demonstrate the applicability of the developed approach.

4 Multi-stage Stochastic Problem for The Natural Gas Market Considering Water Taxation Strategies and Renewables Uncertainty

Andrea Arriet[1,2], Timothy I. Matis[1], Felipe A. Feijoo[3], [1]Texas Tech University, Lubbock, TX, [2]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile; [3]Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile. Contact: andrea.arriet@ttu.edu

Water scarcity is a rising problem in the world as Climate change worsens. Shale plays are usually located in high water-stressed areas, and therefore, water fracking extraction exacerbates the crisis. This problem is particularly severe for North America since its energy independence relies on natural gas. This study addresses this problem by developing a multi-stage stochastic problem for the North American energy sector, considering water scarcity's impact on natural gas extraction and variability from renewable sources. Variability of renewables is addressed by considering wind and solar profiles for production modeling. Water scarcity impact is incorporated by modeling natural gas extraction and penalizing water utilization by different water scarcity indexes. This model runs hourly for the electricity production sector and daily for the natural gas sector.

Tuesday, 5 PM–6:15 PM

TE37

CC - Sagamore 6

Optimization under Uncertainty: Applications in Infrastructure and Community Resilience

General Session

Session Chair

Andres David Gonzalez, University of Oklahoma, Norman, OK

1 Design of Covid-19 Staged Alert Systems with Wastewater Surveillance

Guyi Chen, David Morton, Northwestern University, Evanston, IL, Contact: guyichen2024@u.northwestern.edu

Community mitigation strategies can reduce transmission of SARS-CoV-2. The strictest measures, such as shelter-in-place orders, are effective in slowing the spread of the virus but have a substantial socioeconomic cost. A relaxed mitigation measure may not suffice to curb a surge, prior to overwhelming healthcare capacity. We seek to derive a COVID-19 mitigation strategy to ensure healthcare capacity with minimal closures. We use wastewater surveillance to inform toggling between mitigation stages because a wastewater signal can precede other signals such as hospital admissions. We propose an optimized staged-alert system with a wastewater signal using Cook County in Illinois as a case study.

2 A Two-stage Chance-constrained Stochastic Programming Model for Resilient Disaster Housing Assistance System Design

Sheng-Yin Chen, Yongjia Song, Clemson University, Clemson, SC, Contact: shengyc@g.clemson.edu

We propose and study framework for designing a resilient disaster housing recovery assistance system. Specifically, we utilize the two-stage chance-constrained stochastic programming models here to achieve the balance between long-run logistics operational cost and its resiliency towards extreme disastrous situations. This consideration is reflected in utilizing two operational modalities, one for the normal modality and the other for the emergency modality, and the emergency modality is only allowed to be activated for a limited number of scenarios among all that may arise in the long run, according to a probability distribution estimated from a long-run hurricane activity analysis and the corresponding disaster housing demand estimation. Numerical results with empirical data will be presented.

3 A Two-stage Robust Optimization Approach for Enhanced Community Resilience Under Tornado Hazards

Mehdi Ansari[1], Juan Sebastian Borrero[2], Andres David Gonzalez[3], [1]Oklahoma State University, Stillwater, OK, [2]Oklahoma State University, Stillwater, OK, [3]University of Oklahoma, Norman, OK, Contact: meansar@ostatemail.okstate.edu

Catastrophic tornados can severely damage communities across urban areas. We consider a decision-maker that seeks to optimally allocate resources in retrofitting and recovery strategies to minimize the population dislocation after a catastrophic tornado. As tornado paths are virtually impossible to predict, we model the problem using a two-stage robust optimization problem with a mixed-integer uncertainty set. We explicitly model tornado paths as line segments and assumed an area is affected by the tornado if it is sufficiently close to the path. We solve this problem using a decomposition column and constraint generation algorithm that exploits the geometric properties of the uncertainty set. Results are reported for real instances with over one hundred areas of interest.

4 Resilience Optimization of Interdependent Networks

Armin Tabandeh, Neetesh Sharma, Paolo Gardoni, University of Illinois Urbana-Champaign, Urbana, IL, Contact: tabande2@illinois.edu

Rapid post-disaster recovery of interdependent infrastructure is critical to regional resilience. Successful strategies to improve regional resilience require (a) mathematical models of infrastructure and their recovery, (b) tangible metrics to measure infrastructure resilience, and (c) a computationally manageable approach to optimize resilience. To this end, this work will present a multiscale model of the recovery process that reduces the computation cost while developing realistic recovery schedules that are easily manageable. This work will also discuss resilience metrics that capture the temporal and spatial variabilities of the recovery process. An optimization problem is then formulated to maximize resilience while reducing the recovery cost. Finally, the formulation is illustrated by considering a realistic example.

Tuesday, 5 PM–6:15 PM

TE39

CC - Room 201

Modeling Traffic and Transportation

Contributed Session

Session Chair

Liang Zhang, University of Arizona, Tucson, AZ

1 Optimal Sensor Placement Considering The Observability of Dynamic Traffic Systems Under Various Traffic Conditions

Xinyue Hu[1], Yueyue Fan[2], [1]UC Davis, Davis, CA, [2]University of California, Davis, CA

Traffic sensors serve a crucial role in traffic operation and management. To obtain more information under a limited budget, the strategic placement of traffic sensors has been a popular research topic. Most traffic sensor placement literature focuses on aggregated flow counts and thus does not incorporate the rich information from traffic dynamics. In some recent work where traffic dynamics is incorporated, a systematic and scalable sensor placement strategy that accounts for various traffic conditions is lacking. This research aims to fill this gap and develop a systematic sensor placement strategy to maximize the observability of link density in a highway network. Algebraic and graphical properties of highway network dynamical observability are explored and various traffic conditions are considered under a stochastic programming framework.

2 Real-time Vehicle Re-routing Under Disruption in Cross-dock Network with Time Constraints

Fahim Ahmed[1], Nathan Huynh[2], William G. Ferrell[3], Vishal Badyal[4], Bhavya Padmanabhan[5], [1]University of South Carolina, Columbia, SC, [2]University of South Carolina, Columbia, SC, [3]Clemson University, Greenville, SC, [4]Clemson University, Clemson, SC, [5] Contact: ahmedf@email.sc.edu

This study extends the vehicle routing problem with cross-dock (VRPCD) by incorporating disruption to enroute pickup trucks (e.g., traffic accident or mechanical failure) which becomes unavailable to complete its scheduled pickup of shipments from suppliers and deliver them to the cross dock. A mixed-integer linear program is developed to model the VRPCD under disruption for rerouting the trucks to maintain the flow of goods in the network. To solve the model in real-time, this paper proposes a modified Golden Ball algorithm (mGB). Experiments were performed on a hypothetical network with a cross-dock for varying disruption time and number of vehicles. The results show a significant reduction in computation time using the proposed algorithm compared to exact methods.

3 A Machine Learning-Based Traffic Signal Control Scheme Considering Vehicle Equality

Liang Zhang, Wei-Hua Lin, University of Arizona, Tucson, AZ, Contact: liangzhang@email.arizona.edu

Traffic signal control using vehicle-based data has improved the efficiency of the real-time traffic network. Equality, however, was not considered much for vehicles in the past. This research provides an equitable signal control scheme at signalized intersections using machine learning approaches. The control scheme collects vehicle-based data (speeds, locations and delay times) as the input, several constraints are given to the unsupervised learning approach to get the optimal control scheme while considering the vehicle equality at the same time. Based on the learning results, control schemes under stochastic traffic arrivals with respect to different market penetration levels are also considered. Results suggest that the proposed control schemes can help balance efficiency and equality and reduce the maximum delays at a significant level.

Tuesday, 5 PM–6:15 PM

TE41

CC - Room 203

Advances in Bilevel Optimization

General Session

Session Chair

Erfan Yazdandoost Hamedani, University of Arizona, Tucson, AZ

1 Randomized Stochastic Variance-reduced Methods for Multi-task Stochastic Bilevel Optimization

Quanqi Hu[1], Zhishuai Guo[1], Lijun Zhang[2], Tianbao Yang[3], [1]University of Iowa, Iowa City, IA, [2]Nanjing University, Nanjing, China; [3]The University of Iowa, Iowa City, IA, Contact: quanqi-hu@uiowa.edu

The existing studies on non-convex stochastic bilevel optimization (SBO) problems are limited in two perspectives: (i) sample complexities do not match the state-of-the-art result for non-convex stochastic optimization; (ii) their algorithms are tailored to problems with single lower-level problem. Processing many lower-level problems at each iteration could be prohibitive in practice. To address these limitations, we present a randomized stochastic method for non-convex SBO with m lower level problems, which processes a constant number of lower problems at each iteration, and achieves a sample complexity of no worse than O(m/□^3) for finding an □-stationary point under certain conditions. Moreover, we establish even faster convergence results for gradient-dominant functions.

2 Generalized Frank-Wolfe Algorithm for Bilevel Optimization

Nazanin Abolfazli[1], Ruichen Jiang[2], Aryan Mokhtari[3], Erfan Yazdandoost Hamedani[4], [1]University of Arizona, Tucson, AZ, [2]University of Texas at Austin, Austin, TX, [3]University of Texas at Austin, Austin, TX, [4]University of Arizona, Tucson, AZ, Contact: nazaninabolfazli@email.arizona.edu

In this talk, we consider a class of bilevel optimization problems where we minimize a smooth objective function over the optimal solution set of another convex constrained optimization problem. We propose a generalized Frank-Wolfe (FW) algorithm to solve the considered bilevel problem. When the upper-level objective is convex, we show that our method requires $O(\max\{1/\square_f, 1/\square_g\})$ iterations to find a solution that is $\square_f$-optimal for the upper-level objective and $\square_g$-optimal for the lower-level objective. Moreover, when the upper-level objective is non-convex, our method requires $O(\{1/\square_f^2, 1/(\square_f\square_g)\})$ iterations to find an $(\square_f,\square_g)$-optimal solution. We further prove stronger convergence guarantees under the Holderian error bound assumption on the lower-level problem.

3 Distributed Gradient Tracking Methods for Optimization with Variational Inequality Constraints

Farzad Yousefian, Rutgers University, Piscataway, NJ

We consider a class of distributed constrained optimization problems where the constraint set is the solution set of a distributed variational inequality problem. This problem is motivated by the need for distributed estimation of the efficiency of equilibria in game theory. First, we consider solving this problem over directed networks. We develop an iteratively regularized distributed gradient tracking method where the agents employ a push-pull protocol to communicate over the network. Second, we consider a stochastic variant of this problem over undirected networks and develop an iteratively regularized distributed stochastic gradient tracking method. For both algorithms we derive new convergence rate statements in terms of optimality and consensus violation. We also provide some preliminary numerical results.

4 Maximum-likelihood Inverse Reinforcement Learning with Finite-time Guarantees

Siliang Zeng[1], Chenliang Li[2], Alfredo Garcia[3], Mingyi Hong[4], [1]University of Minnesota, Twin Cities, Minneapolis, MN, [2]The Chinese University of Hong Kong, Shenzhen, Shenzhen, China; [3]Texas A&M University, College Station, TX, [4]University of Minnesota, Minneapolis, MN, Contact: zeng0176@umn.edu

Inverse reinforcement learning (IRL) aims to recover the reward and the associated optimal policy that best fits observed sequences of states and actions implemented by an expert. Many algorithms for IRL have an inherent nested structure: the inner loop finds the optimal policy given parametrized rewards while the outer loop updates the estimates towards optimizing a measure of fit. For high dimensional environments such nested-loop structure entails a significant computational burden. To reduce the computational burden, we develop a novel {\em single-loop} algorithm for IRL that does not compromise reward estimation accuracy. In the proposed algorithm, each policy improvement step is followed by a stochastic gradient step for likelihood maximization. We show that the proposed algorithm provably converges to a stationary solution with a finite-time guarantee.

Tuesday, 5 PM–6:15 PM

TE42

CC - Room 204

Optimization and Surrogate Methods for Black-Box Systems II

General Session

Session Chair

Hadis Anahideh, University of Illinois at Chicago, Chicago, IL

1 Applying Variational Inference on High-dimensional Gaussian Processes with Inducing Points

Moses Chan, Matthew Plumlee, Northwestern University, Evanston, IL, Contact: mosesyhc@u.northwestern.edu

Gaussian process (GP) is a popular choice of surrogates for complex computational-intensive simulation systems. But GP construction is limited by the number of data points, due to the required operations in computing the inverse and determinant of the covariance matrix. Furthermore, the output responses are typically multi-dimensional in modern applications, which significantly increases the computational burden when the output dimension is large. We propose a new surrogate method that combines ideas from principal component analysis, inducing points, and variational inference to scale GP constructions and provide meaningful uncertainty quantification. The construction method compares well with other modern surrogate methods and has potential for scaling up to larger datasets.

2 Deep Gaussian Process Upper Confidence Bound for Optimizing Non-stationary Functions and Its Application in Additive Manufacturing

Raghav Gnanasambandam, Bo Shen, Andrew Law, Zhenyu James Kong, Maede Maftouni, Virginia Tech, Blacksburg, VA

Design problems in engineering often require optimizing the part quality by finding the right combination of controllable input parameters. Bayesian Optimization (BO) is a methodology to optimize such expensive "black-box" functions. BO with GPR surrogate model is used widely for such optimization tasks. GPR has a limitation when it comes to modeling non-stationary functions. Deep Gaussian Process (DGP) can be used to overcome GPR's shortcoming by considering a composition of multiple GPs. Using the Stochastic Imputation based inference, a novel Upper Confidence Bound (UCB) based acquisition function with the DGP surrogate model is proposed for optimizing non-stationary functions. The applicability of this method is demonstrated with analytical test functions and a case study in metal additive manufacturing simulation.

3 A Model Aggregation Approach for High-dimensional Large-scale Optimization

Szu Hui Ng, Haowei Wang, Ercong Zhang, National University of Singapore, Singapore, Singapore. Contact: isensh@nus.edu.sg

Bayesian optimization (BO) has been widely used in machine learning and simulation optimization. As computational resources and storage capacities increase, high-dimensional and large-scale problems are becoming increasingly common in these fields. In this study, we propose a model aggregation method in the Bayesian optimization (MamBO) algorithm to e�ciently solve high-dimensional large-scale optimization problems. MamBO uses a combination of subsampling and subspace embeddings to collectively address high dimensionality and large-scale issues; in addition, it employs a model aggregation method to address the surrogate model uncertainty that arises when embedding is applied. Numerical experiments indicate that our algorithm achieves superior or comparable performance to other commonly used high-dimensional BO algorithms.

Tuesday, 5 PM–6:15 PM

TE43

CC - Room 205

Recent Advances in Planning and Scheduling Under Uncertainty.

General Session

Session Chair

Karmel S. Shehadeh, Lehigh University, Bethlehem, PA

1 Stochastic Optimization Approaches for An Operating Room and Anesthesiologist Scheduling Problem

Man Yiu Tsang[1], Karmel S. Shehadeh[2], Frank E. Curtis[2], Beth Hochman[3], Tricia E. Brentjens[3], [1]Lehigh University, Bethlehem, PA, [2]Lehigh University, Bethlehem, PA, [3]Columbia University Medical Center, New York, NY, Contact: mat420@lehigh.edu

We propose a combined allocation, assignment, sequencing, and scheduling problem under uncertainty involving multiple operation rooms (ORs), anesthesiologists, and surgeries, as well as methodologies for solving such problems. To address uncertainty of surgery duration, we propose and analyze stochastic programming (SP) and distributionally robust optimization (DRO) methodologies. We obtain near-optimal solutions of our SP model using sample average approximation and propose a computationally efficient column-and-constraint generation method to solve our DRO model. In addition, we derive symmetry-breaking inequalities and valid inequalities that improve their solvability. Using real surgery data, we conduct extensive computational experiments comparing the proposed methodologies and derive several managerial insights relevant to practice.

2 Stochastic Programming Models for a Home Service Fleet Sizing and Appointment Scheduling Problem with Random Service and Travel Times

Shutian Li[1], Karmel S. Shehadeh[2], [1]Lehigh University, Bethlehem, PA, [2]Lehigh University, Bethlehem, PA, Contact: shl919@lehigh.edu

We propose a new stochastic programming model (SP) for a home service fleet sizing, routing, and appointment scheduling problem with random service and travel times. Given a set of customers and providers, our models determine the number of providers to hire, customers assignments to providers, and providers' schedules that minimize hiring costs and the expected cost of customers' waiting time and providers' travel time, overtime, and idle times We conduct numerical experiments comparing our model with an extension of an existing model in the literature, demonstrating where significant performance improvements can be gained with our model and derive several managerial insights relevant to practice.

3 Strategial Waiting in Online Driver-request Assginment in Ridesourcing

HAO WANG, Xiaohui Bei, Zhenzhen Yan, Nanyang Technological University, Singapore, Singapore. Contact: yanzz@ntu.edu.sg

Online on-demand ridesourcing service has played a huge role in transforming urban transportation. In this paper, we develop an algorithm to dynamically assign drivers to rider requests that could balance the request waiting times and the driver pick-up distances. Our model allows the requests to wait after their arrival but assumes that they may leave at any time following a quitting function. Our algorithm is able to incorporate future estimated driver arrivals into consideration and make strategic waiting and matching decisions that could balance the waiting time and pick-up distance of the assignment. We prove that our algorithm is optimal ex-ante in the single-request setting, and demonstrate its effectiveness in the general multi-request setting through experiments on both synthetic and real-world datasets.

