Wednesday, 6:00AM - 7:30AM

■ VWA01

Virtual Room 01

Smart Business Strategies Supported by Data-Driven Decisions

Sponsored: Data Mining

Sponsored Session

Chair: Guang Yang, A, AR, United States

1 - Mozrt - AI Orchestrated Learning

Yanbin Ye, Principal Data Scientist, Walmart, Bentonville, AR, United States, Wen Xu, Qixin Wang

Mozrt is a recommender system that focuses on personalizing associates' learning experiences to ensure they recommend the right content to the right people at the right time. One important success metrics is to save associates time. To achieve this goal, we developed an end-to-end machine learning solution that includes not only NLP-based semi-supervise learning models, but also controls user learning engagements data collections. To increase the personalized recommendation accuracy and reduce cold start problems, we used a hybrid recommendation algorithm that combined traditional collaborative filtering with the deepFM model.

2 - FraduFox: Adaptable Fraud Detection in the Real World

Yi Fan, Sr. Applied Scientist, Amazon, Seattle, WA, United States, Matthew Butler, Christos Faloutsos

How suspicious is `Smith', trying to buy $500 shoes, on Monday 3am? How to merge the risk scores from a handful of risk-assessment modules (`oracles') in an adversarial environment? More importantly, given historical data (orders, prices, and outcomes), and business restrictions, which transactions should we `pass', v.s. investigate? These are the two research problems we focus on in this work. One approach to address the first problem (`oracle-weighting'), is by using Extended Kalman Filters with dynamic importance weights, to automatically and continuously update our weights for each 'oracle'. For the second problem, we show how to derive an optimal decision surface, and how to compute the Pareto optimal set, to allow what-if questions. The resulting system, FraudFox, is scalable, adaptable to changing fraudster behavior, effective, and already in production.

■ VWA02

Virtual Room 02

Machine Learning for Marketing Applications

Sponsored: Data Mining

Sponsored Session

Chair: Amin Hosseininasab, University of Florida, Gainesville, FL, 32611-1942, United States

1 - Using Generative Model To Identify Breakthrough Innovation

Zhaoqi Cheng, Carnegie Mellon University, Pittsburgh, PA, 15206-3747, United States

Computational creativity literature has established that an intelligent agent need to first properly identify innovation before creating one. We propose InnoVAE, a customized variational autoencoder (VAE) on a data set of "computing systems" patents to generate and situate patents in an interpretable vector space, consisting of factors of innovation. We argue that three different types of scientific innovation — combinational, exploratory, and transformative — can be distinguished by generative algorithms in an unsupervised, data-driven manner, and test the value of this representation by exploring correlations with economic measures of patent impact. We further discuss the potential utility of generative AI methods for business applications.

2 - Panoramic Market Structure Analysis Leveraging Consumer Location Big Data

Eunkyung An, New York University, New York, NY, 10012, United States, Natasha Zhang Foutz, Xiao Liu, Baohong Sun

Consumers' daily movements and location visitations reveal their 24/7 lifestyle and brand preferences within and across industries. Compared to the traditional, intra-industry, competition-centric market structure, consumer movement data portray a never-before, cross-industry, customer-centric market structure. We employ the heterogeneous network embedding model to population-scale, granular, behavior-rich, individual-level location data to derive panoramic market structure embedding brand-store-customer networks and lifestyle segments. This analysis offers marketers unprecedented business intelligence for targeting, entry/exit strategy, and cross-industrial promotion and brand alliance.

3 -Modeling Lengthy Behavioral Log Data For Customer Churn Management

Daehwan Ahn, Post Doc, University of Pennsylvania, Philadelphia, PA, 19130, United States, Dokyun Lee, Kartik Hosanagar

Churn management has benefited much from advanced feature learning techniques applied to large-scale behavioral log data. Despite its success, the current models can only address sequences of short length ranging from hundreds to thousands. In practice, however, customer log data has a very long sequence that can extend to millions in length that can only be utilized through manual and onerous feature engineering, which requires domain expertise and can be unreliable depending on the data scientist. We propose an automated log-processing approach that extends powerful feature learning approaches to extract valuable signals from lengthy log data. Our proposed framework achieves a significant improvement in customer churn prediction relative to existing manual feature engineering approaches developed by a global game company.

4 - From Client RFPs To Provider Offerings Using NLP

Paul R. Messinger, University of Alberta, Edmonton, AB, Canada, Aly Megahed, Hamid Reza Motahari Nezhad, Ahmed Nazeem, Juan Cappi, Pravar Mahajan, Robert Engel, Yuya Ong

We automate two activities that are done at the beginning of the tender bidding process for large service projects. (1) We extract performance requirements from Requests from Proposals (RFPs) for complex service contracts using customized text analytics and natural language processing techniques. (2) We match these requirements to the capabilities of a large service provider. Winning such large B2B service contracts is critical for the business success of service providers.The proposed methods facilitate faster processing of RFPs, consideration of a larger number of RFPs, and cost reductions.

■ VWA03

Virtual Room 03

Mining Digital Trace Data of Online Communities

Sponsored: Data Mining

Sponsored Session

Chair: Tianjie Deng, University of Denver, University of Denver

1 - Are Critics Really Unbiased? The Impact Of Social Ties On Critics' Rating Behavior

Tianxi Dong, Assistant Professor, Trinity University, San Antonio, TX, United States, Tianjie Deng, Thomás Peña

Grounded in the differentiation theory, this study aims to empirically investigate the relationship between social ties and the rating similarities between critics. We collected an extensive data set from Rotten Tomatoes exploring the critics' social relations in conjunction with their movie-rating behavior. We find that loners (critics who have no connections) give higher ratings than non-loners (critics with at least one connection). What is more, critics tend to give lower ratings when they have more connections. In terms of social tie strengths, critics with strong ties appear to provide similar ratings. These findings raise questions about the reliability of critic ratings as unbiased indicators of quality. Platform stakeholders can adjust their strategies to account for possible review biases resulting from the social interactions among critics.

2 - How Open Source Software Releases Entrain Emergent Routines

Aron Lindberg, Stevens Institute of Technology, Hoboken, NJ, United States

While the literature on release cycles in open source software (OSS) has identified numerous different phases, we know little about the mechanisms that allocate different types of work across these phases. Understanding this would be valuable for project managers, core teams, and corporate sponsors wishing to shape the type of work conducted at different points in the evolution of an OSS project. To investigate how the emergent routines of OSS developers become structured across release cycles of OSS we conduct an abductive, computational study of eight OSS projects. We use relational event modeling to analyze 1,169,489 actions covering 93 major software releases. We find that developer activities are structured both by entrainment mechanisms internal to the emergent routines of developer activities: activity, popularity, and inertia, as well as their interactions with external entrainment mechanisms, i.e., the phases of the release cycle. Before a major release development work tends to be entrained by inertia effects whereby developers focus on issues in which they have invested considerable effort in the past. After a major release development work concentrates around the most active developers. Between major releases developers scan for issues which have become popular. Our theorizing suggests that release cycles constitute an important temporal mechanism that shapes how the development work and their types are allocated between OSS developers.

3 - Online Sustainability Reporting and Value Creation for Firms

Ning Xue, University of Colorado, Denver, CO, United States, Dobin Yim, Jiban Khuntia

This study aims to utilize data mining techniques to extract concepts from firms' digital sustainability reports disclosed on a sustainability reporting platform, and to understand the impacts of two types of practices: employee-orientation (internal) and customer-orientation (external) on firms' financial performance. Considering the current digital transformation of businesses, this study also explores the differences between digital and non-digital firms to provide implications for the digitization and digitalization process. We test our hypotheses with a matched dataset of 682 firms from 2013 to 2015.

4 - Preserving History: Archiving Search Query Results for Future Research

Joshua Madden

Efforts to preserve web pages have been dramatically increased in the past decade. Cheaper data storage and faster processing have allowed for an increase in the number websites archived and the frequency with which they are archived. However, archiving the results of search queries presents unique challenges not easily addressed by traditional web crawling methods. This research outlines some of the potential challenges and presents some possible solutions for archiving these types of pages.

■ VWA04

Virtual Room 04

Analytics & Data Science Program Academic Excellence

Sponsored: Data Mining

Sponsored Session

Chair: Matthew A. Lanham, Purdue University, Lafayette, IN, 47905-4803, United States

1 - Giving Students a Competitive Edge: Integrating CAP into Curriculum and Aligning to Labor Market Demand

Lynn Letukas, SAS Institute, Sas Campus Dr, Cary, NC, 27513, United States, Jacqueline Johnson

Jobs requesting analytics skills such as data analysis, data science, statistics, or business intelligence have grown by 20 percent annually in the last four years with more than 400K jobs currently posted monthly in the US. Despite this growth, data from Gallup shows a sizable gap between the skills and competencies students learn in college and those most requested by employers. This presentation builds upon others in this session by focusing on how labor market data can be used to assist with course development and in-demand skill integration to improve program and student outcomes. Specifically, this talk examines demand for skills associated with the Certified Analytics Professional (CAP) certification and highlights teaching and learning resources available to faculty and students to learn analytics skills.

2 - Teaching INFORMS CAP Principles To Business Leaders

Joseph A. Cazier, Dean's Club Professor, Appalachian State University, Appalachian State Unversity, Department of Decisio, Boone, NC, 28608, United States

This program shares lessons learned in developing INFORMS based analytics educational programs and materials for mid-level managers and executives. Topics include partnering with private firms, tailoring the program to different audiences, building a curriculum and navigating the university ecosystem.

3 - Integrating INFORMS CAP/aCAP Into Your Academic Program

Matthew A. Lanham, Purdue University, 112 Eastland Dr, Lafayette, IN, 47905-4803, United States

We discuss how we are making a proactive attempt to get every future graduate of Purdue's M.S. in Business Analytics & Information Management (BAIM) program and many program alumni to become INFORMS Certified Analytics Professionals (CAPs/aCAPs). We discuss why most programs have not achieved this, why we believe we can, how we are going about it, and challenge any academic program to partner with us to create additional incentives to push our graduates and program outcomes to the next level.

4 - A 10-year Business Analytics Journey: Challenges, Successes and Change

Melissa R. Bowers, University of Tennessee-Knoxville, 242 Stokely Management Center, Statistics, Operati, Knoxville, TN, 37996, United States

The University of Tennessee Business Analytics program graduated its first cohort of MS students in 2011. Throughout our decade-long journey, the program has faced many challenges, shared successes, and introduced numerous changes. We will share details of lessons learned that have positively impacted curriculum, recruiting, our partnerships with industry, and our approach to teaching business soft skills.

■ VWA05

Virtual Room 05

Novel Data Mining Methodologies for Analyzing COVID-19 Data Associations

Sponsored: Data Mining

Sponsored Session

Chair: Javier Cabrera, Rutgers University, Piscataway, NJ, 08854, United States

1 - Novel Adaptive Pattern Extraction and Matching Algorithms for Forecasting COVID-19 Time Series

Debopriya Ghosh, Rutgers University, Newark, NJ, 07102, United States, Dhammika Amaratunga, Michael Katehakis, Jing Wang, Javier Cabrera, Wenting Wang

We build a novel approach for forecasting COVID-19 time series that exhibit evolutionary structural changes and have limited past data. The method involves data preprocessing using modified smoothing and variance stabilizing transformations. Dynamic change point analysis is performed to segment the original time-series into shorter distinct structural patterns. The extracted patterns are made scale invariant by further linear transformations. Finally, an approximate pattern matching approach is used to identify similar patterns for forecasting the future trend by weighted interpolation.

2 - Analyzing the Association of Socio-Economic Factors with the Patterns of COVID-19 Cases and Deaths in New Jersey

Wenting Wang, Rutgers University, Newark, NJ, United States, Dhammika Amaratunga, Javier Cabrera, Debopriya Ghosh, Michael Katehakis, Jin Wang

In this study, 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. Factors considered included population, percentage of elders in the population, percentage of low-income households, access to food and health facilities and distance to New York. In order to acquire socio-economic data related to access to food and health we searched the data from the Yelp Fusion API for all NJ counties. The cumulative daily cases and deaths as a function of time were compared using a dissimilarity based on areas between the curves using Simpson's rule, followed by multidimensional scaling.

3 - Confidence and Prediction Intervals for Forecasting COVID-19 Daily Cases and Deaths Using Adaptive Deep Learning Models

Jin Wang, City University of Hong Kong, Hong Kong, China, Dhammika Amaratunga, Javier Cabrera, Debopriya Ghosh, Michael Katehakis, Prateek Purwar, Wenting Wang, Arpt Yadav

We develop methodology to forecast confirmed COVID daily cases and deaths and provide confidence and prediction intervals for time-series models forecasting. In order to address data irregularities, we develop a pre-processing process that uses modified versions of variance stabilizing transformations and smoothing splines. This is followed by applying LSTM deep learning. Our methods produce confidence and prediction intervals combining LSTM with building block bootstrap. Our method shows good performance for forecasting COVID daily cases and deaths using New Jersey data.

4 - Bootstrap Methods for Constructing Confidence Intervals Using Deep Learning Time Series Models

Dhammika Amaratunga, Javier Cabrera, Yajie Duan, Debopriya Ghosh, Chun-Pang Lin, Michael Katehakis, Jin Wang, Jin Wang

Several methods have been proposed for forecasting the dynamics of the cases and deaths related to Covid-19 from the statistical/machine learning methodology. Such methods include pattern matching forecasting, Deep learning using RNN-LSTM and CNN. Also, there are other important methods for forecasting the annual flu epidemic such as the ARGO models and other long time-series forecasting models. In this presentation we compare deep learning methods with time-series methods for forecasting NJ COVID-19 data. We will provide further insights about the applicability of these methods.

■ VWA06

Virtual Room 06

New Models and Methods in Learning and Data Management

Sponsored: Data Mining

Sponsored Session

Chair: N. Bora Keskin, Duke University, Duke University, Durham, NC, 27708, United States

1 - Competing Streaming Platforms: The Impact Of Exclusive Content

Emily A. Meigs, MIT, Cambridge, MA, 02139-4204, United States

We develop a model to study the joint problem of designing the subscription fee and amount of original content a streaming platform should generate. In our model, the users are heterogeneous in their usage rate and depending on the content on the platforms and their subscription fee decide whether they want to subscribe to a platform or not. The two competing platforms, each choose the subscription fee that they want to offer for (unlimited) access to their content and the investment level they put into their content. The investment in their own content is costly, but higher quality content can potentially be offered at a higher subscription fee to the users. We fully characterize the equilibrium in both the monopolistic and competitive settings. We characterize under what conditions the platforms separate the two types of customers.

2 - Simple Agent, Complex Environment: Efficient Reinforcement Learning With Agent States

Shi Dong, Stanford University, Stanford, CA, United States

We design a simple reinforcement learning agent that, with a specification only of suitable internal state dynamics and a reward function, can operate with some degree of competence in any environment. We establish a regret bound demonstrating convergence to near-optimal per-period performance, where the time taken to achieve near-optimality is polynomial in the number of internal states and actions, as well as the reward averaging time of the best policy within the reference policy class, which is comprised of those that depend on history only through the agent's internal state. Notably, there is no further dependence on the number of environment states or mixing times associated with other policies or statistics of history.

3 - Bootstrapping Fitted Q-Evaluation for Off-Policy Inference

Xiang Ji, Princeton University, Princeton, NJ, United States

Bootstrapping provides a flexible and effective approach for assessing the quality of batch reinforcement learning, yet its theoretical properties are poorly understood. In this paper, we study the use of bootstrapping in off-policy evaluation (OPE), and in particular, we focus on the fitted Q-evaluation (FQE) that is known to be minimax-optimal in the tabular and linear-model cases. We propose a bootstrapping FQE method for inferring the distribution of the policy evaluation error and show that this method is asymptotically efficient and distributionally consistent for off-policy statistical inference. To overcome the computation limit of bootstrapping, we further adapt a subsampling procedure that improves the runtime by an order of magnitude. We numerically evaluate the bootstrapping method in classical RL environments for confidence interval estimation, estimating the variance of off-policy evaluator, and estimating the correlation between multiple off-policy evaluators.

4 - Data-Driven Learning In Nonstationary Newsvendor Problems

Xu Min, Tsinghua University, Beijing, 100084, China, N. Bora Keskin, Jing-Sheng Song

We study a newsvendor problem with unknown demand distribution in a nonstationary environment. The demand in each period consists of a time-varying demand level and an additive random shock. Neither the demand level nor the random shock is separately observable. The amount of change in the demand level over the time horizon is measured by a cumulative variation metric. We design a nonparametric dynamic ordering policy, termed the moving window ordering policy, which computes the order quantity in each period using only the past demand observations. For a finite variation "budget", we prove that our policy is first-order optimal where the regret grows at the smallest possible rate. Through case studies based on real-life data, we show that our policy can save 20-80% of the cost, relative to policies widely used for perishable inventory replenishment and nurse staffing.

■ VWA07

Virtual Room 07

Healthcare Analytics, During the Pandemic and Beyond

Sponsored: Data Mining

Sponsored Session

Chair: Sara Nourazari, California State University-Long Beach, Huntington Beach, CA, 92648-0906, United States

1 - Agent-based Simulation for Emergency Department Throughput

Josh Joseph, Beth Israel Deaconess Medical Center, Boston, MA, United States

Throughput in the emergency department setting reflects a series of dependent queues describing a patient's full evaluation and treatment. While queueing models may provide substantive insight into bottlenecks in emergency department throughput, modeling approaches which allocate set amounts of variability in service times to human factors may tend to over and under-estimate delays to a significant degree. Use of an agent-based framework, informed by knowledge of emergency physician work habits, may lead to more parsimonious models of throughput for staffing and resource allocation.

2 - Adaptive, Real-Time and Automated Systems for Early Detection of COVID-19 Patient and Survivor Symptoms and Preventing Hospitalization

Jakka Sairamesh, CapsicoHealth, Inc., Palo Alto, CA, United States, Suzanne Hynes, Laurent Hasson, William Stein-III

Recent CMS data has shown that over 20 Billion USD was spent on hospitalizations for COVID-19 patients with an average of $25K USD per hospitalized patient. With changing symptoms, identifying and preventing hospitalizations is a great challenge as COVID-19 cases including survivors have to be monitored at home. Our NLP tools analyzed over 100,000 home and ambulatory visit notes and found that a staggering 10% of the patients were estimated to be at a high-risk based. Our dictionaries were designed to adapt to the changing indicators. Our adaptive AI system was able to identify with 87% recall and 90.7% precision the COVID-19 related symptoms. We compared the automated system with clinician review on 5000+ notes. We present an adaptive system approach where the operational system is being used by clinicians on a daily basis for supporting COVID-19 and other vulnerable patients.

3 - Using Surgical Schedule Bed Board Modeling Results From Pandemic For Planning Future Hospital Occupancy

Franklin Dexter, Professor, University of Iowa, Department of Anesthesia, Division of Management C, Iowa City, IA, 52242, United States, Richard Epstein, Pengyi Shi

When the hospital census is high, perioperative medical directors or operating room managers may need to postpone some surgical cases scheduled within a few (e.g., <3) workdays. For the COVID-19 pandemic, we used data from state database and detailed data from a large hospital. Monte-Carlo simulations and time series analyses showed that, for purposes of comparing procedures at the same hospital, there is no loss of information by summarizing the probability distributions of hospital length of stay for elective surgical cases using single numbers, the percentages of cases among patients staying longer than overnight. This finding simplifies the mathematics for constructing dashboards or summaries of information system data to help the medical director make decisions.

4 - Early Detection Of Trend Shifts In Emergency Department Surges During The Covid-19 Pandemic

Sara Nourazari, California State University, Long Beach, Long Beach, CA, 92648-0906, United States, sSamuel Davis, Rachel Granovsky, Dean J. Straff, Joshua W. Joseph, Leon D. Sanchez

A change detection tool is developed for tracking and early detection of trend shifts to help identify patterns in volume surges and declines in emergency departments during and after the COVID-19 pandemic in the U.S. This will allow studying the impact of different state-level and national guidelines and strategies on COVID-19 related restrictions and their downstream effects. At a macro level, this method can help study the impact of the pandemic on population health and emerging patterns of specific conditions such as mental health.