4 Stochastic Optimization Methodologies for Operating Room-to-downstream Elective Surgery Planning Under Uncertainty

Karmel S. Shehadeh[1], Man Yiu Tsang[1], Rema Padman[2], [1]Lehigh University, Bethlehem, PA, [2]Carnegie Mellon University, Pittsburgh, PA, Contact: karmelshehadeh@gmail.com

We present stochastic optimization methodologies for operating room-to-downstream surgery planning. Specifically, given sets of surgery, operating rooms (ORs) and beds in the downstream recovery units, our methodologies solve the following problems simultaneously: an assignment problem that assigns a subset of surgeries to each OR, and a scheduling problem that determines the sequence of start times of surgeries assigned to each OR. To address uncertainty in surgery durations and post-operative recovery time, we propose new stochastic programming and distributionally robust optimization (DRO) models. We propose a computationally efficient column-and-constraint generation method to solve the DRO model. Finally, we present computational experiments comparing the proposed methodologies computationally and operationally and derive managerial insights.

Tuesday, 5 PM–6:15 PM

TE44

CC - Room 206
Discrete Optimization for Society and Technology
General Session

Session Chair
Alfredo Torrico, Polytechnique Montreal, Montreal, QC, Canada.

Session Chair
Andrea Lodi, Cornell Tech, New York, NY

1 Fairness over Time in Traveling Salesman Problem

Guanyi Wang[1], Sriram Sankaranarayanan[2], Andrea Lodi[3], [1]Polytechnique Montréal, Montreal, QC, Canada; [2]IIM Ahmedabad, Ahmedabad, India; [3]Cornell Tech, New York, NY, Contact: wangguanyi2013@gmail.com

This paper studies a variant of the traveling salesman problem (TSP) -- Fairness Over Time Traveling Salesman Problem (FOT-TSP). Unlike TSP, whose target is minimizing the total cost, FOT-TSP is a multiple decision-making problem with multiple clients (i.e., locations). Decisions (feasible TSP tours) of FOT-TSP are made repeatedly in a given period to minimize the total/average unfairness. Our contributions contain three parts. The first part provides a general framework for solving a multiple decision-making problem with theoretical guarantees on unfairness. The second part applies the general framework to the FOT-TSP and solves the proposed FOT-TSP framework using column generation. In the third part, we report numerical results for some typical TSP applications to demonstrate the efficiency of the proposed method.

2 Learning Optimal Prescriptive Trees from Observational Data

Nathanael Jo[1], sina Aghaei[2], Andres Gomez[3], Phebe Vayanos[3], [1]USC Center for AI in Society, Los Angeles, CA, [2]USC, Los Angeles, CA, [3]University of Southern California, Los Angeles, CA, Contact: nathanael.jo@gmail.com

We consider the problem of learning from observational data, i.e., a personalized treatment assignment policy in the form of a binary tree of moderate depth. This problem arises in numerous socially important domains such as public health and personalized medicine, where interpretable and data-driven interventions are sought based on data gathered from deployment rather than from controlled, randomized trials. We propose a method for learning optimal prescriptive trees using mixed-integer optimization (MIO) technology. Moreover, we show that under mild conditions our method is asymptotically exact, i.e., will converge to an optimal out-of-sample treatment policy as the number of historical data samples tends to infinity. This sets us apart from existing literature on the topic which either requires data to be randomized or impose stringent assumptions on the trees.

3 Binary Control Pulse Optimization for Quantum Systems

Xinyu Fei[1], Lucas Brady[2], Jeffrey Larson[3], Sven Leyffer[4], Siqian Shen[5], [1]University of Michigan, Ann Arbor, MI, [2]NASA, Moffett Field, CA, [3]Argonne National Laboratory, Argonne, IL, [4]Argonne National Laboratory, Lemont, IL, [5]University of Michigan, Ann Arbor, MI, Contact: siqian@umich.edu

Quantum control manipulates quantum systems toward certain quantum states or desired operations. We focus on discrete binary quantum control and apply optimization to improve computational efficiency and solution quality. We introduce a squared L_2-penalty function to handle additional side constraints, to model requirements such as allowing at most one control to be active. We introduce a total variation (TV) regularizer to reduce the number of switches in the control. We modify the popular gradient ascent pulse engineering (GRAPE) algorithm, develop a new alternating direction method of multipliers (ADMM) algorithm to solve the continuous relaxation, and then apply rounding techniques to obtain binary control solutions. Our algorithms can obtain high-quality control results, as demonstrated by numerical studies on diverse quantum control examples.

4 Preserving Diversity when Partitioning

Sebastian Perez Salazar[1], Alfredo Torrico[2], Victor Verdugo[3], [1]Georgia Institute of Technology, Atlanta, GA, [2]Polytechnique Montreal, Montreal, QC, Canada; [3]Universidad de O'Higgins, Rancagua, Chile. Contact: torrico.alf@gmail.com

Given a community composed by individuals of different types, we study the problem of dividing this community such that the global diversity is preserved as much as possible in each subgroup. We consider the diversity metric introduced by Simpson in his influential work that, roughly speaking, corresponds to the inverse of the probability that two individuals are from the same type when taken at random, with replacement. We provide a novel perspective by reinterpreting this quantity in geometric terms. We characterize the instances in which the optimal partition exactly preserves the global diversity in each subgroup. When this is not possible, we provide an efficient polynomial-time algorithm that outputs an optimal partition for the

problem with two types. Finally, we discuss further challenges and open questions for the problem that considers more than two types.

Tuesday, 5 PM–6:15 PM

TE45

CC - Room 207

AI4OPT: Ethical AI and Optimization - Part II

General Session

Session Chair

Swati Gupta, ISyE Georgia Tech, Atlanta, GA

1 **Fairness Objectives in Facility Location Problems**

Swati Gupta[1], Jai Moondra[2], Mohit Singh[3], [1]ISyE Georgia Tech, Atlanta, GA, [2]Georgia Tech, Atlanta, GA, [3]Georgia Tech, Atlanta, GA, Contact: jmoondra3@gatech.edu

The classic facility location problem seeks to open a set of facilities to minimize the cost of opening the chosen facilities and the total cost of connecting the customers to their nearby open facilities. Such an objective may induce an unequal cost over certain groups of customers (i.e., total distance traveled by customers in a group). This is important when planning the location of socially relevant facilities such as emergency rooms. In this work, we consider a "fair" version of the problem by minimizing the p-norm of the distances traveled and the cost of opening facilities. This recovers classic facility location (p=1) and the minimization of the maximum distance traveled by an individual or group (p=infinity). We discuss approximation algorithms for the problem with interesting structural properties across p-norms. This is joint work with Swati Gupta and Mohit Singh.

2 **Socially Fair K-clustering**

Mehrdad Ghadiri[1], Samira Samadi[2], Mohit Singh[1], Santosh Vempala[1], [1]Georgia Institute of Technology, Atlanta, GA, [2]Max Planck Institute for Intelligent Systems, Tübingen, Germany.

We show that the popular k-means clustering algorithm (Lloyd's heuristic) can result in outcomes that are unfavorable to subgroups of data, e.g., demographic groups. Such biased clusterings can have deleterious implications for human-centric applications such as resource allocation. We present a fair k-means objective and algorithm to choose cluster centers that provide equitable costs for different groups. Our algorithm, Fair-Lloyd, inherits the simplicity, efficiency, and stability of Lloyd's heuristic and it exhibits unbiased performance on benchmark datasets by providing equitable costs in the output clustering. In comparison to Lloyd's, it only incurs a negligible increase in running time, thus making it a viable fair alternative. Finally, we review recent progress in the approximability of the socially fair k-clustering problem and discuss open problems.

3 **Reproducibility in Learning**

Russell Impagliazzo[1], Rex Lei[1], Toniann Pitassi[2], Jessica Sorrell[1], [1]UCSD, La Jolla, CA, [2]Columbia, New York, NY

Reproducibility is vital to ensuring scientific conclusions are reliable, but failures of reproducibility have been a major issue in nearly all scientific areas of study in recent decades. In this talk, we introduce a new notion of reproducibility for randomized algorithms. This notion ensures that with high probability, an algorithm returns exactly the same output when run with two samples from the same distribution. Despite the exceedingly strong demand of reproducibility, there are efficient reproducible algorithms for several fundamental problems in statistics and learning. We will introduce these problems and the techniques used to design reproducible algorithms for them. Finally, we discuss connections to other well-studied notions of algorithmic stability, such as differential privacy.

4 **Platform-supported Auditing of Social Media Algorithms for Public Interest**

Aleksandra Korolova, Princeton University, Princeton, NJ

Relevance estimators are algorithms used by social media platforms to determine what content is shown to users and its presentation order. These algorithms aim to personalize the platform's experience for users, increasing engagement and, therefore, platform revenue. However, many have concerns that the relevance estimation and personalization algorithms are opaque and can produce outcomes that are harmful to individuals or society. Legislations have been proposed in both the U.S. and the E.U. that mandate auditing of social media algorithms by external researchers. But auditing at scale risks disclosure of users' private data and platforms' proprietary algorithms, and thus far there has been no concrete technical proposal that can provide such auditing. We propose a new method for platform-supported auditing that can meet the goals of the proposed legislations.

Tuesday, 5 PM–6:15 PM

TE46

CC - Room 208

New Challenges and Opportunities in Urban Transportation Vehicle Routing
General Session

Session Chair
Vikrant Vaze, Dartmouth College, Hanover, NH

1 An Exact Solution Approach for An Electric Bus Dispatch Problem
Matias Alvo, Gustavo Angulo, Mathias A. Klapp, Pontificia Universidad Catolica de Chile, Santiago, Chile. Contact: maklapp@ing.puc.cl
We study how to efficiently plan a bus dispatch operation within a public transport terminal working with a mixed fleet of electric and diesel buses and a restricted number of chargers. To meet the daily trip demand, the dispatcher has to assign a trip schedule and a battery charge plan to each bus and also feasibly sequence charging tasks at each charger. We model this problem as an extension of the Vehicle Scheduling Problem, which we later reformulate via a decomposition approach into two subproblems; (1) a master problem assigning bus trip schedules and (2) a satellite problem sequencing charging tasks for a given set of bus trip schedules. Our exact approach dynamically injects cuts into the B&B tree to remove infeasible bus trip schedules. We assess the effectiveness of our approach in computational experiments inspired by a bus operator from Santiago, Chile.

2 Enhancing The Rural Commute: A New Spatial Decomposition Approach for Service Region Design and Fleet Sizing for First-last Mile Transit Access
Yineng Sun, Vikrant Vaze, Dartmouth College, Hanover, NH, Contact: phoebe.sun.th@dartmouth.edu
Over a million US households in primarily rural counties lack access to private cars and must rely on public transit. Yet, 87% of the 200 least productive bus networks are in rural counties. Effective first-last-mile connections via on-demand ridesharing can enhance access, but design of such a system must account for the sparsely distributed demand hotspots and geographically dispersed origins and destinations. To address these distinctive challenges, we propose a two-stage model with service region design and fleet sizing in the first stage and on-demand dynamic pickup and dropoff decisions in the second. We develop a spatial decomposition approach informed by an exact second-stage routing formulation and a vehicle dispatch simulation. On real-world case study instances, our approach outperforms benchmarks, yielding substantial gains to passengers and operators.

3 Centralize or Distribute? Multi-vehicle Pickup Routing with Distributed Disposal Option for Composting Mode Assignments
Lilly Yang, Vikrant Vaze, Laurens G. Debo, Dartmouth College, Hanover, NH, Contact: Lilly.Yang.TH@dartmouth.edu
Food waste in landfills is an avoidable source of methane emissions responsible for global warming. While composting offers a greener alternative increasingly mandated by governments, cost & ability to compost in one's backyard varies unevenly & inequitably across households. Customer dropoffs & curbside pickups enable a centralized composting alternative with lower processing cost due to economies of scale. But it incurs additional transportation cost & raises the question how to minimize total systemwide costs. Mathematically, this amounts to multivehicle pickup routing with a distributed disposal option. We use continuum approximation for a stylized circular city to underscore peculiar discontinuous tradeoff curves unique to this problem. Our real-world computational case study results in the most populous county in Vermont quantify the total cost savings.

4 Back to The School Bus:a Cluster-then-route Heuristic Forruralmixed-loadschoolbusroutingproblem Withendogenous Congestion
Prabhat Hegde, Dartmouth College, Hanover, NH, Contact: Prabhat.Hegde.TH@dartmouth.edu
Shorter school bus commutes improve student performance and well-being, and make the school bus a more attractive travel mode. One-third of US schools, classified as rural schools, are characterized by mixed-loading across a small number of school buses. Sub-optimal rural bus routes encourage car drop-offs leading to school area congestion, which delays school buses and further reduces their mode shares. To break this vicious cycle, we formulate a mixed-load school bus routing problem to minimize student travel time, and propose a road-network aware cluster-then-route heuristic, motivated by the lower-density rural road network. For real-world case study datasets, our approach beats previous benchmarks reducing student travel time by over 20%, and demonstrates the potential that shorter bus commutes have in increasing bus ridership and reducing road congestion.

Tuesday, 5 PM–6:15 PM

TE48

CC - Room 210

Transportation and Natural Disasters

Contributed Session

Session Chair

Saviz Saei, Mississippi State University, Starkville, MS

1 Applying Big Data Techniques to Multimedia Social and Other Data to Assess Road Status in near Real Time

Adetola Odebode[1], Ashlea Bennett Milburn[2], Jose Hernandez Azucena[1], Haitao Liao[2], Serhan Dagtas[3], Christopher Angel[1], Justin Zhan[1], Xiao Huang[1], Sharafat Hossain[4], [1]University of Arkansas, Fayetteville, AR, [2]University of Arkansas, Fayetteville, AR, [3]University of Arkansas-Little Rock, Little Rock, AR, [4]University of Arkansas-Little Rock, Little Rock, AR, Contact: aoodebod@uark.edu

Transportation infrastructure is often damaged following a disaster. Real-time situational awareness detailing the status of roads and bridges along which vital movements (e.g., supply distribution, evacuation, and search and rescue dispatches) must occur is critical for a successful and efficient disaster response. To provide this, we design a framework using state-of-the-art data analytics tools and methods to route critical resources with up-to-date knowledge of disrupted roads. This framework fuses social media data with other data sources such as highway traffic camera streams, stream gauges, and satellite imagery to enhance the credibility of information describing transportation infrastructure. Work in progress towards implementing this framework is presented. Hurricane Harvey is used as an implementation testbed.

2 Characterizing Logistics Operations Within a Federal Staging Area for Hurricane Response: A Qualitative Analysis of Federal, State and Local Perspectives

Jannatul Shefa, Ashlea B. Milburn, University of Arkansas, Fayetteville, AR, Contact: jshefa@uark.edu

A successful deployment of logistics operations following a disaster is a collective contribution of federal, state and local entities to ascertain an efficient and effective response. This paper analyzes data from interviews with disaster response logistics experts from these entities. The objective is to investigate the information sources and planning processes used in these organizations to plan vehicle routes for critical resource deliveries to impacted areas. Special attention is directed to the impacts of incomplete knowledge of infrastructure status, such as road disruptions due to flooding. Supported by both qualitative and quantitative evidence, this research reveals both similarities and differences in logistical decision making among these organization types.

3 Post-Disruption Debris Cleaning Problem: A Reinforcement Learning Approach

Saviz Saei, Nazanin Morshedlou, Mississippi State University, Starkville, MS, Contact: ss4646@msstate.edu

Despite being undervalued, Post disruption debris cleaning is the most critical procedure to recover network connectivity and accelerate residential and casualty evacuation. We study the post-disaster road clearing problem to recover the shortest paths in such critical locations as hospitals, shelters, and emergency warehouses. The objective of this problem is to maximize the residual network performance by clearing the shortest paths to reach the critical nodes. We solve such problems by developing a reinforcement learning-based approach to learn the best cleaning schedule under a partially observed environment. In this problem, vehicles interact with their surrounding road environment observing cleared paths to critical nodes as rewards and prolonged routing times as negative points.

4 Predictive Risk Modeling to Support Boston Public Transportation System Resource Mobilization in Preparation for Inclement Weather Events

Danielle Song, Xiaotong Ding, Ching-Wei Kuo, John Maleyeff, Boston University, Boston, MA

To ensure the safety of passengers and staff, the Massachusetts Bay Transportation Authority takes several actions to prepare the system for approaching winter storms. This presentation describes the use of predictive risk analytics so that these actions ensure safety and cost-effectiveness. The methods included data and feature engineering, machine learning, and multivariate and categorical data analysis. Severity levels are predicted for risks associated with road slickness, ice accumulations on signals and platforms, snow depth in parking lots and bus stops, and train engine clogging due to snow fluffiness. Timely decisions are supported by displaying risk severities on an hourly basis using time series visualizations.

Tuesday, 5 PM–6:15 PM

TE49

CC - Room 211

TSL/Urban Transportation Planning and Modeling Flash Session

Flash Session

Session Chair

Rishi Verma, University of Washington, Seattle, WA

1 Trading Flexibility for Adoption: From Dynamic to Static Walking in Ridesharing

Julia Y. Yan, University of British Columbia, Vancouver, BC, Canada.

On-demand ridesharing aims to fulfill riders' transportation needs anytime and anywhere. Although this is appealing for riders, overall system efficiency can improve substantially if riders can be flexible. We explore riders' flexibility in space via walking to better pickup locations. Ridesharing platforms traditionally use *dynamic walking*, which jointly optimizes rider-driver assignment with pickup locations. We instead propose *static walking*, which presents a fixed pickup location to the rider, then optimizes assignment. We study characteristics of networks that make static walking viable, propose algorithms for static walking, and apply our algorithms to Lyft data in Manhattan.