5 - Decreased Hospital Admissions Through Emergency Departments During The Covid-19 Pandemic

Samuel Davis, Harvard Medical School, Boston, MA, 92648-0901, United States, Sara Nourazari, Rachel Granovsky, Randolph Austin, Dean Straff, Joshua Joseph, Leon Sanchez

Emergency Department (ED) visits decreased significantly during the COVID-19 pandemic. We sought to characterize the impact of COVID-19 on hospital admissions through EDs, with a specific focus on diagnosis group, age, gender, and insurance coverage, via a retrospective, observational study of 501,369 patient visits from twelve EDs in Massachusetts from 1/1/2019-9/9/2019, and 1/1/2020-9/8/2020. We observed a 32% decrease in admissions during weeks 11 to 36 in 2020, with significant decreases in admissions for chronic respiratory conditions and non-orthopedic needs. Decreases were particularly acute among women and children, as well as patients with Medicare or without insurance. Our findings demonstrate decreased hospital admissions through EDs during the pandemic and suggest that several patient populations may have deferred necessary care.

6 - Machine Learning And Clustering-based Approach For County-level Covid-19 Analysis

Charles D. Nicholson, University of Oklahoma, Norman, OK, 73019, United States

COVID-19 is a global pandemic threatening the lives and livelihood of millions of people across the world. Due to its novelty and quick spread, scientists have had difficulty in creating accurate forecasts for this disease. This is especially true for regionally specific predictive models due to either limited case histories or other unique factors characterizing the region. This paper employs both supervised and unsupervised methods to identify the critical county-level demographic, mobility, weather, medical capacity, and health-related county-level factors for studying COVID-19 propagation. We use this feature subspace to aggregate counties into meaningful clusters to support more refined disease analysis efforts.

■ VWA08

Virtual Room 08

Big Data

Contributed Session

Chair: Maryam Mahdikhani, College of Charleston, United States

1 - Data Vs. Algorithm: What Drives AI Performance In Different Domains?

Philipp Back, Aalto University School of Business, Helsinki, Finland, Bikesh Raj Upreti, Pekka Malo, Matti Rossi

The AI hype is concentrated on powerful algorithms, while other AI artifacts - specifically data - receive little attention. But what actually drives the performance of AI systems, rich data or powerful algorithms? We provide a taxonomy of AI problems, and discuss how to evaluate the relative contribution of data vs. algorithm towards overall AI model performance. We empirically evaluate the performance drivers of AI trading agents. Contrary to conventional wisdom, we find that the data - not a superior algorithm - is key for beating the market. Our work helps researchers critically examine new AI solutions, and practitioners to better understand the true limitations of AI-based investment products.

2 - Physics-Informed Spatio-Temporal Modeling For Multi-Source Environmental Data

Guanzhou Wei, University of Arkansas, Fayetteville, AR, United States, Xiao Liu, Venkat Krishnan, Manajit Sengupta, Yu Xie, Haitao Liao

Natural and environmental processes are governed by physics laws, and are often monitored by data from multiple sources, such as remote sensing, field measurements, and so on. This research proposes a general framework for physics-informed spatio-temporal models for environmental processes where observations are available from multiple sources. The proposed modeling approach is illustrated through two environmental processes, including wildfire smoke propagation and sea surface temperature.

3 - Unlocking Reputation Mechanisms Impact On Collaborative Consumption Pricing

Funda Sarican, Bentley University, Waltham, MA, United States,

This paper proposes to empirically explore the relationship between ratings and sharing economy pricing. An important aspect of the sharing economy is the establishment of feedback rating systems to foster trust in peer-to-peer platforms. Ratings and reviews provide information on former transactions and evaluations, and assist in building trust across the platform. However, Dellarocas (2003) raised an important question of "how well does the mechanism work?" while studying eBay's feedback mechanism. This paper intends to unpack this question and contribute to the literature by investigating how rating systems impact Airbnb prices leveraging panel data and fixed effects methodologies.

4 - Predicting Review Helpfulness By Analyzing Imbalanced Classifications

Maryam Mahdikhani, College of Charleston, Charleston, SC, United States

This study is motivated by focusing on online fashion retailing. We seek to identify and extract the most frequent terms for helpful reviews on the fashion field and predict the helpfulness of reviews by proposing a novel method that enhances the accuracy of prediction. Our proposed method first extracts three different sets of features from (i) topics analysis by using the latent Dirichlet allocation (LDA) model, (ii) N-grams by using term frequency-inverse document frequency (TF-IDF) vectorizer, and (iii) topics plus n-grams using the TF-IDF vectorizer. The feature sets are then used to train four effective and robust supervised algorithms on imbalanced classifications.

■ VWA09

Virtual Room 09

Improving Access to Healthcare in Resource-limited Settings

Sponsored: Health Applications Society

Sponsored Session

Chair: Amir Karimi, The University of Texas at San Antonio, Minneapolis, MN, 55408, United States

1 - Mobile Clinic Deployment Under Uncertainty: The Stochastic Multiperiod Prize Collection Problem

Rosemarie Santa Gonzalez, Université du Québec à Montréal, Montreal, QC, Canada, Marilene Cherkesly, Marie-Ève Rancourt, Teodor Gabriel Crainic

Mobile clinic deployments are often used to provide healthcare to populations in need of humanitarian relief. Practitioners strive to deploy clinics that can access populations with the highest needs. However, during humanitarian operations uncertainty arises in the travel time, usability of roads, and access. We model mobile clinic deployment as a Two Stage Stochastic Prize Collection Problem in an effort to maximize the benefit offered by mobile clinics while considering the uncertainty. Additionally, we study the effect of multiple recourse policies on the mobile clinic deployment plans.

2 - Site Reassignment For Mobile Outreach Teams: Investigating The Effectiveness Of Decentralized Decision-making

Lisanne van Rijn, PhD Candidate, Erasmus School of Economics, Rotterdam, Netherlands, Harwin de Vries, Luk N. Van Wassenhove

To improve access to healthcare, mobile outreach teams of healthcare workers visit remote sites to provide healthcare services. Dynamics in demand and supply cause once rational site-to-team assignment decisions to become suboptimal. This paper considers the problem to reassign sites to maximize effectiveness. Outreach teams commonly have much decision-making autonomy, but reassignment requires coordination. To study whether and when a decentralized approach is effective, we examine the trade-off between centralization and effectiveness and study how design choices and information gaps induced by centralization affect this trade-off. We use empirical data from six country outreach programs of NGO MSI Reproductive Choices. Our results suggest that simple decision-making systems, when properly designed, tend to perform close to centralized decision-making.

3 - The Price Of Imposing Vertical Equity Through Asymmetric Outcome Constraints

Thomas Breugem, INSEAD, Fontainebleau, France

Vertical equity is an important aspect in many settings. For example, donors might require a family planning organization to allocate a minimum fraction of the total utility (client volume) to a particular player (e.g., young and poor clients). The price (decrease in client volume) of such requirements is not well-understood and often not accounted for in decision-making. We provide an analytical upper bound on the price (i.e., loss of overall utility) of vertical equity considerations in resource allocation. Our set-up considers a decision maker maximizing total utility over a general convex set, subject to outcome constraints (specifying a minimum percentage of the total utility for each player). We apply our results to practical instances in health delivery.

■ VWA10

Virtual Room 10

Analytical Models for Tackling Pandemics

Sponsored: Health Applications Society

Sponsored Session

Chair: Jagpreet Chhatwal, Harvard Medical School, Mass General Hospital, Boston, MA, 2114, United States

1 - Periodic Vaccination Against SARS-CoV-2: Some Projections For The United States

Jade Xiao, Georgia Institute of Technology, Atlanta, GA, United States, Turgay Ayer, Jagpreet Chhatwal

With the U.S. nearing the end of its inaugural wave of COVID-19 vaccinations, public health authorities are turning their attention to post-pandemic management. The SARS-CoV-2 virus is expected to become endemic. Given that waning immunity to the virus is highly probable, periodic mass vaccination will be necessary for continual outbreak prevention. However, the exact duration of immunity conferred by both vaccines and natural infection is still unknown, making it difficult at present to plan revaccination efforts. We model different periodic vaccination strategies within an SEIR framework based on the COVID-19 Policy Simulator (www.covid19sim.org) to assess their effect on disease burden over the next several years. This study provides qualitative conclusions to aid policymakers in post-pandemic management of COVID-19.

2 - Hospital COVID-19 Demand Redistribution

Felix Parker, Johns Hopkins University, Baltimore, MD, United States,Fardin Ganjkhanloo, Farzin Ahmadi, Kimia Ghobadi

As hospitals cope with the COVID-19 cases, critical resources like ICU beds have become scarce. Better utilization of the currently available capacity can improve access to resources, lower the burden to hospitals and staff, and lead to better patient care. We developed mathematical models that match the demand with available resources in a regional system of hospitals. Our robust mixed-integer linear models minimize the resource shortage while considering operational constraints and desirable allocation properties such as transfer sparsity, consistency, and locality. We validated our models for hospitals in the US and developed an interactive public decision-support website (https://covid-hospital-operations.com/).

3 - Data-driven Adaptive Robust Optimization For Resource Sharing During A Pandemic

Pooyan Kazemian, Case Western Reserve University, Cleveland, OH, 02114-2509, United States, Esmaeil Keyvanshokooh, Mohammad Fattahy, Maryam Zokaeinikoo, Mark P. Van Oyen, Kenneth Freedberg

Amid local outbreaks of COVID-19, many US 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. We conduct a case study of sharing ventilators among regions in Ohio and Michigan during the pandemic's first peak in 2020. We demonstrate that ventilator demand could be satisfied using 22%-65% fewer ventilators with ventilator sharing than no sharing (status quo), thereby allowing hospitals to preserve more elective procedures.

4 - Informing Opening Of Colleges During Covid-19 Pandemic: An Analysis Of 800 Colleges In The U.s.