2 A Hybrid Genetic Algorithm Coupled with Dynamic Programming for Solving Traveling Salesman Problem with Drone

Sasan Mahmoudinazlou, Changhyun Kwon, University of South Florida, Tampa, FL

The Traveling Salesman Problem with Drone (TSP-D) is a new transportation problem, where a drone collaborates with a truck to deliver parcels. This paper introduces a hybrid genetic algorithm with use of various local search methods along with a dynamic programming approach to solve TSP-D problems with the objective of minimizing the makespan. The technique used in this research is to use genetic algorithm for partitioning and sequencing the customers, while using dynamic programming for joining them. The GA generates the sequence and assigns each customer to either the truck or the drone. DP finds the best possible launch and land positions for the drone.

3 Optimal Time to Initiate Hurricane Evacuation Under Uncertainty

Hanwen Liu[1], Qi Luo[2], Yongjia Song[2], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC

Before the hurricane makes landfall, governments must determine when and where to evacuate residents. Finding evacuation policies (traffic flows to different shelters) with limited capacities is difficult due to the unpredictable nature of hurricane forecasts and various transportation constraints. We model the fluctuating demand in a large-scale transportation problem with an optimal stopping model that balances accuracy and computation time. It has no specific requirements for the underlying stochasticity and is capable of producing high-fidelity results in high-dimensional scenarios in a short amount of time.

4 BHH Theorem Through a Big Data Lens: TSP/VRP Approximation for Assessing Urban Transportation Efficiency

Hao Hao[1], Hai Wang[2], Peter Zhang[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Singapore Management University, Singapore, Singapore. Contact: haohao@andrew.cmu.edu

Estimation of optimal vehicle route length in transportation networks is important for evaluating the cost of transportation and transportation-enabled services. The BHH Theorem approximates the length of an optimal TSP tour covering *n* nodes in a region of area *A* as □√(*nA*). Using large-scale transportation data, we calibrate the value □ in BHH-like expressions for several TSP/VRP variants under different demand distributions for hundreds of cities worldwide. We use Interpretable models to identify the key factors that affect □, i.e., affect the efficiency of the transportation networks. The node density, the average node degree, and the city's shape are the most significant predictors of □.

5 Autonomous Modular Vehicle Technology Based Public Transit Paradigm: A Preliminary Investigation

Xi Cheng[1], Jane Lin[2], [1]University of Illinois-Chicago, Chicago, IL, [2]University of Illinois-Chicago, Chicago, IL, Contact: xicheng5@uic.edu

Toward to a more intelligent and green urban transportation future, emerging Autonomous Modular Vehicle Technology (AMVT) makes it possible to help public transit more efficient and attractive, converting more people from private vehicles to public transportation. This study conducts a preliminary investigation on a gridded transit network incorporating this AMVT pods. Four scenarios are proposed, and corresponding optimization frameworks are developed to minimize the time cost from both agency and user sides. These scenarios are compared from the aspect of optimal results, which shows that this new technology help save the cost because of varying pods capacity, especially in the low demand level. Also, some properties about joining and disjoining of pods are investigated.

6 Flash Paper

Ayan Mukhopadhyay, 1</sup

Resource allocation based on algorithmic methods is now prevalent in transportation. Such approaches use data-driven models to forecast a variable of interest and then optimize the allocation of resources based on the forecasting model. A prototypical example of data-driven resource allocation is shared micro-mobility programs, where predicted ridership is used to optimize the allocation of resources (e.g., bike stations). However, such an approach to allocation may unintentionally incorporate implicit bias, resulting in inequity in resource allocation. I will describe such approaches and how unfairness mitigators can be used to ensure fairness in forecasting methods.

7 Quantifying Impacts of Curbside Allocation Policy Using Conditional Value at Risk

Rishi Verma, University of Washington, Seattle, WA, Contact: rverma32@uw.edu

Cities face an important decision on how to allocate the finite and valuable space on the curbside. However, it can be difficult to define metrics that show the impacts of a particular curbside policy. We propose a model that determine the number of curbside spaces in each of three categories (CVLZ, metered parking, PLZ) based on the current demand for commercial unloading, passenger parking, and passenger unloading. We then use Conditional Value at risk to minimize the traffic congestion resulting from unmet demand for space for commercial unloading and thereby quantify the impact of curbside allocation policies in vehicle-minutes per hour.

Tuesday, 5 PM–6:15 PM

TE50

CC - Room 212

FinTech and AI Technologies in Business Operations

General Session

Session Chair

Mariia Petryk, University of Florida, Gainesville, FL

1 The Art of Free Tokens: An Economic Analysis of Promotional Cryptocurrency Airdrops

Xinyu Zang, Xiang Wan, Hsing K. Cheng, University of Florida, Gainesville, FL, Contact: Xinyu.Zang@warrington.ufl.edu

Initial coin offerings (ICOs), as a significant source of fundraising for blockchain projects, have become one of the most prominent topics of extant blockchain-related research. Recently, many blockchain-based startups have employed the strategy of “airdrop” to gain attention from new investors and get more investors trading in it when it lists during the ICO. This study develops a two-period model incorporating the airdrop strategy. Our study has important implications for various stakeholders.

2 The Role of Community Commerce on Product

Hazel Hye Seung Kang, Boston University, Boston, MA

Increasingly more e-commerce platforms are integrating online communities to facilitate and gamify the purchasing decision process of consumers. First, we formally conceptualize this new phenomenon, defined as community commerce, in relation to other traditional WOM mediums such as online reviews and Q&A forums. Second, we explore the mechanism of how the informational transfer within community commerce may modify product evaluations on e-commerce platforms.

3 Get Fit. Improving The Performance of Transfer Learning Models in The Digital Customer Care Context

Katsiaryna Siamionava[1], Saby Mitra[2], Sridhar Narasimhan[3], Zhan Fu[4], Xiaojie Lan[5], Shane McCord[5], [1]Arizona State University, Scottsdale, AZ, [2]University of Florida, Gainesville, FL, [3]Georgia Institute of Technology, Atlanta, GA, [4]AT&T, Plano, TX, [5]AT&T, Plano, TX

Transfer learning (TL) has become an important part of natural language processing and shows a good fit in various text classification and sequence prediction tasks. It is important to understand how TL models can be adjusted to the peculiarities of business environments. In this study, we analyze challenges related to the adoption of a popular TL model, Bidirectional Encoder Representations from Transformers (BERT), in the context of customer satisfaction prediction in technical care chats. We show that unique features of the business domain, as well as customer and agent text quality, may affect BERT performance. We introduce a customized BERT layer with human-curated features that adapt BERT to a particular business problem, and interaction context. We also propose a framework for BERT’s integration in a real-time customer satisfaction monitoring system.

4 Uncover The Hidden Profit: How The Fintech Platform Optimizes Its Profit by Misleading Investors?

Jue Wang[1], Wenyao Hu[2], [1]University of Massachusetts Amherst, Amherst, MA, [2]Saint Mary’s University, Halifax, NS, Canada. Contact: juewang@umass.edu

This paper illustrates a phenomenon in which the P2P platform displays almost 40% of all loans during the first minutes of each releasing hour and charges significantly higher fees than other loans after controlling for loan characteristics and various fixed effects. Furthermore, our causality identification strategies yield that the platform intentionally lists loans with more fees in the first minute to maximize its profit. Moreover, the results are more significant for loans with higher successful funded probability. We further demonstrate that the platform intentionally selects loans into the first minute of an hour by presenting that first-minute loans have higher pre-listing waiting times than others. Finally, we also find that borrowers with loans in the first minutes have less probability of requesting another loan with the platform.

Tuesday, 5 PM–6:15 PM

TE53

M - Denver
Logistics
Contributed Session

Session Chair

Deepankar Sinha, Indian Institute of Foreign Trade, KOLKATA, India.

1 Truck Multi-drone Capacitated Pollution Routing Problem with Simultaneous Delivery and Pickup

Arash Alizadeh, Sharan Srinivas, James Noble, University of Missouri, Columbia, MO, Contact: aadhb@umsystem.edu

In this study, the cooperative routing of a truck multi-drone system for simultaneous parcel delivery and pickup is addressed. Unlike most prior works, we consider capacitated fleets with variable speeds and seek to minimize the logistic costs (i.e., weighted sum of fuel consumption and driving costs). The problem is formulated as mixed integer linear programming model to optimally solve small instances and understand its properties. Subsequently, the insights gained are used to develop an adaptive large neighborhood search (ALNS) algorithm for solving large instances in a reasonable time. Numerical results show a substantial reduction in logistic costs compared to a traditional truck-only delivery. Besides, several practical recommendations on speed optimization and capacitated routing for the hybrid truck-drone fleet are provided.

2 Forecasting of Container Traffic in a Seaport - a Soft Computing-based Hybrid Model

Deepankar SINHA[1], JAYANTA KUMAR DAS[2], Sujit Kumar Mukherjee[3], [1]Indian Institute of Foreign Trade, KOLKATA, India; [2]Indian Institute of Social Welfare and Business Management, KOLKATA, India; [3]Maulana Abul Kalam University of Technology, KOLKATA, India. Contact: dsinha2000@gmail.com

The cargo traffic time series have high complex non-linearity, dynamic variation, and irregularity. Traditional linear models like Box Jenkins fails to capture the non-linearity. Models using soft computing techniques are suitable for short-term forecasting. Thus, the authors attempt to capture such variations to make reasonably accurate forecasts and enable Indian ports to plan effectively. The method uses EEMD (Empirical Envelop Mode Decomposition), Support Vector Machine (SVM), and Single Layer Feed Forward Neural Network as building blocks for a hybrid model to forecast the cargo traffic volume port of Kolkata. This study investigates the method to capture deviations and breaks in the time series, which may be due to several external exogenous factors, and forecast reasonably accurately for a long time. Comparing the RMSE shows better performance.

3 Parallel Vehicle Routing Optimization for Heterogeneous Fleets

Akif Cördük, Nvidia, Munich, Germany. Contact: acoerduek@nvidia.com

In this work, we present a fast CVRPTW optimizer for tightly constrained heterogeneous problems. State of the art local search algorithms don't consider heterogeneous properties of the problem whereas in reality fleets have diverged set of heterogeneous constraints such as earliest and latest shift time, capacities, dropping trips from or to depot, operating costs etc. Considering heterogeneity is needed to efficiently allocate a subset of vehicles from a fleet. We propose a massively parallel GPU implementation that creates a pool of initial solutions that cover the search space homogeneously to handle the structural difficulties of the heterogeneous problem. The pool of solutions are improved using parallel local search algorithms on GPU. We present high quality results on datasets that resemble industry needs and compare against other methods.

4 Robot Dispatching Problem for Compact Storage and Retrieval System

Dongjun Cai, Xing Zheng, National University of Singapore, Singapore, Singapore.

Robotic compact storage and retrieval system (RCSRS) is a grid-based system which has been popularly implemented by online retailers recently. In this system, the inventoried items are stored in bins and the bins are stacked on top of each other, forming the dense storage stacks. . Here we study on the robots dispatching problem for RCSRS system, aiming to reduce robots' empty travelling time and workstations' idle time. In this problem, the robots follow dual-command transaction (DC) which implicates the storage transaction immediately follow a retrieval transaction at workstations. Hence, an Mixed integer programming model catering for the dual command transaction process was formulated to optimise the system performance and an adaptive neighboring search with greedy algorithm was proposed to solve the problem.

Tuesday, 5 PM–6:15 PM

TE54

M - Marriott 1
Linear Programming and Conic Optimization
Contributed Session

Session Chair
Saman Mohsenirad, Virginia Tech, Blacksburg, VA

1 Symmetric Strong Duality in Continuous-time Linear Programming
Evgeny Shindin, IBM Research - Haifa, Haifa, Israel.
Continuous-time linear programs (CLP) were formulated by Bellman in 1953. Duality theory for CLP and its sub-classes has been studied by several authors. However, duality results for Bellman CLP problems obtained so far are still fairly limiting. We consider a generalization of CLP where solutions reside in the space of functions of bounded variation. We formulate a symmetric dual problem and show that under Slater-type conditions both primal and dual problems possess optimal solutions and there is no duality gap.

2 Generalization of Doubly Nonnegative Cone: Focusing on Inner-approximation for Generalized Copositive Cone
Mitsuhiro Nishijima, Kazuhide Nakata, Tokyo Institute of Technology, Meguro-ku, Japan. Contact: nishijima.m.ae@m.titech.ac.jp
We aim to provide better relaxation for generalized completely positive (copositive) programming. We first develop an inner-approximation hierarchy for the generalized copositive cone over a symmetric cone. Exploiting this hierarchy as well as the existing hierarchy proposed by Zuluaga et al. (SIAM J Optim 16(4):1076--1091, 2006), we then propose two generalized doubly nonnegative (GDNN) cones. They are (if defined) always tractable, in contrast to the existing GDNN cone proposed by Burer and Dong (Oper Res Lett 40(3):203--206, 2012). We also investigate the inclusion relationship between the three GDNN cones. The result of solving GDNN programming relaxation problems shows that the proposed GDNN cones provide a tighter bound than the existing one in most cases. To sum up, the proposed GDNN cones have theoretical and numerical superiority over the existing one.

3 Linear Relaxations for Mixed Integer Nonlinear Programs in Natural Gas Transportation Networks
Sai Krishna Kanth Hari, Los Alamos National Laboratory, Los Alamos, NM, Contact: hskkanth@gmail.com
Efficient and profitable transportation of natural gas along pipeline networks requires solving challenging Mixed-Integer Nonlinear Programs (MINLPs) as the gas flow is governed by nonlinear, non-convex physics. Obtaining tight bounds on the objective value of these MINLPs using convex relaxations is of significant interest in the research community. Here, we utilize the recent advancements in the literature of polyhedral relaxations for univariate and bilinear functions to develop Linear Programming and Mixed Integer Linear Programming relaxations for the MINLP.

4 A Methodological Framework for Accounting for Mixed Data in Data Envelopment Analysis (DEA): The Coexistence of Mixed Data in Environmental and Input/output Setup
Saman Mohsenirad[1], Konstantinos P. Triantis[2], Taylan Topcu[1], [1]Virginia Tech, Blacksburg, VA, [2]Virginia Tech, Falls Church, VA, Contact: samanrad@vt.edu
Mixed dataset includes both quantitative and qualitative information. Mixed data poses three problems for DEA. First, qualitative input or output transforms DEA into a non-linear, non-convex problem. Second, qualitative data imprecision can impair DEA's efficiency ranking. Third, qualitative environmental variables can generate DMU heterogeneity in mixed data (e.g., income class, gender, etc.). Multivariate techniques for finding environmental differences among DMUs must be adjusted for qualitative aspects in this case. This study integrates supervised classifiers with Fuzzy DEA to overcome these difficulties. We propose a new Ranking Reliability Index and a new Environmental Dependency Analysis for DEA.

Tuesday, 5 PM–6:15 PM

TE55

M - Marriott 2
Learning in Dynamical Environments

General Session

Session Chair
Gal Mendelson, 1</sup

1 Anytime Concentration of Contractive Stochastic Approximation with Applications in Reinforcement Learning

Siva Theja Maguluri, Georgia Institute of Technology, GA

A large class of RL algorithms are based on stochastic approximation (SA) of operators that are contractive under arbitrary norms. Finite sample convergence guarantees of SA algorithms have been recently established by bounding the mean-square error. The focus of this work is to obtain stronger guarantees on tail of errors, which enables us to provide PAC style guarantees on the algorithms. We first consider SA with additive noise that arises in supervised learning applications, and obtain strong we obtain subgaussian tail bounds that are valid for all time. We then consider SA with multiplicative noise that arises in RL, and obtain superpolynomial tail bounds that reduce to exponential tails when the contraction is strong enough. Key idea of the proof is to use exponential Lyapunov functions to construct supermartingales, and to apply Ville's inequality.

2 Load-Balancing with Unknown Service Rates

Weina Wang, Carnegie Mellon University, CA

Today's computing systems consist of servers that offer highly heterogeneous service rates due to the diverse machine types and the dynamic computing environment. In such a system, to guarantee low latency, load-balancing algorithms need to consider not only the amount of work on servers but also their service rates. However, because of the dynamic nature of the computing environment, the service rates cannot be obtained beforehand and thus have to be learned on the fly. In this talk, we present recent developments in learning-integrated load-balancing policies.

3 A Policy Gradient Algorithm for The Risk-sensitive Exponential Cost MDP

Mehrdad Moharrami[1], Yashaswini Murthy[1], Arghyadip Roy[2], R. Srikant[3], [1]University of Illinois, Urbana, IL, [2]Indian Institute of Technology Guwahati, Guwahati, India; [3]University of Illinois, Urbana, IL

We study the risk-sensitive exponential cost MDP formulation and develop a trajectory-based gradient algorithm to find the stationary point of the cost associated with a set of parameterized policies. We derive a formula that can be used to compute the policy gradient from (state, action, cost) information collected from sample paths of the MDP. Unlike the average-cost problem, standard stochastic approximation theory cannot be used to exploit this formula. We introduce a truncated and smooth version of the risk-sensitive cost and show that this new cost criterion can be used to approximate the risk-sensitive cost and its gradient uniformly under some mild assumptions. We then develop a trajectory-based gradient algorithm to minimize the smooth truncated cost and derive conditions under which a sequence of truncations can be used to solve the untruncated cost problem.

4 Diffusion Asymptotics for Sequential Experiments

Kuang Xu[1], Stefan Wager[2], [1]Stanford Graduate School of Business, Stanford, CA, [2]Stanford GSB, Stanford, CA

We propose a new diffusion-asymptotic analysis for sequentially randomized experiments, including those in solving multi-armed bandit problems. We show that a class of sequentially randomized Markov experiments converges to a diffusion limit, which enables us to derive refined, instance-specific characterization of the stochastic dynamics of adaptive experiments. We use the diffusion limit to obtain several new insights on the regret and belief evolution of sequential experiments, including Thompson sampling. We show that all sampling policies that admit a Lipschitz sampling function necessarily suffer from a sub-optimal regret performance when the reward gaps are relatively large. We then show that a version of Thompson sampling with an asymptotically uninformative prior variance achieves nearly-optimal instance-specific regret scaling in this regime.

Tuesday, 5 PM–6:15 PM

TE56

M - Marriott 3
Online Algorithms for Revenue Management
General Session

Session Chair
Yash Kanoria, Columbia University, Cambridge

Session Chair
Akshit Kumar, New York

1 Approximation Algorithms for Online Resource Allocation with Logarithmic Regret Bound

Jiashuo Jiang, New York Uniersity, New York, NY

We consider a general online resource allocation problem, where there are multiple resources, each with an individual initial capacity. There is a horizon of finite time periods. At each time period, one request arrives and is associated with a random size, which denotes how much resources will be consumed by serving this query, as well as a random reward. The online decision of accepting or rejecting is made after the size and the reward is realized, without knowing the realization of the future queries. We assume that the size/reward of each query is drawn i.i.d. from a joint distribution. For both settings with given or unknown distribution, we develop online algorithms to achieve a logarithmic regret bound, which is of optimal order. Our analysis improves the previous ones in the literature by getting rid of the assumption over the "position" of the fluid benchmark.

2 Dynamic Allocation of Reusable Resources: Logarithmic Regret in Hierarchical Networks

Xinchang Xie[1], Itai Gurvich[2], Simge Küçükyavuz[3], [1]Northwestern University, Evanston, IL, [2]Northwestern University, Kellogg School of Management, Evanston,, IL, [3]Northwestern University, IEMS department, Evanston,, IL, Contact: i-gurvich@kellogg.northwestern.edu

We re-visit a basic problem in revenue management with reusable resources. A decision maker is dynamically allocating multiple types of reusable resources to arriving customers of multiple types. The only decision is whether to accept a request (admit a customer) or decline the request. An admitted customer generates a reward for the decision maker, and occupies (simultaneously) multiple types of resources for a random amount of time.
We prove that in networks that satisfy an overload condition, the performance gap between the optimal policy and the prophet upper bound is logarithmic in the number of resource units. The asymptotic regime is the now standard high-volume man-server regime.
We develop an appealingly simple threshold policy that achieves this near optimality. Importantly, in a network with n customer types and d resource types, the number of thresholds is the same as the number of resources.

3 Multi-secretary Problem with Many Types

Omar Besbes[1], Yash Kanoria[2], Akshit Kumar[3], [1]Columbia University, New York, NY, [2]Columbia Business School, New York, NY, [3]Columbia Business School, New York, NY

We study the multisecretary problem with capacity to hire up to B out of T candidates, and values drawn i.i.d. from a distribution F on $[0,1]$. In this work we consider a large class of distributions which includes the few discrete types as a special case. We establish the insufficiency of the common certainty equivalent heuristic for distributions with many types and "gaps'' (intervals) of absent types; it leads to regret of $\Theta(\sqrt{T})$. We introduce a new algorithmic principle which we call ``conservativeness with respect to gaps'' (CwG), and use it to design an algorithm that applies to any distribution. We establish that the proposed algorithm yields optimal regret scaling of $\Tilde{\Theta}(T^{1/2 - 1/(2(\beta + 1))})$ for a broad class of distributions with gaps. We recover constant regret scaling for the special case of a bounded number of types.

4 Charging Fleets of E-bikes and E-scooters

Alyf Janmohamed[1], Shane Henderson[2], David B. Shmoys[2], [1]Cornell University, Ithaca, NY, [2]Cornell University, Ithaca, NY, Contact: aaj54@cornell.edu

Over the last couple of years, there has been a significant increase in demand for micromobility systems (bike and scooter sharing), especially for electric options. In response, system operators are deploying more e-bikes and e-scooters while some have entirely electric fleets. Electrifying these vehicles creates new operational challenges around charging. We model a dockless e-bike/e-scooter sharing system with employees (juicers) that travel to uncharged vehicles and swap batteries. Juicers are assigned to distinct non-overlapping regions in a city, and the system is modelled as a closed queuing network where each region has two queues: charged and uncharged bikes. We formulate and solve a pricing problem to set static prices for trips between regions and prove performance guarantees relative to the optimal dynamic policy for finite unit systems.

Tuesday, 5 PM–6:15 PM

TE58

M - Marriott 5

Forecasting and Data Science for Renewable Energy

General Session

Session Chair

Ahmed Aziz, Rutgers University, Piscataway, NJ

Session Chair

Feng Ye, [1</sup]

1 Sky Image-informed Deep Learning for Intra-hour Solar Forecasting

Cong Feng, [1</sup]

The exponential growth of solar energy poses challenges to power systems, mostly due to its uncertain and variable characteristics. It makes solar forecasting, at all timescales, beneficial to the reliable and economic power system operations. Compared to longer forecasting scales, very short-term solar forecasting has lagged behind in both research and practice. The issue is compounded as solar forecasting is shifting to the probabilistic paradigm. In this research, we develop a series of deep convolutional neural networks, called SolarNets, to generate deterministic and probabilistic intra-hour operational solar forecasts. The SolarNets utilize the state-of-the-art deep learning architecture and are tailored to the solar forecasting regression problem. The forecast uncertainty is captured by the scenarios generated by the sky image occlusion perturbation and modeled by the Bayesian model averaging. Case studies based on six years of data (over 150,000 data points) demonstrate that the SolarNet has forecast skill scores of 20%-39% over the naive persistence of cloudiness benchmark, even at these very short timescales. The SolarNets also have consistently superior performance when compared to shallow machine learning models with meteorological predictors, where the improvement averages around 7%. The sensitivity analyses show that the sky image length, resolution, and weather conditions have impact on the deep learning model accuracy. In our intra-hour problem with specific setups, two sky images with a 10-minute 128 × 128 resolution yield the most accurate forecasts. The SolarNet can also generate realistic and diverse forecast scenarios with a 0.966 average correlation with the actual time series, and reliable and sharp probabilistic forecasts with a 2.77% normalized continuous ranked probability score

2 Use Probabilistic Forecasts in Reliable and Economic Electricity Market Scheduling and Operations

Binghui Li[1,2], Benjamin Field Hobbs[3], Jie Zhang[1], Thomas Mosier[2], [1]The University of Texas at Dallas, Richardson, TX, [2]Idaho National Laboratory, Idaho Falls, ID, [3]Johns Hopkins University, Baltimore, MD, Contact: binghui.li@utdallas.edu

The value of probabilistic forecasts in electricity market operations is being increasingly recognized lately, however, the use is still limited. This study demonstrates two cases of using probabilistic forecasts in scheduling and operations of the California electricity market. We first develop a data-driven method to give weather-informed estimates of ramping reserves based on short-term probabilistic solar irradiance forecasts. By using forecasts across multiple sites, our proposed method presents advantages over the real-world baseline in terms of system reliability and economics. Our second case uses probabilistic hydro power forecasts in the scheduling of a hydro power plant under economic and environmental constraints. By optimizing the bids into both the day-ahead and real-time markets, our results demonstrate considerable economic benefits.

3 Data Science in Wind Energy

Andrew Kusiak, University of Iowa, Iowa City, IA

The wind energy industry is undergoing a digital transformation. Wind turbines are well suited for applications of data science. The analogy between digitization in manufacturing and wind energy is explored and illustrated with models and algorithms that are common to the two application domains.While the phenomena and processes in wind energy industry differ from those in manufacturing, some of the modeling and solution approaches are similar. Applications of data science in the two industries face data challenges that are discussed.

4 Enabling Offshore Wind Energy Via Physics-guided Spatio-temporal Data Science: Towards Accurate Probabilistic Forecasting with Airu-wrf

Feng Ye[1], Joseph Brodie[2], Ahmed Aziz Ezzat[1], [1]Rutgers University, Piscataway, NJ, [2]Rutgers University, Piscataway, NJ, Contact: aziz.ezzat@rutgers.edu

We present a spatio-temporal data science model, called the AI-powered Rutgers University Weather Research and Forecasting (AIRU-WRF) model, which integrates physics-based numerical weather predictions with high-resolution measurements, in order to make turbine-specific, short-term wind forecasts. In contrast to black-box machine learning or purely physics-based methods, AIRU-WRF is a "physics-guided" statistical approach, i.e., it is designed to capture salient physical features of the offshore wind field, without the need to explicitly solve for those physics. Tested on actual measurements from the New York/New Jersey Bight—in vicinity to at least three ongoing offshore wind project developments—the forecasts made via AIRU-WRF are shown to significantly outperform prevalent benchmarks in the forecasting literature and practice.

Tuesday, 5 PM–6:15 PM

TE59

M - Marriott 6

High-Dimensional Data Analytics for Systems Informatics

General Session

Session Chair

Mostafa Reisi Gahrooei, University of Florida, Gainesville, FL

Session Chair
Meng Zhao, Gainesville

1 Penalized Cp Tensor Completion of High-dimensional Hydraulic Data for Online Burst Detection in Water Distribution Systems

Shenghao Xia, Jian Liu, Kevin Lansey, University of Arizona, Tucson, AZ, Contact: shenghaoxia@arizona.edu

Detecting bursts from high-dimensional hydraulic data in a timely manner is critical for the rapid maintenance of the water distribution system. Traditional burst detection methods based on statistical process control and basis expansion failed to consider the spatial-temporal (ST) correlations embedded in the hydraulic data continuously collected from multiple spatially distributed locations, leading to inaccurate detection and localization of bursts. This research proposes a new method based on Penalized CANDECOMP/ PARAFAC (CP) Tensor Completion, which identifies bursts according to the deviation from the predicted normal hydraulic data. Penalization is adapted in the method to regularize the embedded ST structure and reduce the false alarm rate. The effectiveness of the proposed method is demonstrated with a case study based on high-fidelity simulation.

2 Structural Learning of Functional Directed Graphical Models with Incomplete Signals

Dengyu Li[1], Kaibo Wang[2], [1]Tsinghua University, Beijing, China; [2]Tsinghua University, Beijing, China. Contact: lidy20@mails.tsinghua.edu.cn

Functional directed graph model (DGM) learning has been widely used to analyze complex systems. Most existing works assume that the functional signals are complete, which in reality is not true. To address this problem, in this study, a framework for DGM learning with incomplete signals is proposed. Specifically, a penalty term that integrates information from the graph structure is added to the Maximum Margin Matrix Factorization objective function. The proposed method can be used with a known structure to estimate the functional relationship between nodes or with an unknown structure to estimate the relationship together with the graph structure. Numerical experiments and a real-world case study of monocrystalline silicone manufacturing are performed to verify the effectiveness of the proposed method when the signal matrices are incomplete.

3 Scalable Modeling and Prediction of High-dimensional Data Using Multivariate Gaussian Processes Based on Bayesian Model Averaging

Jinwen Sun[1], Shiyu Zhou[2], Dharmaraj Veeramani[2], [1]University of Wisconsin-Madison, Madison, WI, [2]University of Wisconsin-Madison, Madison, WI, Contact: jsun279@wisc.edu

The multivariate Gaussian process (MGP) model is a flexible nonparametric approach to nonlinear regression problems. In this study, a pairwise structure is adopted by decomposing the full multivariate model into a group of bivariate models. Furthermore, a Bayesian model averaging approach is utilized to combine the prediction results of bivariate models. And a model selection scheme based on the Bayesian factor is employed to alleviate negative transfer and further facilitate the model scalability by discarding the weakly correlated outputs. The key feature of the proposed model is that the prediction and uncertainty quantification performance can be improved compared with the traditional MGP models.

4 An Active Learning Graph Neural Network (AGNN) for Predictive Modeling of Multiple Chronic Conditions

Julian Carvajal Rico, Adel Alaeddini, The University of Texas at San Antonio, San Antonio, TX, Contact: julian.carvajal@utsa.edu

Multiple chronic conditions (MCC) are one of the major recent challenges of healthcare systems. People with MCC are at an increased risk of new chronic conditions and mortality. The evolution of MCC follows a complex stochastic process that is influenced by pre-existing conditions and patient level risk factors. We propose an active learning graph neural network (AGNN) model to analyze the relationship between 5 chronic conditions (diabetes, obesity, cognitive impairment, hyperlipidemia, and hypertension), patient level risk factors, and pre-existing conditions. We use historical data from the Cameron County Hispanic Cohort (CCHC) to validate the proposed method.

Tuesday, 5 PM–6:15 PM

TE60

M - Marriott 7

Modeling for Cost-effective Carbon Capture, Transport, and Storage Supply Chains

General Session

Session Chair
Arya Gunawan, 1</sup

1 Reaching Zero: Pathways to Decarbonize the US Electricity System with Carbon Capture

Richard Middleton, Jeffrey Bennett, Kevin Ellett, Michael

Ford, Peter Johnson, Erin Middleton, Jonathan Ogland-Hand, Carl Talsma, Carbon Solutions LLC, Bloomington, IN, Contact: richard.middleton@carbonsolutionsllc.com

The US has pledged to develop a carbon pollution-free power sector by 2035. CO2 capture and storage (CCS) technology for exiting and future fossil-based power will be a key part of this goal. We present a national study that applied the SimCCSPRO optimization software—a framework that identifies where, when, and how to capture, transport, and store CO2—to understand how present and future CO2 tax credits will impact CCS technology for natural gas and coal power plants. Our results suggest that it is possible for CCS to play a key goal in reaching the 2035 climate goal because there is abundant CO2 storage capacity available at low cost across the US that can be relatively easily accessed by most power plants.

2 Spatio-temporal Optimization of Ccs Hubs in Louisiana

Tubagus Aryandi Gunawan, Eric Larson, Chris Greig, Princeton University, Princeton, NJ, Contact: arya.gunawan@princeton.edu

Industrial activities contribute to more than half of total CO_2 emissions in Louisiana, or 121 million tonnes in 2019. Geologically, more than half of total subsurface CO_2 storage capacity in the US is distributed in porous rock formations underneath the Gulf Coast region. Louisiana has a goal of cutting total CO_2 emissions in half by 2030 and to net-zero by 2050. The CCS infrastructures are techno-economically optimized (1) via process simulations to size CO_2 capture equipment, (2) via CO_2 pipeline simulation to determine the routes, and (3) via Monte Carlo simulation to estimate CO_2 injectivity. These elements will be combined to evaluate alternative potential time-evolutions of CCS networks.

3 Environmental and Economic Efficacy of Algae Biofuels as a CO_2 Capture and Utilization Strategy

Udayan Singh, Sudhanya Banerjee, Troy R. Hawkins, Argonne National Laboratory, Lemont, IL, Contact: usingh@anl.gov

Production of algae biofuels is a prominently discussed approach for CO_2 capture and utilization, though there is substantial uncertainty associated with its environmental and economic efficacy. This analysis seeks to evaluate and harmonize the life-cycle greenhouse gas (GHG) burdens and costs associated with CO_2 sourcing for algae biofuel production. The sources of CO_2 considered here include those from high-purity biogenic CO_2 (e.g., corn ethanol plants), industrial fossil use (e.g., cement plants), fossil power plants and the ambient air, i.e., direct air capture. The primary environmental metric evaluated here is the net GHG emissions per MJ of biofuel produced. In addition, two separate economic metrics are calculated: costs per gasoline gallon equivalent and the costs of CO_2 avoidance.

4 Direct Air Capture Siting Considering Geologic Storage Capacity, Regional Capacity Targets, and Environmental Justice Impacts

Jonathan Ogland-Hand, Carbon Solutions LLC, Grand Rapids, MI

Addressing climate change may require constructing hundreds to thousands of direct air CO2 capture and storage facilities (DAC). Deploying this infrastructure will have environmental and social impacts, but quantifying these impacts is difficult in part because there are no siting tools for DAC. Here, we introduce the Negative CO2 Emission Transition Roadmap (NECTAR), a new tool for siting negative emission technologies. Using a case study of low-temperature DAC, capacity expansion targets from the US-REGEN model, geospatially-distributed geologic CO2 storage costs, and EPA Environmental Justice (EJ) screening tool metrics, our results suggest where DACCS could be deployed at a fine resolution and implications of that deployment on EJ.

Tuesday, 5 PM–6:15 PM

TE61

M - Marriott 8

Power System Long-term Expansion Planning

General Session

Session Chair

Enzo E. Sauma, Pontificia Universidad Catolica de Chile, Santiago, Chile.

1 Co-optimizing Substation Hardening and Transmission Expansion Against Earthquakes: A Decision-dependent Probability Approach

Rodrigo Moreno[1], Diego Alvarado[2], Alexandre Street[3], Mathaios Panteli[4], Pierluigi Mancarella[5], Goran Strbac[6], [1]University of Chile, Santiago, Chile; [2]Instituto Sistemas Complejos de Ingenieria (ISCI), Santiago, Chile; [3]PUC Rio de Janeiro, Rio de Janeiro, Brazil; [4]University of Cyprus, Nikosia, Cyprus; [5]University of Melbourne, Melbourne, Australia; [6]Imperial College London, London, United Kingdom. Contact: rmorenovieyra@ing.uchile.cl

In light of the rising frequency and impact of natural hazards on power systems, planning resilient network investments is becoming increasingly important. This task, however, needs, in addition to widely accepted investment options focused on installing new infrastructure, explicit recognition of investment propositions to harden existing infrastructure such as substations. Hardening networks is fundamentally challenging to incorporate in optimization problems since it affects outage probabilities. Therefore, we propose an optimization approach to determine optimal portfolios of resilient network investments, considering endogenous probabilities that change with hardening investment options. Case studies applied on earthquakes in Chile demonstrate the benefits of our proposed network planning approach.