Jagpreet Chhatwal, Associate Director, Harvard Medical School, Boston, MA, United States, Turgay Ayer

■ VWA11

Virtual Room 11

Healthcare Optimization

Sponsored: Health Applications Society

Sponsored Session

Chair: Kimia Ghobadi, Johns Hopkins University, Baltimore, MD, 21218-2625, United States

Co-Chair: Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

1 - Radiotherapy Patient Scheduling During Pandemics

Shamim Raeisi, University of Waterloo, Waterloo, ON, Canada

With the Covid-19 outbreak happening worldwide, clinically vulnerable people should be of concern, as they are more likely to be exposed to the virus. Cancer patients with weak immune systems are a group of aforementioned people that often have to go to hospitals for radiotherapy treatment sessions every day for several weeks. Therefore, special measures are to take place for more protection. Our research focuses on scheduling radiotherapy patients, using mixed-integer linear programming, minimizing the total number of potential interactions among patients and between staff members and patients. We use numerical examples to demonstrate the effectiveness of the proposed approach.

2 - Data-driven Inverse Optimization For Radiation Therapy Treatment Planning

Farzin Ahmadi, Johns Hopkins University, Baltimore, MD, 21210-3200, United States, Todd McNutt, Tinglong Dai, Kimia Ghobadi

Devising radiation therapy treatment plans for cancer patients is complex. Dose-volume histograms (DVH) are often employed to achieve clinically acceptable plans and spare healthy organs as much as possible. However, exact and personalized DVH goals are challenging to know a priori to input in the optimization models. To learn the best DVH objectives that clinicians aim for, we develop inverse optimization methods using historical patient treatment plans. We use linear terms for DVH objectives and show that inverse optimization is indeed capable of improving plan quality by recovering the best Achievable DVH objectives.

3 - A Geometric Approach To Beam Angle Selection In Radiation Therapy Treatment Planning

Houra Mahmoudzadeh, University of Waterloo, Sciences Univ. Of Department Of Man. University Av, Waterloo, ON, N2L 3G1, Canada, Danielle Ripsman, Sibel Alumur Alev

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.

4 - Developing Personalized Diabetic Retinopathy Screening Recommendations

Poria Dorali, University of Houston - Cullen College of Engineering, Houston, TX, 77204, United States, Zahed Shahmoradi, Christina Weng, Christina Weng, Taewoo Lee

Diabetic retinopathy (DR) is the leading cause of blindness among working-age Americans. While timely screenings can help prevent up to 98% of DR-related vision loss, currently only 30-60% of the patients are screened on a yearly basis due to high cost and inconvenience. Teleretinal imaging (TRI) is emerging as an affordable screening tool that has the potential to increase screening rate, yet there are questions as to how it can be implemented to maximize clinical benefit and patient adherence. We develop a POMDP model that determines patient-specific optimal screening policies that takes into account health and cost savings preferences as well as compliance behavior.

5 - Inverse Optimization For Standardizing Cancer Care Guidelines

Kimia Ghobadi, Johns Hopkins University, Baltimore, MD, 21218-2625, United States, Houra Mahmoudzadeh

Radiation therapy treatment is a time-consuming process in cancer care that often involves iterative manual planning by a planner and feedback/approval by an oncologist. There are clinical guidelines on radiation dose thresholds, but these guidelines are not universally agreed upon and differ per institution and oncologist. By considering the historically approved plans as feasible points to an LP, we employ an inverse optimization framework to find the underlying constraints. Finding such constraints enables us to better understand the implicit logic in approving or rejecting treatment plans. In doing so, we help standardize the guidelines and care practices, assess plan feasibility based on past observations, improve the quality of the final plans by preventing low-quality initial plans, and reduce the number of iterations between planners and oncologists.

■ VWA12

Virtual Room 12

OR for Equity in Health and Society

Sponsored: Health Applications Society

Sponsored Session

Chair: Karen T Hicklin, University of Florida, Chapel Hill, NC, 27599-7411, United States

Co-Chair: Toyya Pujol, Purdue University, Purdue University, Chicago, IL, 60606, United States

1 - Optimizing Use Of Annual Wellness Visits To Reduce Geographic And Racial Disparities In Diabetes Preventive Care

Jennifer M. Lobo, University Of Virginia, Charlottesville, VA, 22908-0717, United States, Hyojung Kang, Soyoun Kim, Timothy L. McMurry, Min-Woong Sohn

The Diabetes Belt is an area in the rural southeastern US and Appalachia identified by the CDC to have a high diabetes prevalence. Preventive care can reduce the risk of diabetes complications. Since 2011, Medicare beneficiaries can make Annual Wellness Visits (AWVs) to discuss a patient-specific plan for preventive care. We present a Markov decision process model to determine the optimal timing of AWVs to reduce geographic (Diabetes Belt vs surrounding) and racial (non-Hispanic White vs non-Hispanic Black) disparities among Medicare patients and to estimate the impact of AWVs on disparities in preventive care use. This model is part of our work to develop optimal policy recommendations to inform future interventions to reduce disparities in diabetes complications.

2 - Ensuring Equity And Effectiveness Over Time In A Network For Good: A Multi-period Distribution Model For Food Banks With Stochastic Capacity

Irem Sengul Orgut, University of Alabama, Tuscaloosa, AL, 35406-3105, United States, Julie Simmons Ivy, Reha Uzsoy, James R. Wilson

Food insecurity is an increasing threat to people's health status and quality of life. Based on our decade-long partnership with a food bank, we address the equitable and effective distribution of food donations to charitable agencies with stochastic receiving capacities over a finite planning horizon. We develop a multi-period stochastic model that ensures equitable food distribution decisions by the food bank. We use the structural properties of this model to obtain bounds on the optimal shipment amounts and develop heuristics. An extensive numerical study, based on data from our partner food bank, demonstrates the promising performance of the heuristics.

3 - Applications Of Nonnegative Tensor Completion Via Integer Optimization

Caleb Bugg, University of California-Berkeley, Industrial Engineering & Ope, Berkeley, CA, 94720, United States

There is an unresolved tension in the literature on tensor completion. One set of approaches has polynomial-time computation but requires exponentially more samples than the information-theoretic rate, whereas another set of approaches achieves the information-theoretic rate but requires solving NP-hard problems for which there are no known numerical algorithms to compute global minima. This paper resolves this tension for nonnegative tensors by developing a numerical algorithm that provably converges to a global minima in a linear (in numerical tolerance) number of oracle steps while achieving the information-theoretic rate. We then show the usefulness of our algorithm on health-related data.

4 - Presenter

Jonathan W. Welburn, RAND Corporation, Santa Monica, CA, 90401, United States

Persistent inequities and systemic racism have resulted in the current American disparity where Black households hold a tenth the wealth of their white peers. Calls for reparations from have regained significant attention as a solution for addressing the harms of slavery and of the de jure segregation and institutionalized discrimination that followed. We introduce a microsimulation model of intergenerational wealth to analyze the potential impact of policy interventions, from reparations to baby bonds, and their affect on the Black-white wealth gap.

■ VWA13

Virtual Room 13

Health Care, Modeling and Optimization IV

Contributed Session

Chair: Robert Lee, University of Amsterdam, Amsterdam, 1018TV, Netherlands

1 - Simulating Bed Cleaning Logistics Considering Operators' Behaviour

Gaspard Hosteins, Technical University of Denmark, Kgs. Lyngby, Denmark, Allan Larsen, Dario Pacino, Christian Michel Soerup

Beds are a crucial resource, which must be adequately managed both in use with the patient and after for a well-performing hospital. The staff ensures that sterile beds are always available for patients performing, transport, and storage under high pressure, reacting to uncertain patient arrival. We work jointly with Rigshospitalet, a public hospital in Denmark, building a simulation tool for the bed flow with a tension level indicator modeling the stress on the cleaning unit and the induced behavioral change of the workers. Using this simulation tool, we propose adaptations of the cleaning unit to increase efficiency and robustness.

2 - Maximizing Equity And Accessibility To Community Pharmacies: A Data-driven Approach To Reduce Pharmacy Deserts

MD Morshedul Alam, PhD Candidate, University of Louisville, Louisville, KY, United States, Lihui Bai

Despite the growing number of pharmacies, their distribution and accessibility of services to all U.S. residents may not equitable. A data-driven and comprehensive study is conducted to understand and optimize efficiency and equity in pharmacy accessibility. A location-allocation optimization model is developed, to maximize equity and accessibility considering demographics, unhealthy days, travel distance, public transit, and vehicle ownership, among others. Considering both geographic and non-geographic factors in Jefferson County KY, we identified the pharmacy desert to help policymakers to improve equitable access to pharmacies.

3 - Temporal Network Architectures Of Neurocognitive And Psychological Symptoms In Collegiate Athletes With Sport-related Concussion

Caroline G. Turner, United States Naval Academy, Annapolis, MD, United States, Anna Svirsko, Gian-Gabriel P. Garcia, Spencer Liebel

Concussions are a common brain injury, affecting millions of Americans each year but, the relationship between concussion symptoms during the healing process is not well understood. In order to further understand the concussion recovery process, we develop a weighted temporal network to analyze how concussion symptoms are interrelated, mutually reinforcing, and amplifying. In analyzing this network, we look to identify each symptom's evolution through the healing process and how symptoms influence each other over to allow for a better understanding of the concussion recovery process.

4 - Split Liver Transplantation: An Analytical Decision Support Model

Alan Scheller-Wolf, Tepper School of Business, Pittsburgh, PA, 15213-3815, United States, Yanhan Tang, Sridhar R. Tayur

Split liver transplantation (SLT) is a procedure that saves two lives using one liver. Despite SLT's potential to relieve the acute shortage of donated livers, it is rarely used in the US. Barriers to increase SLT utilization include surgical expertise, geography, and the complexities of donor-recipient matching. We analytically model the deceased-donor liver allocation system incorporating both SLT and fairness concerns. We formulate a multi-queue fluid system, incorporating the specifics of donor-recipient size matching and dynamically changing health conditions. Our formulation enables us to find the optimal matching and evaluate the performance of different allocation policies.

5 - Appointment Scheduling With Multiple Servers And Optional Batch Arrivals

Robert H. Lee, University of Amsterdam, Amsterdam, Netherlands, Alex Kuiper

In healthcare appointment scheduling one often seeks to minimize a weighted sum of patient waiting time and physician idle time. It is common to suppose that patients arrive singly and that the schedule is served by a single physician. However, these assumptions are frequently relaxed. By formulating an appointment schedule as a queue where patients arrive in batches of size at least one, and where there are one or more servers, a Db/M/c queue, one can analytically investigate the effect on optimal appointment schedules of varying the batch size and the number of servers independently of one another.