2 Improved Bounds to Accelerate The Column and Constraint Generation for Two-stage Distributionally Robust Problems with First Moment Constraints

Alexandre Street[1], David Pozo[2], Alexandre Velloso[3], [1]LAMPS PUC-Rio, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil; [2]Skolkovo Institute of Science and Technology, Moscow, Russian Federation; [3]FINEP / LAMPS PUC-Rio, Pontifical Catholic University of Rio de Janeiro, Rio de Janeiro, Brazil.

In this talk, we show a Dantzig-Wolfe (DW)-based improved lower bound for two-stage distributional robust optimization problems with first-moment constraints. The bound is based on an improved representation of the recourse function of the problem. A nested column and constraint generation (CCG) algorithm with a DW inner step is developed based on this idea. A case study based on the long-term transmission planning problem under uncertainty shows improved performances in comparison to the traditional CCG algorithm corroborating the effectiveness of the proposed bound and algorithm to this relevant problem of the electricity sector.

3 Formulation of a Hydrogen Production Model that Optimizes The Interaction with The Power System Network

Byron Hurtubia[1], Enzo E. Sauma[2], [1]Pontificia Universidad Catolica de Chile, Santiago, Chile; [2]Pontificia Universidad Catolica de Chile, Santiago, Chile. Contact: esauma@ing.puc.cl

In this work we formulate a model that minimizes the operation costs of an electrolysis hydrogen (H2) production plant, from the perspective of the H2 producer, explicitly modeling the low dynamic load range restriction of the ALK technology. We characterize the H2 production when using ALK electrolyzers and when using PEM electrolyzers in two locations of Chile (one in the north of Chile and one in the south of Chile). We use the proposed model to assess both the economic and the environmental impacts of complementing green H2 production with electricity from the power grid, when using ALK electrolyzers and when using PEM electrolyzers, in the selected locations of Chile. Finally, we study the existing tradeoff between reducing the LCOH with more hydrogen production using grid electricity and increasing CO2 emissions by producing more H2 with grid electricity in Chile.

4 Climate￼Aware Generation and Transmission Expansion Planning

Alexandre Moreira[1], David Pozo[2], Alexandre Street[3], Enzo E. Sauma[4], Goran Strbac[5], [1]Lawrence Berkeley National Laboratory, Berkeley, CA, [2]Skolkovo Institute of Science and Technology, Moscow, Russian Federation; [3]University of Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil; [4]Pontificia Universidad Catolica de Chile, Santiago, Chile; [5]Imperial College London, London, United Kingdom.

We propose a three-stage robust generation and transmission expansion planning model considering generation profiles of renewable energy sources (RES) affected by different long-term climate states. We extend the broadly utilized two-stage modeling approach to properly consider partial information of climate states with conditional short-term scenarios of RES output and outages. The proposed model is formulated as a five-level optimization problem. To solve the problem, a variant of the nested column-and-constraint-generation algorithm is proposed with a global-optimality guarantee in a finite number of steps. A case study based on the Chilean system illustrates the applicability of the model in a realistic network.

Tuesday, 5 PM–6:15 PM

TE62

M - Marriott 9

Optimization Approach to Pollution and Sustainable Logistics Problems

General Session

Session Chair

Monireh Mahmoudi, Michigan State University, East Lansing, MI

Session Co-Chair: Irandokht Parviziomran

1 Managing Transportation Operations of Reusable Packages: An Assignment-based

Decomposition Approach for Vehicle Routing Problem with Backhauls

Irandokht Parviziomran[1], Monireh Mahmoudi[1], Xuesong Simon Zhou[2], [1]Michigan State University, East Lansing, MI, [2]Arizona State University, Tempe, AZ

In this study, we present a new mixed-integer programming model for managing transportation operations of reusable packages, i.e., delivery of full packages and picking up empty ones. Our proposed mathematical model follows the assumptions of the standard vehicle routing problem with backhauls and utilizes an assignment-based decomposition approach to decompose the main problem into two open vehicle routing problems and one assignment problem. We also present a cluster-first route-second solution approach to examine our proposed model on large-scale transportation networks.

2 Decomposing The Location and Routing Problems in Sustainable Logistics System Design of Hybrid Commercial Drones

Nima Molavi[1], Yue Zhang[2], Marcelo Alvarado-Vargas[2], [1]Elizabeth City State University, Elizabeth City, NC, [2]University of Toledo, Toledo, OH, Contact: nmolavi@ecsu.edu

This research is the continuation of the previous work aiming to design a sustainable logistics system for hybrid commercial drones in B2B commerce with deterministic demand locations. An integrated hybrid drone location and routing problem is modeled as a mixed-integer linear program with the objective of maximizing the sustainability of the system including operational costs as well as social concerns and environmental impacts being neglected in previous literature. Due to the difficulty of solving large instances of the integrated location and routing problem, the problem is decomposed into a location master problem and routing subproblems. Based on computational experiments, it is found that the decomposed model has better performance for large instances and more dynamic instances, in which the changes in demand locations are expected in the problem's setting.

3 A Novel Optimization Model for Controlling Harmful Algal Blooms in Lake Okeechobee

Hanieh Rastegar[1], Vahid Mahmoodian[2], Ashim Khanal[1], Hadi Charkhgard[3], [1]University of South Florida, Tampa, FL, [2]USF, Tampa, FL, [3]University of South Florida, Tampa, FL, Contact: hrastegarmoghaddamb@usf.edu

Lake Okeechobee in Florida is suffering from the overgrowth of harmful algal blooms due to nutrient contamination. Two types of remedies are often suggested in the literature to reduce nutrient contamination. The first approach includes some rules or policies called Best Management Practices (BMPs). The second approach includes some Water Treatment Technologies (WTTs) that need to be implemented on rivers or reaches to refine nutrients from the water. In this study, we develop a generic mathematical optimization model to minimize nutrient contamination by determining the best combination of BMPs and WTTs as well as the optimal locations to implement them. We show how the model can be extended to include the uncertainty available in the performance of the BMPs and WTTs. The results show that the model can effectively minimize the nutrient contamination in the lake.

Tuesday, 5 PM–6:15 PM

TE63

M - Marriott 10

Innovative Model and Data Couplings for Multisector Human-earth Systems Analysis

General Session

Session Chair

Stuart Cohen, 1</sup

1 Multi-model Coupling to Explore Electricity System Grid Stress Under Energy System Transitions and Heat Waves

Jennie S. Rice[1], Zarrar Khan[2], Nathalie Voisin[3], Konstantinos Oikonomou[4], Kendall Mongird[5], Casey Burleyson[6], [1]Pacific Northwest National Laboratory, College Park, MD, [2]Pacific Northwest National Laboratory, College Park, MD, [3]Pacific Northwest National Lab., Seattle, WA, [4]PNNL, Richland, WA, [5]Pacific Northwest National Laboratory, Richland, WA, [6]Pacific Northwest National Laboratory, Seattle, WA

The Integrated Multisector, Multiscale Modeling (IM3) foundational science research project (im3.pnnl.gov) develops flexible, open-source, multi-model capabilities that capture the multiscale interactions within and between human and natural systems. We are addressing a significant research gap regarding the understanding of potential future electricity system grid stress in the United States. We are coupling open-source models of global change, U.S. state-level electricity system expansion, power plant siting at 1km2, hourly electricity demand, and hourly grid operations at the balancing authority scale in each of the three major U.S. electric grid interconnections to investigate potential 21st century grid stress under alternative energy system transitions and a wide range of future climate and socioeconomic conditions.

2 Interactions Between Wildfires and Electric Power Infrastructure

Sofia Taylor[1], Line Roald[2], [1]University of Wisconsin - Madison, Madison, WI, [2]University of Wisconsin - Madison, Madison, WI, Contact: smtaylor8@wisc.edu

The changing climate is forcing us to think differently about how electricity is delivered. Specifically, this presentation examines the interactions between wildfires and electric power infrastructure. Mitigating the risk of wildfire ignitions from electric power lines is a crucial effort, especially as wildfires in the United States are becoming more frequent and severe. However, ignition prevention strategies, such as putting power lines underground, are very expensive. This work utilizes GIS modeling and optimization to define the relative wildfire ignition risk of power infrastructure and make grid planning decisions. By jointly considering nature and energy systems, we can design a future electric grid that is more resilient and adaptable to changing environmental conditions.

3 Deploying Closed-Loop Pumped Hydropower Energy Storage Under Constrained Water Availability

Stuart Cohen, National Renewable Energy Laboratory, Golden, CO

Energy storage is expected to play an increasing role in balancing electricity supply and demand as wind and solar generation gain increasing shares of electricity supply. Pumped storage hydropower (PSH) is the largest existing form of energy storage on the grid, and there is growing U.S. interest in closed-loop PSH that reduces environmental impacts by being isolated from existing waterways. This research explores PSH deployment opportunities using a capacity expansion model of the U.S. electric sector enhanced by a new nationwide resource and cost assessment for closed-loop PSH along with water availability constraints for filling new PSH reservoirs. This approach integrates water, electricity, environmental, and legal considerations to study tradeoffs in deploying PSH, other flexible grid technologies, and variable renewable generation.

Tuesday, 5 PM–6:15 PM

TE64

M - Indiana A

Large Markets and Mechanism Design

General Session

Session Chair

Martin Bichler, Technical University of Munich, Garching B. München, Germany.

1 Equilibrium Learning and Bilateral Bargaining

Martin Bichler, Nils Kohring, Matthias Oberlechner, Fabian Pieroth, Technical University of Munich, Garching B. München, Germany.

Bilateral bargaining of a single good among one buyer and one seller describes the simplest form of trade, yet Bayes-Nash equilibrium strategies are largely unknown. Recent advances in equilibrium learning provide a numerical approach to auction games, which can push the boundaries of existing results. We analyze Neural Pseudogradient Ascent (NPGA) and Simultaneous Online Dual Averaging (SODA), two new equilibrium learning algorithms for Bayesian games with continuous type and action spaces. We show that both algorithms consistently learn equilibrium even in this challenging environment. In our analysis, we derive equilibrium bid functions for non-uniform priors, risk-averse traders, and markets with multiple traders on each side, which has been impossible so far. Besides, we provide a new convergence result for NPGA.

2 Ascending-price Mechanism for General Multi-sided Markets

Dvir Gilor[1], Rica Gonen[1], Erel Segal-Halevi[2], [1]OUI, Raanan, Israel; [2]Ariel University, Ariel, Israel. Contact: ricagonen@gmail.com

We present an ascending-price mechanism for a multi-sided market with a variety of participants, such as manufacturers, logistics agents, insurance providers, and assemblers. Each deal in the market may consist of a combination of agents from separate categories, and different such combinations are simultaneously allowed. This flexibility lets multiple intersecting markets be resolved as a single global market. Our mechanism is obviously- truthful, strongly budget-balanced, individually rational, and attains almost the optimal gain-from- trade when the market is sufficiently large. We evaluate the performance of the suggested mechanism with experiments on real stock market data and synthetically produced data.

3 Minimum Price Equilibrium in The Assignment Market: The Serial Vickrey Mechanism

Shigehiro Serizawa, 1</sup

We study an assignment market where multiple heterogenous objects are sold to unit-demand agents who have general preferences that accommodate income effects and market frictions. The minimum price equilibrium (MPE) is one of the most important equilibrium notions in such settings. Nevertheless, none of the well-known mechanisms that find the MPEs in quasi-linear environment can identify or even approximate the MPEs for general preferences. We establish novel structural characterizations of MPEs and design the "Serial Vickrey (SV) mechanism" based on the characterizations. The SV mechanism finds an MPE for general preferences in a finite number of steps. Moreover, the SV mechanism only requires agents to report finite-dimensional prices finitely many times, and also has nice dynamic incentive properties.

Tuesday, 5 PM–6:15 PM

TE65

M - Indiana B

Economics and Computation V

Award Session

Session Chair

Amanda Kube, University of Chicago, CHICAGO, IL

1 [ec2022] The Challenge of Understanding What Users Want: Inconsistent Preferences and Engagement Optimization

Jon M. Kleinberg[1], Sendhil Mullainathan[2], Manish Raghavan[3], [1]Cornell University, Ithaca, NY, [2]University of Chicago, Chicago, IL, [3]Harvard University, Cambridge, CA

Despite the wealth of data that online platforms use to optimize user experience, many users regret the time they spend on these platforms. We suggest this problem stems from a mistaken foundational assumption. To understand what users want, platforms look at what they do. Yet research has demonstrated that we often make choices in the moment that are inconsistent with what we actually want: we can choose mindlessly or myopically.
In this work, we develop a model of media consumption where users have inconsistent preferences. Our model produces phenomena related to overconsumption that are familiar from everyday experience, but difficult to capture in traditional user interaction models. We show how the relationship between engagement and utility depends on the structure of the content manifold, characterizing when engagement optimization leads to good utility outcomes.

2 [ec2022] Just Resource Allocation? How Algorithmic Predictions and Human Notions of Justice Interact

Amanda R. Kube[1], Sanmay Das[2], Patrick J. Fowler[3], Yevgeniy Vorobeychik[4], [1]Washington University in St. Louis, Saint Louis, MO, [2]George Mason University, Fairfax, VA, [3]Washington University in St. Louis, Saint Louis, MO, [4]Washington University in St. Louis, University City, MO, Contact: amanda.kube@wustl.edu

Increased focus has centered on ethical implications of algorithmic decision-aids used to improve decision accuracy across social domains. We examine how prior views of justice influence human decision-making in the presence of algorithmic predictions by eliciting preferences for prioritizing either more vulnerable homeless households or those who would benefit most from services. We find we can group participants into two types: vulnerability- and outcome-oriented. For a subset of decision-makers, preferences change from vulnerability- to outcome-oriented when previously exposed to predictions. When presented with predictions along with household descriptions, participants make allocation decisions that reinforce their prioritization preferences. This work emphasizes the importance of aligning data-driven decision aids with allocation goals.

Tuesday, 5 PM–6:15 PM

TE67

M - Indiana D

Learning and Optimization for Revenue Management

General Session

1 Exact Logit-Based Product Design

Irem Akcakus, Velibor Misic, Anderson School of Management, University of California, Los Angeles, Los Angeles, CA

The share-of-choice product design problem is to find the product that maximizes market share arising from a collection of customer segments. When customers follow a logit model of choice, the market share is given by a weighted sum of logistic probabilities, leading to a challenging problem to solve: one must optimize an objective function that is neither convex nor concave, over an exponentially-sized set of attribute combinations. We develop an exact methodology for solving this problem based on modern integer, convex and conic optimization by showing that the resulting problem can be reformulated as a mixed-integer convex program, which can be further reformulated using conic constraints.

Using synthetic problem instances and instances derived from real conjoint data sets, we show that our approach can solve large instances in operationally feasible time frames.

Session Chair
Raghav Singal, NH

2 Selling Personalized Upgraded Substitutes and Co-purchases in Online Grocery Retail

Gah-Yi Ban[1], Mohammed Hichame Benbitour[2], Boxiao Beryl Chen[3], [1]Robert H. Smith Business School, University of Maryland, Maryland, MD, [2]EM Normandie, Paris, France; [3]UIC College of Business Administration, University of Illinois at Chicago, Chicago, IL, Contact: mbenbitour@em-normandie.fr

Many retailers are making significant investments to get better data and make better recommendations to their customers. We propose a model that can help retailers recommend upgraded substitutes and co-purchases, which maximize the retailer's expected revenue and the consumer surplus. We propose solutions to solve the maximization problem efficiently. We apply our recommendation model to the case of a large grocery chain.

3 Assortment Planning in Store Networks with Limited Product Availability

Mert Çetin, Victor Martínez de Albéniz, IESE Business School, Barcelona, Spain. Contact: mcetin@iese.edu

When allocating products to brick-and-mortar stores, retailers face product availability constraints which force them to balance product offerings across stores. Under a multinomial logit demand, we show that the product-store assignment problem is NP-hard. We develop a continuous relaxation of the problem which can be solved in polynomial time, which provides an upper bound and generates near-optimal solutions. We use data from a large multinational apparel retailer to show, using a Heckman framework, that the allocation decision fails to consider match the right products with the right stores. Under the estimated demand structure, our algorithm improves expected revenues significantly.

4 Model-free Approximate Bayesian Learning for Conversion Funnel Optimization

Garud N. Iyengar[1], Raghav Singal[2], [1]Columbia University, New York, NY, [2]Dartmouth College, Hanover, NH

We study sequential interventions from the point-of-view of a firm promoting a product under a conversion funnel model of consumer behavior. Our model captures the consumer state (e.g. interaction history with the firm) and allows consumer behavior to vary as a function of her state and firm's interventions (e.g. emails). The firm's wishes to maximize conversion probability (product purchase) but does not know the state-specific effects of interventions and must learn on the fly. We propose a new learning algorithm for this problem, which inherits the simplicity of Thompson sampling. We prove its asymptotic optimality and benchmark its performance with existing approaches on a real-world dataset.

Tuesday, 5 PM–6:15 PM

TE68

M - Indiana E
Marketplace Innovation
General Session

Session Chair
Kostas Bimpikis, Stanford University, Stanford, CA

Session Chair
Vasiliki Kostami, HEC Paris, Jouy-En-Josas, France.

1 Advertising by Recruiting Influencers

Maya Jalloul[1], Vasiliki Kostami[2], [1]HEC Paris, Paris, France; [2]HEC Paris, Jouy-En-Josas, France.

The persistent growth of social media platforms has led to the rise of social media influencers who inspire customers by sharing their experiences. Customers also rely on the reviews of past consumers. We address some of the firm's challenges of influencer marketing by considering different types of influencers and different partnership schemes with them. We also consider influencers that differ in their target audiences, and we examine how the firm's decisions are affected by social learning.

2 Capacity Control and Online Platforms in The Hospitality Industry

Antoine Feylessoufi, University College London, Cambridge, United Kingdom.