■ VWA14

Virtual Room 14

Platform Operations

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Pnina Feldman, Boston University, Boston, MA, 2215, United States

Co-Chair: Elnaz Karimi, Boston University, Boston, MA, 02134-1937, United States

1 - Entropy As A Driver Of Engagement In Online Discussion Platforms

Joseph Carlstein, University of Pennsylvania, Philadelphia, PA, 19104, United States, Gad Allon, Yonatan Gur

With the rise of remote work and remote learning, it has become increasingly imperative for firms and educators to facilitate discussions in a clear and organized fashion. There are many possible objectives of these discussions, depending on the situation, from identifying a correct answer to a question, to building consensus, to sparking debate. However, in this presentation, we will focus on determining the key drivers of engagement in a group discussion on a closed online platform, and how the platform can leverage comment-level and discussion-level engagement drivers to design effective practical recommendation algorithms for directing traffic to different parts of the discussion, in order to maximize user engagement.

2 - Pricing In A Two-sided Market With Time-sensitive Customers And Suppliers

Mustafa Akan, Carnegie Mellon University, Pittsburgh, PA, 15217, United States, Philipp Afeche

We consider a firm that matches stochastically arriving and time-sensitive customers and suppliers. We characterize the structure and performance of the profit-maximizing and socially optimal pricing policies.

3 - Matching Technology And Competition In Ride-hailing Marketplaces

Kaitlin M. Daniels, Washington University in St. Louis, Saint Louis, MO, 63112-1207, United States, Danko Turcic

Taxis' and Uber's matching technologies differ: taxis random-walk in search of curbside pick-ups while Uber centrally dispatches drivers. We study how taxis can defend against Uber encroachment. We find that taxi market share plummets when mimicking Uber's centralized dispatch. Taxis benefit from a low-tech alternative: restricting their service area.

4 - Courier Dispatch In On-demand Delivery

Mingliu Chen, Columbia University, New York, NY, 10128, United States

We study a courier dispatching problem in an on-demand delivery system where customers are sensitive to delay. The effect of temporal pooling is evaluated by comparing systems using the dedicated strategy, where only one order is delivered per trip, vs. the pooling strategy, where a batch of sequential orders is delivered on each trip. We capture the courier delivery system's spatial dimension with a service region analogous to a circular city. We obtain concise but informative results when there is a single courier and customers' underlying arrival rate is large enough, meaning a crowded market such as rush hour delivery. We also extend our model to incorporate a general arrival rate that does not have to be large, a non-uniform distribution of orders in the service region, and multiple couriers. We find that most observations in our base model still hold in these extensions.

■ VWA15

Virtual Room 15

Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Rene A. Caldentey, The University of Chicago, Chicago, IL, 60637-1656, United States

Co-Chair: Puping Jiang, Washington University in St. Louis, MO, United States

1 - Online Optimization On Asset Selling Platforms

Phil (Puping) Jiang, Washington University in St.Louis, Olin Business School, Washington University Olin Business School, Knight, St.Louis, MO, 63130-4899, United States, Rene A. Caldentey, Lingxiu Dong

Asset selling platforms like used car platforms (e.g., CarMax, Guazi) acquire assets from individual sellers and sell those assets to individual buyers. To keep a high inventory turnover rate, the platforms typically set a salvage deadline for each unit of asset. In this work, we formulate a discounted infinite-horizon problem for asset selling platforms. We characterize the optimal acquisition and pricing strategies and construct an approximation scheme for the problem. Finally, under the scenario of parameter learning, we propose a learning strategy that is adaptive to the on-hand inventory profile.

2 - Product-line Pricing With Dual Objective

Hongmin Li, Arizona State University, WP Carey School of Business, Dept of Supply Chain, Tempe, AZ, 85287, United States, Woonghee Tim Huh

The current literature on pricing and revenue management stresses the profit objective but rarely considers customer utility in the firm's objective function. In this research, we deviate from this conventional profit objective and study multi-product pricing with a balanced objective of profit and customer utility.

3 - Tight Guarantees For Multi-unit Prophet Inequalities And Online Knapsack

Jiawei Zhang, New York University, New York, NY, 10012-1106, United States, Jiashuo Jiang, Will Ma

Prophet inequalities are a fundamental tool for comparing the performance of online vs. offline algorithms. In the basic setting of k-unit prophet inequalities, the celebrated algorithm of Alaei (2011) with a performance guarantee of 1-1/sqrt{k+3} has been applied in online advertising, healthcare scheduling, and revenue management. Despite its wide applicability for rounding an LP solution, the tightness of this guarantee for a given k has remained unknown. In this paper we resolve this question, characterizing the tight bound using differential equations and deriving the best-known guarantee for k-unit prophet inequalities. In the generalization of the online knapsack problem, we also derive an improved and tight guarantee of 1/(3+1/e^2)~0.319, by bypassing the splitting of large vs. small items in our analysis.

4 - Posted Price Versus Auction Mechanisms In Freight Transportation Marketplaces

Sungwoo Kim, Georgia Tech, Atlanta, GA, United States, He Wang, Xuan Wang

We consider a truckload transportation marketplace in which a platform serves an intermediary to match shippers, who make payment to the platform for transportation services, with carriers, who book loads and get compensation from the platform for transporting the loads. The objective of the platform is to design a policy that specifies how to set prices for shippers and payments to carriers, as well as how carriers and loads should be matched, in order to maximize its long-run average profit. This research analyzes theoretical performances of posted price, auction, and hybrid mechanisms which combine posted price and auction mechanisms.

■ VWA16

Virtual Room 16

experimental design for marketplaces

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Chen Chen, BoBooth School of Business, The University of Chicago, Chicago, IL, 27708-9972, United States

Co-Chair: Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, 94305-5008, United States

Co-Chair: Ozan Candogan, University of Chicago, Chicago, IL, 27708, United States

1 - Synthetic Controls For Experimental Design

Jinglong Zhao, Massachusetts Institute of Technology, Cambridge, MA, 2139, United States, Alberto Abadie

This article studies experimental design in settings where the experimental units are large aggregate entities (e.g., markets), and only one or a small number of units can be exposed to the treatment. In such settings, randomization of the treatment may induce large estimation biases under many or all possible treatment assignments. We propose a variety of synthetic control designs as experimental designs to select treated units in non-randomized experimentswith large aggregate units, as well as the untreated units to be used as a control group. Average potential outcomes are estimated as weighted averages, of treated units for potential outcomes with treatment, and control units for potential outcomes without treatment. We analyze the properties of such estimators and propose inferential techniques.

2 - Balancing Covariates In Randomized Experiments With The Gram-schmidt Walk Design

Christopher Harshaw, Yale University, New Haven, CT, United States, Fredrik Sävje, Daniel Spielman, Peng Zhang

In the design and analysis of Randomized Control Trials, it is widely accepted that balancing pre-treatment covariates between the treatment groups may lead to improved precision of treatment effect estimates when the covariates are correlated with outcomes. However, we argue that there is a fundamental trade-off between efficiency gained by covariate balance and robustness of these estimates. We present the Gram-Schmidt Walk Design, which allows experimenters to optimally navigate this trade-off. The design utilizes recent advances in algorithmic discrepancy theory [Bansal et al 2019]. We provide a tight analysis of the design, including non-asymptotic bounds on the variance and tails of the Horvitz-Thompson estimator. Based on these results, we develop estimators for non-asymptotic confidence intervals.

4 - Interference, Bias, And Variance In Two-sided Marketplace Experimentation: Guidance For Platforms

Geng Zhao, Stanford University, Stanford, CA, United States, Hannah Li, Ramesh Johari, Gabriel Weintraub

Two-sided marketplace platforms often run experiments to test the effect of an intervention before launching it platform-wide. A typical approach is to randomize individuals into the treatment group, which receives the intervention, and the control group, which does not, and compare the performance in the two groups to estimate the effect if the intervention were launched to everyone. We focus on two common experiment types, where the platform randomizes individuals either on the supply side or on the demand side.We develop a simple tractable market model to study bias and variance in these experiments with interference between individuals. We study how the choices of experiment type and treatment allocation proportion affect the bias and variance of the resulting estimators, and propose how a platform can navigate this tradeoff and best choose the treatment proportion.

5 - Near-optimal Experimental Design For Networks: Independent Block Randomization

Chen Chen, Booth School of Business, The University of Chicago, Chicago, IL, 27708-9972, United States, Ozan Candogan, Rad Niazadeh

We consider the problem of designing a randomized experiment for a network of users. A decision-maker uses an unbiased Horvitz-Thompson estimator to estimate the total market effect of the treatment and chooses an optimal joint distribution of randomized assignments to minimize the worst-case variance of this estimator. For networks that can be partitioned into densely connected communities by ignoring only a small number of connections, it is near-optimal to assign all users in the same community to the same variant. We develop a family of independent block randomization (IBR) experiments, and we show these policies are asymptotically optimal when the number of communities grows large and no community size dominates the rest. Beyond the asymptotic regime, the IBR experiment is 7/3-approximation for any problem instance.

■ VWA18

Virtual Room 18

Information Systems II

Contributed Session

Chair: Qizhi Dai, Drexel University, Philadelphia, PA, 19104, United States

1 - Improving Machine Learning Algorithms By Collecting Diverse And Granular Data In Crowdsourcing Platforms

Aida Khosh Raftar Nouri, Memorial University of Newfoundland, St John's, NL, Canada, Jeffrey Parsons

Citizen science volunteers have played an essential role in creating training data for the machine learning algorithm. Furthermore, using crowdsourcing maximizes the undiscovered value of the data. This research aims to develop, implement, and evaluate design principles for data collection in crowdsourcing platforms with the ability to collect granular and diverse data. This study also conducts experiments to show that information diversity and granularity as the pertinent dimension of information quality in crowdsourced data improve machine learning algorithms.

2 - Increasing Healthcare Organizations Agility Via Cloud Analytics Platforms

Hossein Kalantar, University of Colorado-Denver, Denver, CO, United States

Healthcare organizations should constantly and swiftly detect and respond to environmental opportunities and threats. The COVID-19 outbreak demands fast and precise actions from healthcare organizations across the globe more than ever before. These organizations can utilize various analytics tools on the cloud-based platform to increase their agility in the operational domain and clinical areas. In this study, we investigate the impact of cloud analytics platform adoption on healthcare organizations' agility.

3 - Study Of Health Outcomes In A Technology Enabled Virtual Setting.

Maxim Terekhov, University Of Florida, Gainesville, FL, United States

This paper presents an empirical analysis of health insurance claims data to explore telemedicine outcomes. Specifically, I utilize causal forests and a retrospective matched case control study design to demonstrate statistically significant changes in costs, utilization, and medication adherence of telehealth users. These findings provide insight on the value of telemedicine and have important implications for stakeholders in healthcare field.

4 - Spillover Effects Of Doctors' Knowledge Sharing On Patients-Evidence From An Online Healthcare Platform

Liu Yan, Huazhong Agricultural University, Wuhan, China, Junwei Kuang, Wanxin Qiao

The success of online healthcare platforms (OHPs) depends on the continued participation and contributions of doctors and patients. Little is known about the spillover effects of doctors' online contributions, especially their knowledge-sharing behavior, on patients in these platforms. Based on the signaling and expectation-confirmation theory, we examine the causal effects of doctors' knowledge sharing on patients-generated information (PGI). Our results reveal that doctors' knowledge sharing significantly increases both the volume and quality of PGI. The new findings provide implications for service operation management of OHPs.

5 - Platform Thinking In Digital Product Development: The Case Of Power BI

Qizhi Dai, Drexel University, Philadelphia, PA, United States,

A digital product can become a platform that lays a foundation upon which related or complementary products and services are developed. Taking Microsoft Power BI, a business intelligence platform, as a specific case, we study how such platform thinking affects the design and development of components and features of the digital product. We find multiple dimensions for modularization, parallel offering of integrated and loosely coupled packages, and double role as a platform and a complementor in the product development practice. These digital innovation strategies lead to platform leadership through flexibility of modularization and positive network effects.

■ VWA19

Virtual Room 19

Topics in Monte Carlo Methods and Rare Event Sampling

Sponsored: Applied Probability Society

Sponsored Session

Chair: Mariana Olvera-Cravioto, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27514-3601, United States

Co-Chair: Michael Conroy, University of North Carolina, Chapel Hill, Chapel Hill, NC, 27510, United States

1 - Importance Sampling For Maxima On Trees

Michael Conroy, University of Arizona, Tucson, AZ, 27510, United States, Mariana Olvera-Cravioto, Bojan Basrak, Zbigniew Palmowski

We develop an unbiased and strongly efficient importance sampler for tail events of solutions to max-type stochastic fixed point equations that are constructed on weighted, marked Galton-Watson processes. These solutions are also describable as the all-time maximum of a branching random walk with a perturbation. The sampler is based on a representation of the tail events after a change of measure, generalizing non-branching representations that are standard in Cramer-Lundberg theory. Related to spine changes of measure often used in the branching process literature, the new measure tilts only one path of the walk, inducing a structure on the underlying branching process that suggests even more efficient algorithms to approximate tail events for branching random walks.

2 - Approximating Quasi-stationary Distributions with Interacting Reinforced Random Walks

Adam Waterbury, UC-Santa Barbara, Santa Barbara, CA, United States

We propose two numerical schemes for approximating quasi-stationary distributions (QSD) of finite state Markov chains with absorbing states. Both schemes are described in terms of certain interacting chains in which the interaction is given in terms of the total time occupation measure of all particles in the system. The schemes can be viewed as combining the key features of the two basic methods for approximating QSD originating from the works of Fleming and Viot (1979) and Aldous, Flannery, and Palacios (1998), respectively. I will describe the two schemes, discuss their convergence properties, and present some exploratory numerical results comparing them to other QSD approximation methods.

3 - On The Impacts Of Tail Model Uncertainty In Rare-event Estimation

Zhiyuan Huang, Tongji University, Shanghai, China, Henry Lam, Zhenyuan Liu

Rare-event probabilities and risk measures that quantify the likelihood of catastrophic or failure events can be sensitive to the accuracy of the underlying input models, especially regarding their tail behaviors. We investigate how the lack of tail information of the input can affect the output extremal measures, in relation to the level of data that are needed to inform the input tail. Using the basic setting of estimating the probability of the overshoot of an aggregation of i.i.d. input variables, we argue that heavy-tailed problems are much more vulnerable to input uncertainty than light-tailed problems. We explain this phenomenon via their large deviations behaviors, and substantiate with some numerical experiments.

4 - Exact Derivative Estimation: Unbiased Estimation For Markov Chain Steady-state Expectations

Jeffrey Wang, Northwestern University, Evanston, IL, United States, Chang-Han Rhee

Consider a family of Markov chains whose transition dynamics are affected by model parameters, and suppose that we are interested in the performance measures associated with the steady-state distributions of the Markov chains. The derivatives of such performance measures w.r.t. the parameters play important roles in many contexts including optimization of the performance measures and quantification of the uncertainties in the parameter estimation. In this talk, we propose unbiased estimators with the canonical square root convergence rate for such derivatives. Our estimators build on the probabilistic representation of the derivatives characterized in Rhee and Glynn (2021; arXiv:1707.03870) and the exact estimation technique propose in Glynn and Rhee (2014; Journal of Applied Probability, 51A:377-389).

■ VWA20

Virtual Room 20

Cutting-Edge Methods for Data-Driven Decision-Making

Sponsored: Applied Probability Society

Sponsored Session

Chair: Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States

1 - Fast Rates For Contextual Linear Optimization

Nathan Kallus, Cornell University, Ithaca, NY, 10044-1501, United States

Incorporating predictive contextual observations in decision making can reduce uncertainty and boost performance. While one may use off-the-shelf ML to learn a predictive model and plug it in, recent work emphasizes integrated approaches that fit models to directly optimize downstream 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 such integrated methods. Our results are overall positive for practice: predictive models are easy and fast to train using existing tools, simple to interpret and reuse for decision support, and, as we show, lead to decisions that actually perform very well.

2 - Online Learning Via Offline Greedy Algorithms: Applications In Market Design And Optimization

Rad Niazadeh, Chicago Booth School of Business, Chicago, IL, 94305-5008, United States, Negin Golrezaei, Fransisca Susan, Joshua Wang, Ashwinkumar Badanidiyuru

Motivated by online decision-making in time-varying combinatorial environments, we study the problem of transforming offline algorithms to their online counterparts. We focus on offline combinatorial problems that are amenable to a constant factor approximation using a greedy algorithm that is robust to local errors. For such problems, we provide a general framework that efficiently transforms offline robust greedy algorithms to online ones using Blackwell approachability. Demonstrating the flexibility of our framework, we apply our offline-to-online transformation to several problems at the intersection of revenue management, market design, and online optimization.

3 - Calibrating Sales Forecast In A Pandemic Using Online Non-parametric Regression Model

Ruihao Zhu, Massachusetts Institute of Technology, Cambridge, MA, 02139-4230, United States, David Simchi-Levi, Rui Sun, Michelle Wu

Motivated by our collaboration with AB InBev, a consumer packaged goods company, we consider the problem of forecasting sales under the coronavirus disease 2019 (COVID19) pandemic. Our approach combines online learning and pandemic modeling to develop a data-driven online non-parametric regression method. Specifically, the method takes the future COVID-19 case number estimates, which can be simulated via the SIR epidemic model, as an input, and outputs the level of calibration of the baseline sales forecast generated by AB InBev's offline learning algorithm. We demonstrate the performances of our algorithm on both synthetic and AB InBev's datasets of three different geographical regions. The AB InBev's numerical experiments show that our method is capable of reducing the forecasting error in terms of WMAPE and MSE by more than 50%.

4 - Decision Forest: A Nonparametric Approach to Modeling Irrational Choice

Yi-Chun Chen, UCLA Anderson School of Management, Los Angeles, CA, United States, Velibor Misic

We propose a new nonparametric choice model that can represent any customer choice model, including those that are inconsistent with weak rationality. In the proposed model, each customer type is associated with a binary decision tree, which represents a decision process for making a purchase based on checking for the existence of specific products in the assortment. We theoretically characterize the model complexity and propose two practical estimation methods. Using real-world transaction data, we show that the proposed model outperforms benchmark models in out-of-sample predictive ability. We also demonstrate how the proposed model can extract insights about substitution and complementarity effects and identify interesting customer behaviors within a specific product category.

5 - Estimating Direct Causal Effect Under Hierarchical Interference On Networks In Observational Studies

Fei Fang, Duke University, Durham, NC, 27705-4547, United States, Alexandre Belloni, Alexander Volfovsky

We study causal estimators for direct treatment effect under interference given network and treatment assignment. Our estimators are constructed by hierarchical trees whose nodes represent distinguished pattern graphs, under interference associated with treated neighborhood graphs. Applying our pruning procedure to these trees, oracle inequalities and corresponding adaptive rates are established to the estimators. Our results are generic to different hierarchical structures of interference and data generating processes. A theoretical example whose explicit rate of convergence is investigated when the graph is generated by stochastic block model. Finally, we examine the empirical performance of our estimators by simulations and real datasets.

■ VWA21

Virtual Room 21

Robust Optimization

Contributed Session

Chair: Jing-Rung Yu, PhD, Puli, Nantou, 545, Taiwan

1 - Data-driven Optimization For Transmission And Storage Capacity Expansion Under Seismic Risk

Alfredo Ernesto Oneto, Pontificia Universidad Católica de Chile, Santiago, Chile, Álvaro Hugo Lorca

Seismic events can cause significant damages to electric power networks and induce considerable economic losses. Hence, it is crucial to have a general framework to plan resilient networks against these hazards. This work presents a data-driven stochastic-robust optimization scheme and a practical solution method to find optimal investments for the expansion of transmission and energy storage assets in highly renewable power systems. The model leverages distributional information about seismic sources and effectively models high-dimensional uncertain parameters through a novel data-driven uncertainty set for robust optimization. We test our approach on a 281-bus Chilean power network.