With the advent of platforms in the hospitality industry, consumers can now often choose between booking a room directly through the hotel or indirectly through a platform. An underexplored problem is however the decision from the perspective of the hotel: should they offer their rooms on one (or multiple) platforms and if so, is there an optimal allocation? Platforms may help them reach a larger customer base but it comes at the expense of the profit margin. We explore this decision process using a novel dataset spanning over 4 years from a hotel chain in France.

3 Competitive Pricing in The Presence of Manipulable Information in Online Platforms

Harish Guda, Hongmin Li, Yuqi Yang, Arizona State University, Tempe, AZ, Contact: yyang450@asu.edu

To entice customers to purchase, sellers on online platforms often engage in misrepresenting the perceived quality of their goods/services, e.g., by manipulating customer opinions. We analyze an oligopoly where sellers, heterogeneous in their true quality, jointly choose their prices and the extent of manipulation. We show that higher quality firms have a greater incentive to manipulate than lower quality firms, and thereby manipulate more and choose higher prices. Manipulation benefits higher quality firms and hurts lower quality firms. Under a revenue-sharing contract (between the sellers and the platform), the platform benefits from such manipulation. Finally, network effects exacerbate the incentives to manipulate, and benefit the higher quality firms.

Tuesday, 5 PM–6:15 PM

TE69

M - Indiana F

Advanced Topics in Revenue and Market Analytics

General Session

Session Chair

Gustavo J. Vulcano, Universidad Torcuato di Tella, Ciudad Autónoma Buenos Aires, Argentina.

1 Cournot Equilibria in Two-sided Markets with Capacity Constraints

Rene A. Caldentey[1], Martin Haugh[2], [1]The University of Chicago, Chicago, IL, [2]Imperial College Business School, London, United Kingdom.

We study Cournot Equilibria in two-sided markets in which a set of suppliers compete by deciding how to allocate their limited production capacity (or available inventory) on a set of alternative consumers' markets. The per unit profit margin on each market is a function of the cumulative capacity that all suppliers allocate to each market.

2 Fluid Approximations for Revenue Management Under High-variance Demand: Good and Bad Formulations

Huseyin Topaloglu[1], Yicheng Bai[2], Omar El Housni[1], Billy Jin[3], Paat Rusmevichientong[4], David P. Williamson[5], [1]Cornell Tech, New York, NY, [2]Cornell University, New York, NY, [3]Cornell, Ithaca, NY, [4]USC, Los Angeles, CA, [5]Cornell University, Ithaca, NY

One of the most common demand models in revenue management works with a fixed number of time periods in the selling horizon with at most one customer arrival at each time period. This demand model is equivalent to a discrete-time approximation to a Poisson arrival process, but it has an important shortcoming: If the mean number of arrivals is to be large, then the coefficient of variation of the number of arrivals must be small. We consider a revenue management model where the number of customer arrivals has an arbitrary distribution. While a quick natural fluid approximation of this problem turns out to be not asymptotically tight, we show how to "fix" this fluid approximation to get back asymptotic tightness.

3 Double Sided Platforms with Stochastic Supply and Demand

Victor Araman, American University of Beirut, Beirut, Lebanon.

Double sided platforms offer convenience for customers and flexibility for workers. For instance, in the context of ride hailing the convenience translates in customers requesting rides anytime from any location to any destination (within some boundaries). Moreover, drivers are flexible to decide when to be available to accept requests and when to be unavailable. Therefore, by design, supply and demand are stochastic. We model these features following a queueing theoretic approach. In the single class case, the problem can be viewed as a typical queueing system with a stochastically changing number of available servers. We analyze the stability of such system and obtain diffusion approximations to quantify its performance. We discuss how our results can be generalized to the context of a queueing network.

4 Evaluation of The Performance of Machine Learning Methods in Discrete Choice

Gerardo Berbeglia[1], Daró Turco[2], Gustavo J. Vulcano[3], [1]Melbourne Business School - Centre for Business Analytics, newport, Australia; [2]Universidad de Buenos Aires, Ciudad Autónoma Buenos Aires, Argentina; [3]Universidad Torcuato di Tella, Ciudad Autónoma Buenos Aires, Argentina. Contact: gvulcano@utdt.edu

We conduct a systematic, empirical study of different ML-based methods to estimate consumer preferences. Through an exhaustive set of numerical experiments on synthetic and real data, we provide comparative statistics of the predictive power and derived revenue performance of an ample collection of methods, characterizing operational environments suitable for different implementations.

Tuesday, 5 PM–6:15 PM

TE70

M - Indiana G

Convex Optimization and its Applications in Machine Learning and Quantum Information Theory

General Session

Session Chair

Boshi Yang, Clemson University, Clemson, SC

Session Chair

Hao Hu, Clemson University, Clemson, SC

1 **Revisiting Degeneracy, Strict Feasibility, Stability, in Linear Programming**

Henry Wolkowicz, University of Waterloo, Waterloo, ON, Canada.

Unlike general conic programs, LPs do not require strict feasibility in order to establish strong duality. In this talk we discuss that the specific degeneracy that arises from lack of strict feasibility necessarily causes difficulties in both simplex and interior point methods. In particular, we show that the lack of strict feasibility implies that every basic feasible solution is degenerate. This leads to efficient preprocessing techniques. We provide illustrations using various problems sets including the NETLIB problem set.

2 **A New Family of Features that Strengthens Recovery Guarantees of Sum-of-norms Clustering**

Tao Jiang[1], Samuel Tan[1], Stephen Vavasis[2], [1]Cornell University, Ithaca, NY, [2]University of Waterloo, Waterloo, ON, Canada.

Sum-of-norms (SON) clustering is a convex formulation of the clustering problem that comes with several desirable guarantees. It produces a hierarchical family of clusterings (Chiquet et al., 2017), and the method is guaranteed to recover a mixture of Gaussians provided that the standard deviations are bounded (Jiang et al., 2020). However, SON clustering also has some limitations including its inability to recover non-convex clusters (Nguyen and Mamitsuka, 2021). We propose a new family of features that improve the recovery guarantees of SON clustering. When these new features are appended to the original data points, clusters are recovered from points sampled from arbitrary distributions provided clusters have disjoint supports. Points sampled from mixtures of Gaussians are recovered for a less restrictive choice of standard deviations.

3 **Robust Interior Point Methods for Key Rate Computation in Quantum Key Distribution**

Hao Hu, Clemson University, Clemson, SC, Contact: hhu2@clemson.edu

We study semidefinite programs for computing the key rate in finite dimensional quantum key distribution (QKD) problems. Through facial reduction, we derive a semidefinite program which is robust and stable in the numerical computation. Our program avoids the difficulties for current algorithms from singularities that arise due to loss of positive definiteness. This allows for the derivation of an efficient Gauss-Newton interior point approach. We provide provable lower and upper bounds for the hard nonlinear semidefinite programming problem. Empirical evidence illustrates the strength of this approach as we obtain high accuracy solutions and theoretically guaranteed upper and lower bounds for QKD. We compare with other current approaches in the literature.

4 **A Note on The Existence of Optimal Solutions of Qcqps**

Alexander Joyce, Clemson University, Central, SC

We consider the existence of optimal solutions of quadratically constrained quadratic programs. Existing works have focused on feasible regions defined by convex functions. In this talk, we discuss cases when nonconvex functions are involved in defining the feasible regions. The discussion is based on the analysis of the asymptotic directions of quadratic functions.

Tuesday, 5 PM–6:15 PM

TE71

M - Arizona

Finding Sets of Near-optimal Solutions for Mixed-integer Programs

General Session

Session Chair

Izuwa Ahanor, The University of Tennessee, Knoxville, TN

1 **Characterizing Fairness over The Set of Good Models Under Selective Labels**

Amanda Coston, Carnegie Mellon University, Pittsburgh, PA, Contact: acoston@andrew.cmu.edu

Algorithmic models are used to inform decisions in high-stakes settings. Often multiple predictive models deliver similar overall performance but differ markedly in their individual predictions--the "Rashomon Effect." We develop a method for characterizing predictive fairness properties over the set of models that deliver similar overall performance. We show how this problem can be transformed to a constrained classification problem, which we solve by finding the approximate saddle point of a min-max problem. We address the challenge of selectively labelled data in the setting where the selection decision and outcome are unconfounded given the observed data. Our framework can be used to replace an existing model with one that has better fairness properties or audit for predictive bias. We illustrate these use cases on credit-scoring and recidivism prediction tasks.

2 Ignoring the obvious: what about close to optimal solutions to spatial optimization problems

Richard Church, University of California, Santa Barbara, Santa Barbara, CA

3 Solving multiplicative programs by binary-encoding the multiplication operation

Hadi Charkhgard[1], Payman Ghasemi Saghand[2], Fabian Rigterink[3], Vahid Mahmoodian[4], [1]University of South Florida, Tampa, FL, [2]University of South Florida, Lutz, FL, [3]University of Newcastle, Callaghan, Australia; [4]USF, Tampa, FL

Multiplicative programs in the form of maximization and/or minimization have numerous applications in conservation planning, game theory, and multi-objective optimization settings. In practice, multiplicative programs are challenging to solve because of their multiplicative objective function (a product of continuous or integer variables). These challenges are twofold: 1. As the number of factors in the objective increases, so does the solution time, and the problems become computationally expensive to solve. 2. If all factors are in (0, 1) or in (1,+inf), the objective may cause ill-conditioning and numerical instability. The solution methods proposed in this paper help overcome both of these challenges. The main idea is to binary-encode the multiplication operation analogously to how a computer conducts it internally.

4 DiversiTree: A new method to efficiently compute diverse sets of near-optimal solutions to mixed-integer optimization problems

Izuwa Ahanor[1], Hugh Medal[1], Andrew C. Trapp[2], [1]University of Tennessee, Knoxville, TN, [2]Worcester Polytechnic Institute, Worcester, MA, Contact: iahanor@tennessee.edu

While most methods for solving mixed-integer optimization problems compute a single optimal solution, a diverse set of near-optimal solutions can often be more useful. We present a new method for finding a set of diverse solutions by emphasizing diversity within the search for near-optimal solutions in a branch-and-bound framework. Our results indicate that our approach significantly increases diversity of the final solution set. When compared with two existing methods, our method runs with similar runtime as regular node selection methods and gives a diversity improvement of up to 140%. In contrast, popular node selection rules such as best-first search gives an improvement in diversity of no more than 40%. Our method can be easily incorporated into integer programming solvers and has the potential to significantly increase diversity of solution sets.

Tuesday, 5 PM–6:15 PM

TE73

M - Colorado

Analytics Applications in Service Research

General Session

Session Chair

Bernardo (Bernie) F. Quiroga, West Virginia University, Morgantown, WV

1 Incentive Ratcheting and Productivity

Raicho Bojilov[1], Francisco Brahm[2], Joaquin Poblete[1], [1]Pontificia Universidad Catolica de Chile, Santiago, Chile; [2]London Business School, London, United Kingdom. Contact: joaco.poblete@gmail.com

This paper estimates the effect of incentive ratcheting by managers on worker output using rich data from the restructuring of some sales units the salesforce of a large Chilean producer and distributor of beverages. The results reveal the presence of a large heterogeneity in the subjective extent of ratcheting exerted on of salespersons which translates in large variation in the resulting reduction in output: from 11 to 34 percent in most cases, with the average reduction equal to 20%. These results are robust to changes in the measures of output and ratcheting and do not depend on the assignment of salespersons to supervisors.

2 An Operational Perspective on Micro-financing in Developing Countries

Elaheh Rashidinejad[1], Opher Baron[2], Gonzalo Romero[3],

[1]Rotman School of Management, University of Toronto, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada; [3]Rotman, University of Toronto, Toronto, ON, Canada. Contact: e.rashidinejad@rotman.utoronto.ca

We compare two microfinancing structures in developing countries where an entrepreneur with zero initial budget borrows a loan to start a business. The entrepreneur faces a Newsvendor problem with finance and effort considerations. We characterize conditions under which a community bank, which can apply social pressure on the entrepreneur to pay all of its debt back, improves individual and social welfare in comparison with a social bank, which has no such mechanism. We study the banks under profit maximization or zero profit objectives. Our theoretical model provides insight for policymakers when designing microfinancing structures to maximize social impact and help alleviate poverty.

3 Electric Vehicles and Solar Panels Co-adoption Via Diffusion Models

Sebastian Souyris[1], Subhonmesh Bose[2], Sridhar Seshadri[3], [1]Rensselaer Polytechnic Institute, Troy, NY, [2]University of Illinois at Urbana Champaign, Urbana, IL, [3]University of Illinois, Champaign, IL, Contact: souyrs@rpi.edu

Electrification has been identified as a critical enabler of the decarbonization of transportation. Therefore, it is imperative to study the adoption growth in solar photovoltaics (PVs) and electric vehicles (EVs) to plan for this impending transformation. However, existing PV and EV adoption studies typically ignore the influence between them and other green technologies, such as the evolution of charging stations. We employ state-of-art techniques in structural economics, the dynamic discrete choice model, to study the diffusion of these technologies. Our work projects the adoption of PV and EV trends into the future under plausible counterfactual scenarios.

Tuesday, 5 PM–6:15 PM

TE74

M - Florida

Estimation of Distributions with Linear Regression and Applications

General Session

Session Chair

Stanislav Uryasev, Stony Brook University, Stony Brook, NY

Session Chair

Cheng Peng, 1</sup

1 Factor Model of Mixtures

Stanislav Uryasev, Cheng Peng, Stony Brook University, Stony Brook, NY, Contact: stanislav.uryasev@stonybrook.edu

We propose a novel framework to model nonlinear dependence structure between factors and a univariate random variable. The framework characterizes the distribution conditioned on some factors with a mixture (linear combination) of characterizing functions. Depending on the user's preference, the characterizing functions can be quantiles, CVaRs and expectiles. The conditional distribution is flexible in both tail and body, since we can include arbitrary valid characterizing functions in the mixture. Furthermore, it has a closed-form expression. The model calibration is formulated as a linear-regression problem. It can be efficiently solved by convex optimization and in some cases reduced to linear programming. Various types of constraints, such as cardinality of the number of functions in the mixture, and penalties can be included in the optimization problem.

2 Mixture Quantiles Calibrated with Constrained Linear Regression

Yizhou Li, Cheng Peng, Stan URYASEV, Stony Brook University, Stony Brook, NY

We study a family of distributions defined by mixtures of quantiles. This family can be efficiently calibrated by linear regression with constraints.

3 Optimal Selling Strategy in The Residential Real Estate

Anton Malandii, Stony Brook University, Stony Brook, NY, Contact: anton.malandii@stonybrook.edu

The paper suggests a new approach for estimation of the conditional distribution of sale time for real estate, under the condition that a sale has happened.

4 Diversification Quotients: Quantifying Diversification Via Risk Measures

Lin Liyuan, Xia Han, Ruodu Wang, University of Waterloo, Waterloo, ON, Canada. Contact: l89lin@uwaterloo.ca

We introduce the diversification quotient (DQ) to quantify portfolio diversification. Defined through a parametric family of risk measures, DQ satisfies three natural properties, namely, non-negativity, location invariance and scale invariance, which are shown to be conflicting for any traditional diversification index based on a single risk measure. DQs based on the popular risk measures Value-at-Risk and Expected Shortfall enjoy many convenient features and are efficient to optimize in portfolio selection. Applied to multivariate elliptical and regular varying models, we find that DQ can properly capture tail heaviness and common shocks which are neglected by traditional diversification indices. When illustrated with financial data, DQ is intuitive to interpret, and its performance is competitive against other diversification indices.

Tuesday, 5 PM–6:15 PM

TE75

M - Illinois
Cryptocurrencies
General Session

Session Chair
Vasundhara Sharma, McCombs School of Business, Austin, TX

1 **Sabotage & Reciprocity in Contests: The Case of Cryptocurrency Mining Pools**
John A. Biechele-Speziale[1], Abhishek Ray[2], Mario Ventresca[3], Hong Wan[4], [1]Purdue University, West Lafayette, IN, [2]George Mason University, West Lafayette, [3]Purdue University, Lafayette, IN, [4]NC State University, Raleigh, NC
Cryptocurrency mining is a contest that rewards the winner with crypto-coins via reward contracts. Given the limit on coin supply, fierce rivalry for rewards has become common, which has resulted in mining pools using sabotage to undercut each other. Past work suggests sabotage and resulting retaliation results in 'eye-for-an-eye' behavior which endangers pool operations, transaction stability, and cryptocurrency viability. Our work reveals that this may not always hold: using a game-theoretic and agent-based simulation approach, we show the availability of many sabotage choices, and reciprocal sabotage between pools results in asymmetric equilibria with higher social welfare; thus contradicting the 'eye-for-an-eye' principle. Finally, we show the impossibility of designing linear, quasi-linear, or individually rational contracts to prevent sabotage.

2 **An Economic Model of Consensus on Distributed Ledgers**
Hanna Halaburda[1], Zhiguo He[2], Jiasun Li[3], [1]NYU Stern, New York, NY, [2]University of Chicago, Chicago, IL, [3]George Mason University, Fairfax, VA, Contact: jli29@gmu.edu
Many new blockchain applications are inspired by the Byzantine fault tolerance (BFT) problem. While traditional BFT protocols assume most system nodes are honest, blockchains nodes are subject to strategic incentives. This paper develops an economic framework for analyzing such cases. We explicitly study incentives in the consensus process and assume that non-Byzantine nodes are Knightian uncertain about Byzantine actions. Consensus then induces a cheap talk game. We characterize all equilibria, in some of which rational leaders withhold messages. These findings enrich traditional BFT protocols, where honest leaders always send messages to all. We study how progress in communication technology affects equilibrium outcomes.