2 - Robust Transmission, Renewable Generation And Storage Capacity Expansion Planning Considering Reserve Provision Of Wind Power Units

Cristina Roldán González, Postdoctoral Researcher, Universidad de Castilla-La Mancha, Ciudad Real, Spain, Raquel García Bertrand

This work presents a robust optimization approach for transmission, renewable generation and storage capacity expansion planning considering the participation of renewable units in reserve markets. Long-term uncertainties of renewable generation and load are modeled using a cardinality constrained uncertainty set, while the uncertainty regarding the short-term operation of the system is modeled using a set of representative time periods of the planning horizon. A case study is solved to show the effects of considering the provision reserve capacity of wind power units in expansion decisions.

3 - Stock Price Movement Prediction By Using Robust Classification

Chieh-Hui Wei, National Chi-Nan University, Nantou, Taiwan, Jing-Rung Yu, Wan-Jiun Paul Chiou, Chun-Yu Lin

This study applies robust optimization approach to cope with data uncertainty in classification. Our portfolio model adopts robust mechanism via perturbing the features within a deterministic uncertainty set and considers the worst-case scenario. The comparisons with nominal classification methods in predicting the trends of the composite stock prices in S&P 500 Index show the superiority of robust classification.

■ VWA22

Virtual Room 22

Analysis of Sensor Networks with High-dimensional Data for Data-driven Decision Raking

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Ana Maria Estrada-Gomez, Georgia Institute of Technology, Atlanta, GA, 30318, United States

1 - Understanding Multi-modal Sensor Networks: Combining Uni-modal Sensing And Edge-cloud Computing Analytics

Ankur Verma, Pennsylvania State University, University Park, PA, United States, Soundar Kumara

Sensor networks consist of several multi-modal sensors embedded in industrial and consumer IoT environments. These sensors give real-time visibility, and enhance dynamic decision making capabilities. Applications range from industrial asset monitoring to smart homes, with benefits like increased efficiency and throughput, reduced downtime, and others per the use case. The edge-connectivity-cloud layer for a single sensor is the basis to understand the engineering and data analytics challenges for a multi-modal sensor network. This presentation will detail some uni-modal sensors for machine health monitoring, and elaborate on the analytics techniques required for high-fidelity multi-modal sensor data, centered around a machine vibration monitoring case study. Hardware-software co-design, signal processing, and data-driven techniques will be presented.

2 - Multi-scale Brain Network Analysis For Connectomics

Steven Winter, Duke University, Durham, NC, United States, David Dunson, Zhengwu Zhang

In brain connectomics, it is common to divide the cortical surface into discrete regions of interest (ROIs) and then to use these regions to induce a graph. The structure of the resulting adjacency matrices depends critically on the chosen regions, leading to dramatically different inference when different regions are chosen. To solve this problem we develop a multi-scale graph model, which links together scale-specific factorizations through common individual-specific latent factors. These scores combine information across from different parcellations to produce a single interpretable summary of an individuals brain structure. We develop a simple, efficient algorithm, and illustrate substantial advantages over comparable single-scale methods in both simulations and analyses of the Human Connectome Project dataset.

3 - Online Monitoring Of Dynamic Spectral Functional xvGraphical Models

Ana M. Estrada Gomez, Georgia Institute of Technology, Atlanta, GA, 30318, United States, Kamran Paynabar

Many important problems can be modeled as a system of interconnected entities producing time-dependent streaming data. In these problems, it is critical to learn the complex cross-correlation structure between the system's entities and to monitor for changes in the structure due to system evolution. In this paper, we propose an online structural change-point detection methodology. We exploit the spectral information contained in the data to learn sparse functional probabilistic graphical models over time. We enforce the similarity of the graphs to detect structural changes in the system. An efficient method based on ADMM is proposed for online optimization and change-point detection. The effectiveness of the proposed methodology is demonstrated through a simulation study and a real case study using neurological data.

4 - Adaptive Partially-observed Sequential Change Point Detection For Covid-19 Hotspots Detection

Jiuyun Hu, Arizona State University, Tempe, AZ, United States, Hao Yan

The authors derive an algorithm to detect the hotspots in Covid-19 case. The challenge is the limited resources and how to distribute next day's tests based on previous data. The algorithm uses Bayesian weighted update to get the posterior distribution of test statistics, then use Upper Confidence Bounds (UCB) to get the optimal distribution of next day, and finally use CUSUM statistics to detect the hotspots. The authors also compare the algorithm to the benchmark of evenly distributed tests and distribute all tests once a county. In Washington State example, the hotspot detected is Yakima County.

■ VWA23

Virtual Room 23

Data-driven Prognosis and Analytics for IoT Enabled Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yuxin Wen, Chapman University, Santa Ana, CA, 92705, United States

Co-Chair: Chao Wang, University of Iowa, Iowa City, IA, 52240, United States

1 - Spatial Modeling With Long-term Memory Effect And Application In Quality Control Of Surface Roughness

Yunfei Shao, Wichita State University, Wichita, KS, United States, Wujun Si

Characterization of material's surface roughness is critical in quality control of manufacturing process. Recently, a long-term memory effect has been detected in the manufacturing field. However, none of existing spatial models of surface roughness considers the long-term memory effect, which may lead to inefficient result of quality control. In this paper, we propose a new spatial model of surface roughness considering long-term memory effect. A maximum likelihood estimation approach is developed to estimate the model parameters. A simulation study is implemented to verify the performance of the proposed method. A case study on surface roughness is conducted to further demonstrate the superiority of the proposed model.

2 - Unsupervised spectral-band identification for process change detection

Akash Tiwari, Texas A&M University, TX, United States

Identification of spectral bands for anomaly detection is an important consideration in many industrial processes. A novel unsupervised spectral-band identification method based on joint expectation-maximization of Gaussian-Mixture models is presented. Spectral-bands obtained from the method detect changes in process operating conditions with up to 98.3% accuracy for spherical-shell polishing processes.

3 - Data-level Transfer Learning For Degradation Modeling And Prognosis

Amirhossein Fallahdizcheh, University of Iowa, Iowa City, IA, United States, Chao Wang

Most of the work in data-driven prognosis is based on training a model with historical data and then use the model to predict failure for in-service unit assuming that historical and in-service data are from same process. However, we can observe different but related processes that can provide useful prognosis data for each other. In this paper, we model data in each process using mixed-effects model and facilitate information share among different models using a hierarchical Bayesian structure. Since various processes might not be from same dimension, we propose a transformation to achieve consistent dimension. The performance of this method is validated in numerical studies and two case studies.

4 - A Neural Network Based Proportional Hazard Model For IoT Signal Fusion And Failure Prediction

Yuxin Wen, Chapman University, Orange, CA, 92705, United States, Xingxin Guo, Junbo Son, Jianguo Wu

Accurate prediction of remaining useful life (RUL) plays a critical role in optimizing condition-based maintenance decisions. A novel joint prognostic modeling framework that simultaneously combines both time-to-event data and multi-sensor degradation signals is proposed. To take full advantage of the modern IoT-enabled engineering systems, we propose a specialized framework for RUL prediction at the level of individual unit. The advantageous features of the proposed method are demonstrated through thorough simulation studies and the application to high-fidelity gas turbine engine dataset.

5 - Online Reliability Prediction And Optimal Maintenance Of Manufacturing Systems Based On Sensor Network Streaming

Faisal G. Alsaedi, Wayne State University, Detroit, MI, United States

Energy sector is an essential industry in which complex manufacturing systems are generally equipped with multiple sensors providing streaming data. This research develops an online reliability prediction and optimal maintenance of complex manufacturing systems by integrating sensor network information. The developed methods are illustrated and verified by a boiler system for oil refinery.

■ VWA24

Virtual Room 24

Challenging Research Problems in the Automotive Industry

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

1 - Challenging Research Problems in the Automotive Industry
Arman Sabbaghi, Purdue University, West Lafayette, IN, 47907-2067, United States

Novel challenges in the automotive industry have led to fundamentally new research opportunities in quality, statistics, and reliability. The panelists in this session will discuss the new research problems that they are investigating in their work in the automotive industry.

2 - Panelist
Saman Alani-Azar, Ford Motor Company, Canton, MI, 48188, United States

3 - Panelist
Frank Sun, Tesla, Silicone Valley, CA, United States

4 - Panelist
Weihong Guo, Rutgers, The State University of New Jersey,Piscataway, NJ, 8854, United States

5 - Panelist
Shiming Duan, GM, Detroit, MI, United States

■ VWA25

Virtual Room 25

Probabilistic Forecasting

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Ville Satopaa, INSEAD, Paris, 75012, France

1 - Joint Bottom-up Method For Forecasting Grouped Time-series: Application To Australian Domestic Tourism
Nicolò Bertani, INSEAD, Boulevard De Constance, Fontainebleau, 77300, France, Ville Satopaa, Shane T. Jensen

We introduce a new method to model and forecast a large number of time-series and their aggregates (grouped forecasting). Relying on Bayesian learning, the method models these series jointly, takes into account their contemporaneous covariance, and performs automatic selection of lag terms both within and across series using Spike-and-Slab mixture priors. This enables the method to faithfully learn the hidden and complex data generating process. Testing the method on the benchmark grouped Australian tourism data, the method achieves higher forecast accuracy compared to the state-of-the-art alternatives. Moreover, it reveals complementarity and substitution effects across geographies and tourism types.

2 - New Results On The Connection Between Multi-Agent Scoring Rules And Strategy-Proof Allocation Mechanisms Without Money
Jens Witkowski, Frankfurt School of Finance & Management, Adickesallee 32-34, Frankfurt, 60322, Germany, Rupert Freeman

We build upon a recently discovered equivalence between the class of weakly budget-balanced wagering mechanisms (multi-agent scoring rules) designed for eliciting probabilities and the class of allocation mechanisms for divisible goods as studied in fair division. This 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.

3 - Using L2 Scores to Optimise Combinations of Density Forecasts
Xiaochun Meng, University of Sussex Business School, Brighton, United Kingdom, James W. Taylor

Combining density forecasts has become common practice for various applications. The optimal weights are often obtained by minimising a chosen proper scoring rule, where the log score is most commonly used in the literature. Unfortunately, with the log score, closed-form solutions generally do not exist for the combining weights. In this paper, we optimise the weights by minimising L2 scores. We establish the closed-form representations for the optimal weights, and then use them to incorporate time-varying structure to provide further improvement in forecast accuracy. We use simulated and real data to illustrate our results.