3 **How Shall I Trust in a Supposedly Trust-free System? Exploring Trust Formation in Dapps on Ethereum**
Daniel Obermeier, NYU Stern, New York City, NY
Trust is generally considered an important precondition for the adoption of web apps. Yet, proponents of blockchain technology have argued that for dApps (i.e., blockchain-based web apps) trust becomes dispensable as all parties can ex-ante ascertain the mechanisms that determine the future behavior of the other party by reading the smart contract that predefines the transaction logic of a dApp. To scrutinize this claim, we develop and test a new model of trust formation in the context of dApps. In addition to classical trust building, our model accounts for a new type of trust that is the consequence of the possibility to read the smart contract. Using a new survey dApp that allows us to send surveys to dApp users and pseudonymously link their responses to their transaction history, we find that this new type of trust complements rather than substitutes classical trust building.

4 **An Investigation of The Fee-speed Relationship in Cryptocurrency Transactions**
Noyan Ilk[1], Guangzhi Shang[2], Shaokun Fan[3], [1]Florida State University, Tallahassee, FL, [2]Florida State Unviersity, Tallahassee, FL, [3]Oregon State University, Corvallis, OR, Contact: nilk@business.fsu.edu
The growing popularity of blockchain-based cryptocurrencies is driven by the flexibility in transaction fee offerings, among other factors. Yet, the time it takes a cryptocurrency transaction to be confirmed in the blockchain is not only affected by the fee offered, but also by the contemporaneous congestion level and the inherent randomness in the verification process. In this work, we stylize the transaction confirmation process, propose a theoretical framework that maps the causal path from fee to speed, and estimate this framework using Bitcoin transaction data under periods of high volatility. Based on our empirical findings, we develop an efficient computational procedure that helps Bitcoin users to accurately estimate fees based on their confirmation delay preferences.

Tuesday, 5 PM–6:15 PM

TE76

M - Michigan
Sustainable Operations
General Session

Session Chair
Paolo Letizia, University of Tennessee

1 **Environmental Performance and Product Quality in The Automotive Industry: An Empirical Investigation**
Donggyu Jeon[1], George Ball[1], Gilvan Souza[2], [1]Kelley School of Business, Indiana University, Bloomington, IN, [2]Haslam College of Business, University of Tennessee, Knoxville, TN, Contact: djeon93@indiana.edu
In this study, we empirically examine the impact of firms' efforts to improve the environmental performance of a vehicle (measured as MPG) on product quality (measured as the number of quality complaints) in the US automotive industry. We provide operational and strategic managerial implications of improving sustainability on product quality.

2 **Strategic Sell-by Dates**
Karthik Murali[1], Nicholas C. Petruzzi[2], Aditya Vedantam[3], [1]Oregon State University, Corvallis, OR, [2]University of Wisconsin-Madison, Madison, WI, [3]State University of New York at Buffalo, Williamsville, NY, Contact: karthik.murali@oregonstate.edu
We identify a manufacturer's optimal choice of shelf life for perishable products when this information is used by retailers to adjust ordering policies. We show that strategic manipulation of shelf lives can lead to increased manufacturer profitability at the cost of increased food waste.

3 **Impact of Taxes on The Adoption of Green Technologies**
Gal Raz, Western Unversity, London, ON, Canada.
A tax on emissions represents a cost to manufacturers adopting a dirty technology; thus, it should always encourage the adoption of a clean technology. However, our work shows that in an oligopoly this is not always the case: competing manufacturers may choose asymmetric equilibria with respect to the technology to adopt depending on the cost and the gap between the emissions intensities of the two production technologies.

4 **The Economic and Environmental Impact of Sharing Economy**
Fahimeh Rahmanniyay, University of Massachusetts, Boston, Boston, MA
The sharing economy has recently received much attention to determine whether it is economically viable and environmentally friendly. The main tradeoff is between a decrease in production quantity, which could benefit the environment but reduce the manufacturer's profits, and an increase in product usage, which could be detrimental to the environment but beneficial to the manufacturer's profits. Given these arguments, we investigate the economic and environmental impact of the sharing economy business model and compare it with other more traditional models such as pure sales and servicizing. Our analytical results show that the sharing economy can lead to a win-win outcome with respect to both the manufacturer's profits and the environmental impact.

Tuesday, 5 PM–6:15 PM

TE78

M - Utah
Digital Platforms and Online Marketplaces
General Session

Session Chair
Zhuoxin Li, Boston College, Philadelphia

1 **The Efficacy of Need-based Attentional Interventions in Educational Crowdfunding**
Amin Sabzehzar[1], Gordon Burtch[2], Yili Kevin Hong[3], Raghu Santanam[4], [1]Tulane University, Tempe, AZ, [2]Boston University, Boston, MA, [3]University of Miami, Pinecrest, FL, [4]Arizona State University, Tempe, AZ, Contact: asabzehz@asu.edu
The inequalities in the U.S. education system lead to some students in a fairly wealthy schools having access to the resources that are not an option for their peers. Many teachers, often serving the poor students and minorities, have begun to rely on crowdfunding platforms to acquire classroom supplies. We aim to understand whether and how social biases influence online education fundraising. Using data from DonorsChoose.org, we first confirm biases toward the poor and racially marginalized students. We then show the equity-focused label's causal effects on education fundraising for disadvantaged students. In particular, results indicate the equity-focus label has a significant positive

impact on funding status (whether a project gets funded) and funding speed (how fast a project gets funded) of projects for classrooms with poor or racially marginalized students.

2 The Impact of Goal-setting on Online User Behavior

Nasim Mousavi[1], Jesse Bockstedt[2], [1]Emory University, Atlanta, GA, [2]Emory University, Atlanta, GA, Contact: nasim.mousavi@emory.edu

Despite their flexibility and ease of access, Massive Open Online Courses (MOOCs) suffer from low user engagement and retention. This study explores how goal-setting can impact user behavior in MOOCs. By conducting a randomized field experiment, we identified different behavioral patterns toward distinct types of goals. This study contributes to online user behavior and goal setting literature and provides significant practical implications.

3 The Role of On-demand Delivery Platforms in Restaurants

Zhuoxin Li, University of Wisconsin-Madison, Madison, WI

Restaurants are increasingly relying on on-demand delivery platforms (e.g., DoorDash, Grubhub, and Uber Eats) to reach customers and fulfill takeout orders. Although on-demand delivery is a valuable option for consumers, whether restaurants benefit from or are being hurt by partnering with these platforms remains unclear. The paper investigates whether and to what extent the platform delivery channel substitutes restaurants' own takeout/dine-in channels and the net impact on restaurant revenue.

4 Achieving the Double Bottom Line with Artificial Intelligence by Addressing Inequity: A Global Comparative Analysis of an Educational Technology Firm

Dahae Jeong[1], Donghyuk Shin[2], Seigyoung Auh[1], Sang Pil Han[3], [1]Arizona State University, Tempe, AZ, [2]Arizona State University, Tempe, AZ, [3]Arizona State University, Tempe, AZ, Contact: djeong3@asu.edu

Can companies use artificial intelligence to attain the Double Bottom Line (simultaneous pursuit of financial performance and social impact) by enhancing equity? Furthermore, can companies increase firm performance via increasing equity? Drawing on equity theory, this paper develops a conceptual model whereby the quality of artificial intelligence perceived by consumers positively affects firm performance that is mediated by equity in the educational technology sector. Our research contributes to the growing popularity of the blended value proposition (simultaneous pursuit of financial and social interest) by transforming a business model from a bottom line to a double bottom line approach.

Tuesday, 5 PM–6:15 PM

TE79

JWM - Room 201

Reverse Logistics and Remanufacturing

Contributed Session

Session Chair

Patrick O'Reilly, West Virginia University and Colorado School of Mines, Golden, CO

1 The Optimal Offering of Imperfect Remanufactured Products Based on Empirical Investigations of Consumers' Valuation

Mengyun Zhang[1], Harry Neil Geismar[2], James Duane Abbey[2], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: mzhang@mays.tamu.edu

This paper investigates practitioners' offering of remanufactured products that are not as good as new but have imperfections in cosmetic quality. We conduct lab experiments to make assumptions about how consumers value different offerings of remanufactured products. Building on these empirical findings, we develop models to evaluate three typical offerings of remanufactured products. Our study provides managerial insights on the offering of remanufactured products.

2 Optimizing Hazardous Waste Logistics with Uncertain Release Dates

Saeed Tasouji Hassanpour[1], Ginger Y. Ke[1], Jiahong Zhao[2], [1]Memorial University of Newfoundland, St. John's, NL, Canada; [2]Guangdong University of Technology, Guangzhou, China. Contact: gke@mun.ca

This research develops a multi-stage decision framework for a three-echelon collection network for hazardous waste considering random release dates. Applying a cost-based clustering approach, the first stage decisions involve locating the transfer stations and allocating generation nodes to the chosen facilities. The corresponding results, along with a subjective risk aversion notion and estimated release dates, are utilized to generate an a priori collection plan, which can be further revised once the actual release dates are realized. The findings can facilitate relevant authorities with practical and realistic strategic and operational decisions.

3 Supply Risk in Reverse Supply Chain Networks for Electronic Waste

Patrick O'Reilly, West Virginia University, Golden, CO,

Contact: poreilly@mines.edu

Electronics recycling has been modeled as a reverse-supply-chain flow network, reflecting market features like decentralization, competition, and stages of production. End-users either prefer landfills, or some path where reuse or recycling is possible. I extend a deterministic multi-tier variational inequality formulation to investigate the influence of end-user (supplier) uncertainty on final-goods producers (via randomized stockout and inventory penalties). In comparing the underlying deterministic case against variations of the random-supply case with numerical examples, I find that large increases in risk span, excess supply penalty, and end-user landfill costs result in inelastic responses in both flow and final demand prices.

Tuesday, 5 PM–6:15 PM

TE80

JWM - Room 202

Multiple Criteria Decision Making and Decision Analysis

General Session

Session Chair

K. Nadia Papamichail, The University of Manchester, Manchester, United Kingdom.

1 Feasibility Pump Based Heuristic Approach for Maximum Multiplicative Integer Linear Program

Ashim Khanal, Hadi Charkhgard, University of South Florida, Tampa, FL

We study an approach to solve a class of single-objective nonlinear optimization problems, called Mixed Integer Linear Maximum Multiplicative Programs (MILMMP). This class of optimization problems can be viewed as a special case of the problem of optimization over the efficient set in multi-objective optimization and has applications in different fields of study including but not limited to game theory, systems reliability, and conservative planning. In this talk, we present a Feasibility Pump based heuristic approach to solve MILMMP instances. Particularly we show that for binary instances, our proposed heuristic quickly finds near-optimal solutions. Through a computational study, we show the efficacy of our proposed approach and compare its performance with an exact solution method.

2 An Algorithm for Biobjective Mixed Integer Quadratic Programs

Pubudu Jayasekara, Margaret M. Wiecek, Clemson University, Clemson, SC, Contact: pwijesi@g.clemson.edu

We present a branch and bound algorithm for biobjective mixed integer quadratic programs (BOMIQPs). The algorithm computes the exact Pareto set and the associated efficient solutions in closed parametric form. The algorithm consists of five modules: a node problem solver to solve a relaxed BOMIQP at each node of the BB tree; a branching module that is integrated with the node problem solver; a new objective space fathoming module to fathom nodes of the BB tree; a new set domination procedure to filter the dominated points and update the current nondominated set of the BOMIQP; and initial efficient and Pareto sets to support the fathoming and set dominance modules. Numerical results are included.

3 Optimized Lease Planning for Real Estate Portfolios

Fearghal O'Donncha, John D. Sheehan, Fabio Lorenzi, Joern Ploennigs, IBM Research Europe - Dublin, Dublin, Ireland. Contact: feardonn@ie.ibm.com

Real Estate has long been the second highest annual operating expense for companies after labor cost. However, real estate decisions are also intimately connected with productivity and company success. Real Estate portfolios therefore need to be both cost-effective and aim for an efficient utilization of space through optimized decisions on which leases should be adopted, dropped or extended. These require an intelligent decision framework that considers economic and performance metrics.

We introduce an Integer Linear Programming formulation for Portfolio optimisation. The modelling framework identifies and evaluates several metrics that make certain leases preferrable to others. We conduct numerical simulations on Lease Datasets in a Real Estate Portfolio Management of 5000 buildings.

4 Data-driven Decision Support for Post-optimization Design Support

Frank Patterson, Zach Welz, Georgia Tech Research Institute, Atlanta, GA, Contact: frank.patterson@gtri.gatech.edu

In recent years, the DoD has drawn on modern methods and tools to address acquisition and sustainment needs for increasingly complex systems in equally complex multidimensional problem spaces. The Program, Planning, Budget, and Execution (PPBE) process is a critical area where the DoD decides how to coordinate funding across thousands of programs to best suit their needs. This work explores leveraging machine learning to support decision makers as they navigate results of a multi-objective DoD portfolio optimization problem. Several approaches, including clustering (Louvain and hierarchical) and classification models, are utilized to help decision makers integrate human insight with computational methods across a complex solution space.

Tuesday, 5 PM–6:15 PM

TE81

JWM - Room 203
Industry Applications
Contributed Session

Session Chair
Bibek Ray Chaudhuri, Indian Institute of Foreign Trade, Kolkata, India.

1 **Organic Waste Management Through Integration in Acid Production and LIB Bioleaching**
Majid Alipanah[1], Hongyue Jin[2], Sunday Usman[1], [1]University of Arizona, Tucson, AZ, [2]University of Arizona, Tucson, AZ, Contact: majidalipanah@email.arizona.edu
Material Recycling Facilities (MRFs) equipped with advanced sortation facilities are able to effectively separate organic wastes such as food/yard and paper wastes from others. The organic waste could be used as a new source for producing organic acid needed for bio-hydrometallurgical recycling of batteries. The feasibility of organic acid production from wastes and battery recycling through bioleaching were already published. This study tries to design a comprehensive supply chain in US for battery recycling by connecting MRFs, acid producers, and bioleaching factories. The model will decide about the location and flow of the designed network to minimize occurring costs.

2 **Dynamic Oht Routing Using Travel Time Approximation Based on Deep Neural Network**
Jaewon Choi[1], Dong Gu Choi[2], Taeyoung Yu[1], [1]Pohang University of Science and Technology (POSTECH), Pohang, Gyeongsangbukdo, Korea, Republic of; [2]Pohang University of Science and Technology (POSTECH), Pohang, Gyeongbuk, Korea, Republic of.
This study develops a dynamic overhead hoisting transport (OHT) routing method in a complex semiconductor fabrication plant (fab). The proposed method consists of two models to approximate congestion-aware travel times of different parts of a candidate route. Local path approximation model evaluates the travel time of paths within a short range based on the current rail conditions. Global path approximation model evaluates the travel time of a distant range through a deep neural network, considering additional features to reflect future traffic conditions. The simulation experiments show that the proposed method improves delivery time and throughput compared to the benchmark models. Our routing scheme successfully utilizes layout information to route the OHTs and balances the traffic in a complex fab.

3 **Predicting Supply Market Closures: A Constrained Logistics Regression Model**
Bibek Ray Chaudhuri[1], DEEPANKAR SINHA[2], [1]Indian Institute of Foreign Trade, Kolkata, India; [2]Indian Institute of Foreign Trade - Kolkata Campus, Kolkata, India. Contact: brchaudhuri@iift.edu
Global events such as the US-China trade war, the NATO sanctions, and the withdrawal of GSP by the US for a country like India led to the closure of supply markets. Studies have distinguished between the political and macro risks that impact the overall business of the industry and specific activities of firms in particular. The recent events show that policies can be country-specific and non-uniform. Thus, the extent of supply risk becomes increases manifold, especially for firms sourcing from other countries. In this paper, the authors propose a constrained logistics regression model based on relevant trade indices to predict the closure of supply sources. Results indicate that indices such as trade intensity index (TII) and trade complementarity index are good indicators of market closures under constraints of exchange rate movements and GDP.

4 **Trajectory Prediction with LSTm and Physical Information**
Xi Chen, University of Arizona, Tucson, AZ, Contact: xic@email.arizona.edu
We propose to predict vehicle trajectories in a connected environment using LSTM leveraging physic informations.

Tuesday, 5 PM–6:15 PM

TE82

JWM - Room 204
Improving Health in Everyday Life
General Session

Session Chair
Alexandra M. Newman, Colorado School of Mines, Golden, CO

1 **Why Can'T We Have Both? Exploring Equity Vs Efficiency in Inter-hospital Unit Transfer of Psych Patients**

Nathan Adeyemi[1], Kayse Lee Maass[2], Mohammad Dehghani[2], Kalyan Pasupathy[3], [1]Northeastern University, Boston, MA, [2]Northeastern University, Boston, MA, [3]University of Illinois at Chicago, Chicago, IL, Contact: adeyemi.n@northeastern.edu

Emergency Departments (EDs) are commonly the first point of contact for a significant portion of psychiatric patients in need of urgent acute care. However, once inpatient (IP) admission is deemed necessary, a patient may spend hours or days awaiting inpatient bed availability. In this project we simulate a network of ED and psychiatric IP units and the patient transfers between them, to estimate multiple sources of delay preceding inpatient treatment. This simulation is then integrated in a multi-objective bed reallocation problem designed to simultaneously minimize patient treatment delay and equitably distribute IP beds throughout hospitals to ensure there an appropriate number of beds are in close proximity to communities.

2 Congestion and Emissions Impacts of Switching from In-person to Online Grocery Delivery: A Seattle Case Study

Mateo Samudio, Carnegie Mellon, Pittsburgh, PA, Contact: csamudio@andrew.cmu.edu

The use of grocery delivery services is on the rise. This shift in the way customers do their grocery shopping will have impacts on the transportation network. Instead of in-store shopping, delivery vehicles will populate the roads. This work analyzes the impacts on emissions, energy use, and traffic congestion caused by this new trend in several different scenarios. It also characterizes the relationship of the magnitude and direction of these impacts with key variables that are set by the demand and supply side of the grocery sector.

3 Incorporating Ventilation and Heat in Short-term Underground Mine Production Scheduling

John Ayaburi, Colorado School of Mines, Golden, CO

The accumulation of heat in underground mines not only disrupts the schedule but also affects the health and safety of mine workers. We develop a large-scale, short-term production scheduling model that minimizes deviation between i) medium- and short-term schedules and ii) production goals. Constraints include precedence, resource consumption and heat limits. We correspondingly present novel techniques to improve model tractability. The model produces a consistent schedule while ensuring the safety of the work environment.

4 Incorporating Heat Constraints in Mine Production Scheduling

Aaron Swift, Colorado School of Mines, Golden, CO

Battery electric vehicles are becoming more common in mining applications. One benefit of battery electric vehicles (BEVs) in an underground mining setting is the absence of diesel emissions. However, BEVs still generate heat, which can lead to unsafe working conditions. This research compares the heat produced by BEVs relative to diesel vehicles in executing mining activities. The results inform heat constraints in a production scheduling optimization model.

5 A Time-windows Solution Technique for Underground Mine Scheduling under Uncertainty

Patricio Andres Lamas[1], Marcos Goycoolea[2], Alexandra M. Newman[3], Bernardo Kulnig Pagnoncelli[4], [1]AlicantoLabs, Santiago, Chile; [2]Universidad Adolfo Ibanez, Penalolen Santiago, Chile; [3]Colorado School of Mines, Golden, CO, [4]SKEMA Business School, Lille, France.

Uncertainty is present in every underground mine project. However, traditional mine scheduling approaches assume deterministic parameters. We propose a scheduling technique that assigns to each activity of the project a time window corresponding to a range of time periods in which the corresponding activity must start. Numerical experiments show that our technique generates schedules that dominate those generated by traditional deterministic approaches.

Tuesday, 5 PM–6:15 PM

TE83

JWM - Room 205

Simulation Modeling and Its Applications

General Session

Session Chair

Yuan Zhou, University of Texas at Arlington, Arlington, TX

1 Impact of Catastrophic Risk in Inventory Stocking Decisions

Canan Gunes Corlu[1], Bahar Biller[2], Elliot Wolf[3], Enver Yucesan[4], [1]Boston University, Boston, MA, [2]SAS Institute, Cary, NC, [3]Chemours Company, Willington, DE, [4]INSEAD, Fontainebleau, France. Contact: canan@bu.edu

We study inventory stocking problems in the presence of catastrophic disruptions which tend to be devastating and persist longer compared to disruptions that stem from demand uncertainties. Using stochastic simulation, we obtain insights for managing inventory under catastrophic risk by combining the inventory models capturing demand uncertainty costs with catastrophe models capturing the cost of supply disruption and also the cost of recovery.

2 Physician Shift Scheduling to Reduce Emergency Department Crowding and Patient Handoffs

Vishnunarayan Girishan Prabhu[1], Kevin M. Taaffe[2], Ronald G. Pirrallo[3], William Jackson[3], Michael Ramsay[3], Jessica Hobbs[3], [1]Clemson University, Clemson, SC, [2]Clemson University, Clemson, SC, [3]Prisma Health-Upstate, Greenville, SC, Contact: vgirish@g.clemson.edu

Emergency Department (ED) overcrowding continues to be a public health issue as well as a patient safety issue. Additionally, over 140 million annual visits are made to US EDs, making it one of the most complex healthcare settings prone to medical errors. Although various factors lead to overcrowding and errors, a few primary factors include inadequate staffing and patient handoffs. After interviewing 85 practicing ED physicians, we developed a mixed-integer programming model to generate physician schedules that improves patient flow and patient safety by reducing the patient time in the ED and handoffs. Simulating these schedules in the validated simulation model over a three-week duration, we observed that patient time in the ED and handoffs can be reduced by as much as 5.4% and 8.7%, along with a slight decrease in full-time equivalents compared to the current practices.

3 An Agent-based Modeling for Patrol Operations Decision Analytics

Yasaman Ghasemi, Loyola Marymount University, Los Angeles, CA

Police patrolling plays a vital role in ensuring communities' safety and sustainable development. The complex nature of the policing system often makes it very challenging to manage and control. The dynamic and stochastic criminal behavior, compounded with limited policing resources, rendered current police operations inefficient. An agent-based policing framework is developed to conquer these weaknesses by addressing the dynamically changing complexities and uncertainties in police operations and adaptively optimizing operational performance based on the state of the policing system. A real-world case study is conducted to illustrate how this framework is used in dynamic patrol deployment planning.

4 Simulation Driven Prediction for Emergency Department Boarding Levels

Eniola Suley[1], Yuan Zhou[2], Shouyi Wang[2], Victoria C. P. Chen[1], Yan Xiao[1], [1]The University of Texas at Arlington, Arlington, TX, [2]University of Texas at Arlington, Arlington, TX, Contact: eniola.suley@mavs.uta.edu

Early warning for crowding continues to be of interest to ED administrators. In this paper, we present an early warning detection of overcrowding using a simulation-driven machine learning model. With operational information collected along patient workflow from arrival to departure, the model can predict the number of boarding patients in future time steps, an indicator for future ED crowding. Various algorithms were compared and we show that ARMA and ETS models achieve almost double the prediction accuracy of using historical data when predicting one-hour and one-week ahead respectively. Our approach can provide ED staff with overcrowding signals, allowing them take proactive mitigation steps.

Tuesday, 5 PM–6:15 PM

TE84

JWM - Room 206

Service Industry Applications

General Session

Session Chair

Rainer Dronzek, Engineering USA, Verona, WI

1 Leveraging Simulation to Boost Ai and Keep Pace with the Future

Mike Cramer, McDonald's, Chicago, IL

McDonald's Corporation has relied significantly on multiple simulation methods in concert with advanced analytics and AI to drive its successful business track over the past 5 years. The latest innovation will be shared, where we leverage simulation to act as a supervisor to AI and as a means by which to rapidly pivot when change is required.In this session, we will describe McDonald's view on the importance of keeping pace with the rapidly changing customer needs states, the operating conditions for our employees and uncertainties in supply and how we are resourced to do so.We will share examples of how we framed the problems, worked collaboratively to rapidly develop solutions and what we learned along the way.

2 Model Parameterization Reduces Rework: A Restaurant Case Study

Chris Schopp, SimWell, Laval, QC, Canada.

One way to improve the utility of simulation models is to design and develop them using external parameters. This approach 1) helps reduce model logic changes when the process changes, 2) allows the casual user to configure, run, and analyze a model, 3) reduces the need to re-verify models when a configuration changes, and 4) bundles input parameters and output results into a manageable and traceable configuration. A quick service restaurant case study will be used to showcase model parameterization.

3 Crowd Modeling

Rainer Dronzek, Simulation Modeling Services, VERONA, WI

A case study and demonstration of the agent-based modeling of pedestrian autonomous movement, including interaction with other pedestrians, retail and service facilities, and transportation systems. The model supports the analysis of congestion, movement, transit schedules, and emergency evacuation. The approach used to model dynamic crowd conditions in a mass transit center will be highlighted, as well as a novel method for quantifying density, the connection to near-real-time data to predict impending risks, and alert messaging to a central monitoring system.

Tuesday, 5 PM–6:15 PM

TE85

JWM - Room 207

Stackelberg Games

Contributed Session

Session Chair

Wendy Olsder, Eindhoven University of Technology, Eindhoven, Netherlands.

1 Stackelberg Model for Microgrids Operation with Power-to-x Technologies

Yolanda Matamala[1], Felipe A. Feijoo[2], [1]Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile; [2]Pontificia Universidad Católica de Valparaíso, Valparaiso, Chile. Contact: yolanda.matamala.a@mail.pucv.cl

Power-to-X technologies provide renewable substitutes for fossil fuels and grid balancing services due to their flexible operation and long-term storage capacity. Hydrogen-focused multi-energy supply microgrids covering different types of energy, such as electricity, heat, cooling, and hydrogen demands, could be considered a solution to renewable generation losses. We propose a stochastic Stackelberg formulation to support the planning of microgrids in grid-connected mode with the integration of Power-To-X technologies subject to uncertainty in generation capacity. The study, carried out on a network of 5- buses over one year, demonstrates the economic feasibility of electricity-hydrogen-heat coordination at the microgrid level, as well as stochastic modeling.

2 Computing An Equilibrium of a Generalized Stackelberg Game for Sharing Platforms

Jihwan Yu, Jaeyeon Jo, Jinkyoo Park, Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of. Contact: jihwan14@kaist.ac.kr

Sharing platforms, constructed based upon the sharing economy concept, have enabled the efficient usage of limited resources by connecting consumers and suppliers. However, obtaining the optimal operating strategy of the platform to increase the service quality and profit is generally challenging due to the complex game-theoretic interactions among the platform operators and users. Here, to understand these complex interactions and propose an effective platform operating strategy, we model such complex interactions between a platform operator and users using the 1-N generalized Stackelberg game and propose a general methodology to find the generalized Stackelberg equilibrium of the 1-N generalized Stackelberg game. We validate the proposed approaches using the two problems of deriving operating strategies for EV charging stations.

3 Adaptive Approval of Drugs for Rare Diseases

Wendy Olsder[1], Tugce Martagan[1], Jan C. Fransoo[2], Carla Hollak[3], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Tilburg University, Tilburg, Netherlands; [3]Academic Medical Center, Amsterdam, Netherlands. Contact: w.olsder@tue.nl

Adaptive approval is a novel regulatory program that enables earlier patient access to new drugs for rare diseases. The program has been in place for almost a decade, however, industry participation has been surprisingly low. To understand why industry participation has been low, we present a Stackelberg game-theoretic model that captures the strategic interactions between a profit-maximizing pharmaceutical firm and utility-maximizing patients. We analyze various redesigns of the adaptive approval programs, such as the inclusion of subsidies, a change in the market exit requirement, and an extension of the market exclusivity period. Our results inform healthcare policymakers on ways to redesign adaptive approval programs such that both firm participation and patients' access to new drugs will increase.

Tuesday, 5 PM–6:15 PM

TE86

JWM - Room 208

Integration and Equity Issues in Advanced Air Mobility

General Session

Session Chair

Max Zhaoyu Li, University of Michigan, Ann Arbor, Cambridge, MA

1 Autonomous Operations for AAM: Considerations and Challenges

Pavan Yedavalli, Wisk Aero, San Francisco, CA, Contact: pavan.yedavalli@wisk.aero

As most industry and academic studies predict, advanced air mobility (AAM) is expected to become profitable only when autonomy is fully enabled. However, Air Traffic Management and AAM Concepts of Operations have yet to consider autonomy-specific procedures and infrastructure that enable seamless operation at scale. In this talk, three components of autonomous operations are detailed. First, the passenger journey from origin to destination vertiport is established, reviewing the upgrades, retrofits, and tailored procedure changes to accommodate safe flight. Then, a summary of route design, incorporating autonomous air traffic control interactions and off-nominal procedures, is given. Third, vertiport network design and constraints are presented. The relevant stakeholders in AAM can glean insights from these considerations for successful future deployment.

2 A Simulation Study of Uas Risk-aware Path Planning in Mitigating Third-party Risks Considering Flight Volume

Xinyu He[1], Lishuai Li[2], Chengpeng Jiang[3], Henk A. P. Blom[3], [1]City University of Hong Kong, Kowloon Tang, Hong Kong; [2]City University of Hong Kong, Kowloon Tang, Hong Kong; [3]Delft University of Technology, Delft, Netherlands. Contact: xinyuhe5-c@my.cityu.edu.hk

There will be a large volume of UAS operations in urban areas in the future. These flights pose risks to people on the ground, referred to as third-party risks. Risk-aware path planning methods have been developed to generate a nominal path with relatively low risk. However, it is unclear whether current path planning effectively reduces the risks when considering the real-world scenario with many flight operations over multiple paths. We designed and conducted a set of simulation experiments to test how the third-party risks change when flight volume increases, and how risk-to-distance ratios in the risk-aware path planning algorithm affect the third-party risks considering flight volume. Our results show that the current path planning method can reduce the total number of fatalities in an area but at the cost of increasing individual fatality probability in some areas.

3 Vertiport Location Selection for Urban Air Mobility Based on Urban Taxi Mobility Data

Seyun Kim[1], Yoonjin Yoon[2], [1]Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of; [2]Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of. Contact: whataud@kaist.ac.kr

Urban Air Mobility (UAM), which transports people and cargo in urban airspace, is one of the promising future mobility that can transform people's lifestyles. For the smooth implementation and spread of the UAM system, the locations of vertiports need to be carefully selected at where users want to travel by UAM. It can be helpful to analyze the usage history of the existing urban transportation system to understand potential demand and selecting vertiport location. In this research, urban taxi mobility data is processed and used to analyze the potential trip demand that can be replaced by UAM.

4 Understanding Tradeoffs in Traffic Flow Management for Advanced Air Mobility

Jungwoo Cho, Korea Transport Institute, Sejong, Korea, Republic of. Contact: jjw9171@gmail.com

The density and frequency of UAM operations in 2030s are expected to be higher than those of today's commercial air traffic. Developing a scalable traffic flow management strategy is thus essential to manage the growing urban air traffic. In this study, we propose an algorithm for allocating multiple routes for multiple aircraft in consideration of system efficiency, safety, and fairness. Specifically, we consider safety by allocating routes that do not violate the separation minima between aircraft, and consider efficiency by minimizing the flight time of all aircraft rather than the flight time of a specific aircraft. Fairness is taken into account by adjusting detours and delays not to be concentrated on some aircraft. Finally, we derive conflict-free solutions for over 100 aircraft and evaluate the tradeoffs between safety, delay, and fairness in each solution.

Wednesday, 8AM–9AM

WP

JWM - White River E

Plenary: Morse Lectureship - Alvin E. Roth

Plenary Session

Session Chair
Sheldon H. Jacobson, University of Illinois, Urbana, IL

1 **Market Design: The Dialog Between Simple Abstract Models and Practical Implementation**
Alvin E. Roth, Stanford University, Stanford, CA
I'll review some of the elegantly simple models that underlie the initial designs for matching processes like the medical residency Match, school choice and kidney exchange, and the modifications, complications and computations that were needed to get new designs adopted, implemented and maintained over the years.

Wednesday, 9:15AM–11:15AM

W

JWM - White River E
Freestyle O.R. Supreme Game Show (Pre-registration & Additional Fee Applies)
General Session

Session Chair
Carrie Beam, University of Arkansas, Walnut Creek, CA

1 **Freestyle O.R. Supreme Game Show**
Carrie Beam, University of California, Davis, Walnut Creek, CA
Calling all students, early-career professionals and anybody else who wants to build a resume! Freestyle O.R. Supreme Expo is our fast-moving live game show, in which teams frame a real-life problem and present a solution in real time. This is a great opportunity to participate in the conference without having to write a paper or make a poster. An industry "client" will present a 10 - 15 minute overview of a real-world problem to solve. Your team will have a 30 minute break out session to craft your 3 - 5 minute O.R. presentation with recommendations for methodology for an implementable solution. The client will listen to each team and give feedback on their presentations, and will select a winner from the presentations. Fame and glory can be yours. Sign up today! https://docs.google.com/spreadsheets/d/1ks9rQxRXFXoAmc6VnnA1w4rwUptZAe2JtXbTSmcb3Xo/edit?usp=sharing

Wednesday, 9:15AM–5 PM

W

JWM - White River AB
Workshop on Transit Oriented Innovations in Emerging Mobility – Service Designs, Algorithms and Societal Implications
Workshop Session

Session Chair
Samitha Samaranayake, Cornell University, Ithaca, NY

Session Chair
Pascal Van Hentenryck, ISyE Georgia Tech, Atlanta, GA

Wednesday, 9:15AM–10:45AM

WA01

JWM - White River GH
INFORMS Advocacy Program: Expanding Your Reach & Impact through Advocacy & Outreach
Panel Session

1 ***Panel Discussion*: Expanding Your Reach & Impact through Advocacy & Outreach**
Kara M. Morgan, Chair of Advocacy Governance Committee, Dublin, OH
The panel will discuss the importance and benefits of INFORMS members engaging with policymakers, other government officials, and the media to promote the ways in which how O.R, analytics, and their research and contributions regarding how our community's work saves lives, saves money, and solves problems.

2 **Panelist**
Laura Albert, University of Wisconsin-Madison, Madison, WI

3 **Panelist**
Michael P. Johnson, University of Massachusetts, Boston, MA

4 **Panelist**
Ramayya Krishnan, Carnegie Mellon University, Pittsburgh, PA

5 **Panelist**
Kayse Lee Maass, Northeastern University, Boston, MA

6 **Panelist**
Anna B. Nagurney, University of Massachusetts-Amherst, Amherst, MA

Wednesday, 11AM–12:30 PM

WB01

JWM - White River GH

INFORMS Advocacy Program: How to Convey a Message of Influence and Impact in 11 Minutes or Less

General Session

1 ***Workshop*: How to Convey a Message of Influence and Impact in 11 Minutes or Less**

Mark R. Mills, Mills Strategic Communications, Inc., Orlando, FL

Recognizing that communicating an effective message to policymakers and the media in a condensed timeframe is an essential communication skill for successful leaders, researchers, teachers, practitioners, and others, Annual Meeting attendees are invited to participate in a a 90-minute workshop, "How to Communicate a Message of Impact and Influence in 11 Minutes or Less". In this first of a kind workshop for INFORMS, which will be led by Mark R. Mills, a professional leadership engagement and public persuasion coach, participants will be provided with an opportunity to learn and apply proven key strategies for effective time-sensitive communication via media interviews, meetings with policymakers, or other communications with the public.