4 - Stable Reliability Diagrams For Probabilistic Classifiers
Timo Dimitriadis, Heidelberg University, Heidelberg, Germany, t

A probability forecast or probabilistic classifier is reliable or calibrated if the predicted probabilities are matched by ex post observed frequencies, as examined visually in reliability diagrams. The classical binning and counting approach to plotting reliability diagrams has been hampered by a lack of stability under unavoidable, ad hoc implementation decisions. Here, we introduce the CORP approach, which generates statistically consistent, optimally binned, and reproducible reliability diagrams in an automated way. CORP is based on nonparametric isotonic regression and implemented via the pool-adjacent-violators (PAV) algorithm. The CORP approach furnishes a numerical measure of miscalibration, and provides a CORP-based Brier-score decomposition that generalizes to any proper scoring rule.

5 - Human Forest Vs. Random Forest In Time-sensitive Covid-19 Clinical Trial Prediction
Pavel Atanasov, Pytho LLC, Brooklyn, NY, United States, Regina Joseph, Felipe A. Feijoo, Max Marshall, Sauleh Ahmad Siddiqui

What methods generate the most accurate forecasts about clinical trial phase success? We describe the first multi-method clinical trial forecasting tournament, comparing machine learning models and crowdsourcing methods that estimate the time-dependent probability of phase transition for COVID-19 vaccines and treatments. The crowdsourcing approach uses the Human Forest process and software, which enables forecasters to define custom reference classes, query a historical database and review resulting base rates. The base rates, and forecaster-adjusted probabilistic estimates, are aggregated. Accuracy was compared against a random survival forest machine model, across 28 questions. Results show that Human Forest significantly outperformed the RSF model, registering 32%-48% better Brier scores. Human Forest's advantage was due to better calibration.

■ VWA27

Virtual Room 27

Sustainability II

Contributed Session

Chair: Shimaa Al-Quradaghi, Qatar University, United States

1 - An Integrative Multiperiod Framework With Sustainable Investment Under Externality Cost
Michelle Li, Babson College, Babson Park, MA, United States, Jose Cruz

We analyze the multiperiod effects of sustainability investments on a multitier supply chain network's economic, social, and environmental decision making. The network consists of suppliers, manufacturers, and retailers who decide on production, distribution, inventory, and prices, as well as the level of sustainability investment to maximize net return. Also, the decision makers are constrained by externality costs and consumers' preference and willingness to pay for sustainable products. The model allows us to investigate the interplay of different decision-makers and to compute the resultant network equilibrium pattern of transactions, inventory, prices, and sustainability levels.

2 - Does Leader Disability Status Improve Productivity Performance For Workers With A Disability? An Empirical Analysis In The Apparel Industry.
Dustin Cole, Michigan State University, East Lansing, MI, United States, Sriram Narayanan, Shawnee Vickery

This research examines impact of leader disability status on the productivity of workers with disabilities using a unique set of data collected at a social enterprise. Our results show that a leader who does have personal experience with a disability is able to improve the productivity of workers with a disability by mitigating the potential productivity decline as the number and ratio of workers with a disability increases. The quantitative finding is built upon using a case study approach at two different, but similar organizations.

3 - Quantification Of Potential Emission Reduction In Order Fulfilment Optimization.
Reginald Bryant, Research Scientist, IBM Research, Nairobi, Kenya, Kedar Kulkarni, Isaac Waweru

Most competitive retailers are using omni-channel networks to fulfil home-delivery orders while simultaneously driving reductions in their carbon footprint. We analyzed the carbon emissions associated with the last-mile delivery of retail packages under two scenarios: one based on order-fulfilment heuristics, the other using an optimization approach. Afterwards, a series of experiments were conducted to assess the potential further reductions with relaxed customer-side service-level-agreements. Experiments suggest that emissions and cost reductions can be achieved without drastic operation changes.

4 - Eco Industrial Park For End Of Life Vehicles

Shimaa Al-Quradaghi, Qatar University, Doha, Qatar, jQipeng Phil Zheng, Alberto Betancourt, Ali Elkamel

The aim of this paper is to provide a mathematical model to optimize the exchange of material flows in the network of Eco-Industrial Park for End-of-Life Vehicles. The model finds the optimal processing routes while maximizing the yield of the component of interest, maximizing profit, minimizing cost, or minimizing waste, depending on which weights are chosen. Finally, the model is illustrated on a case study of ELVs recovery network in Qatar and the optimal network infrastructure is obtained. The results are analyzed to provide insights about the network and to prepare for capacity planning.

■ VWA28

Virtual Room 28

Healthcare Operations Management

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Alex Mills, Baruch College, City University of New York, New York, NY, 10010-5585, United States

Co-Chair: Masoud Kamalahmadi, University of Miami, Bloomington, IN, 47405-1701, United States

1 - Cross-functional Team Co-location

Temidayo Adepoju, Boston University, Boston, MA, United States, Anita L Tucker, Cherisse Carlo, Chris Manasseh

We investigate the impact of team co-location in improving the efficiency of a dedicated observation unit (DOU). The DOU is a unit in the hospital designed to treat observation patients (low risk). In July 2018, the unit expanded to treat patients with higher medical complexity which increased the demand and variability in the unit. Using a difference-in-difference approach and instrumental variables approach we examine the operational cost and the efficiency gain respectively, of this expansion. We find that the observation LOS increases in the unit after the unit expanded. However, through team co-location which enhances coordination, the DOU gains efficiency that results in a reduction in LOS for the observation patients cared for in the unit compared to observation patients cared for off-service in the inpatient unit.

2 - Multichannel Delivery In Healthcare: The Impact Of Telemedicine In Southern India

Kraig Delana, University of Oregon, Eugene, OR, 97403, United States, Sarang Deo, Kamalini Ramdas, Ganesh Babu, Thulasiraj Ravilla

We empirically study the impact of telemedicine centers on patients' access, outcomes, and costs at the Aravind Eye Care System in Southern India. We find that telemedicine centers increase visit rates, particularly for new patients, as well as glasses prescription rates while decreasing indirect costs of travel for patients.

3 - Optimization Of Pediatric Vaccines Distribution Network Configuration Under Uncertainty

Zahra Azadi, University of Miami Herbert Business School, Coral Gables, FL, 33158, United States, Sandra D. Eksioglu, Harry Neil Geismar

Millions of young people are not immunized in low- and middle-income countries because of low vaccine availability resulting from inefficiencies in cold supply chains. We create supply chain network design and distribution models to address the unique characteristics and challenges facing vaccine supply chains in these countries. The models capture the uncertainties of demand and the resulting impacts on immunization, the unique challenges of vaccine administration, the interactions between technological improvements of vaccines and immunizations, and the trade-offs between immunization coverage rates and available resources. The objective is to maximize the percentage of fully immunized children and the vaccine availability in clinics. We tested the model using Niger's Expanded Program on Immunization, which is sponsored by the World Health Organization.

4 - Telehealth Expansion And Patient Demand In Acute Care

Ozden Engin Cakici, American University, Washington, DC, 20016, United States, Alex Mills

Many healthcare providers have recently expanded telehealth services where patients can see a doctor online. In theory, increasing capacity of telehealth services should expand the provider's panel size because telehealth is more convenient, but the drawback of telehealth is that it may require a follow up visit for a physical exam. We model the patient's strategic choice for acute care among balking, telehealth, and walk-in office visit using a game theoretic model, as a function of the provider's capacity allocation to telehealth. We find that too much expansion of telehealth can decrease the provider's panel size, and we discuss policy implications that emerge from this result.

■ VWA29

Virtual Room 29

Supply chain finance & risk management

Sponsored: MSOM/iForm

Sponsored Session

Chair: Heikki Peura, Imperial College Business School, London, SW7 2AZ, United Kingdom

1 - Presenter

Fehmi Tanrisever, Bilkent University, Merkez Kampus Lojmanlari 80/5, Ankara, 6800, Turkey

2 - The Economic Rationale For Technology In Supply Chain Finance

Florian Lucker, Cass Business School, London, EC1Y 8TZ, United Kingdom, Benoit Chevalier-Roignant, ManMohan S. Sodhi

We study technology-based supply chain finance solutions, including reverse factoring and dynamic discounting. We find that the buyer may be worse off and the supplier often benefits ex post under technology-based solutions, even in a monopsony.

3 - Supply Chain Finance During The Corona Pandemic

David Wuttke, TUM School of Management, HN Campus, Heilbronn, Germany, Begimai Marlenova, Eve Rosenzweig

COVID-19 has disrupted many supply chains around the world. Some suppliers, for example, have struggled to maintain their financial liquidity, and thus their continuity of supply, during the pandemic. Supply chain finance (SCF) can help mitigate this effect, especially for smaller suppliers. In this paper, we examine the impact of COVID-19 on how buyers and their suppliers use SCF. We test several hypotheses using a global dataset provided by a leading SCF provider.

4 - Capacity Expansion In Service Platforms Financing Vs. Employment

Heikki Peura, Imperial College Business School, South Kensington Campus Imperial College, London, SW7 2AZ, United Kingdom, S. Alex Yang

Service platforms expand capacity by attracting new providers who do not yet possess the requisite assets to deliver the service (e.g., cars suitable for ride-hailing). We use a game-theoretic model to examine the viability and relative performance of two mechanisms platforms have trialed to attract prospective providers: financing and employment. While traditional bank financing results in capacity under-investment and under-utilization, both mechanisms may alleviate these issues. Compared to financing, the platform prefers employing providers when the investment cost is low, the market demand is high, and when the providers' outside options are unattractive.

■ VWA30

Virtual Room 30

Service Optimization and Innovation

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Man Yu, Hong Kong University of Science and Technology, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

1 - Social Learning And Polarization On Content Platforms

Dongwook Shin, HKUST Business School, Lee Shau Kee Building, Hong Kong Univer, Clear Water Bay, Hong Kong, Bharadwaj Kadiyala

We consider a problem of (online) content market consisting of three players: a content platform, a content provider, and a consumer population. A content provider creates a content and posts it on a monopolistic platform at the start of time horizon. Following that, consumers sequentially arrive at the platform and decide whether or not to consume (view, listen, or read) the content. A salient feature of our problem is that the intrinsic quality of the content is unknown to consumers, but it can be learned from its popularity score (e.g., total number of views). Our analysis shows that customers may fail to learn the content's quality, which in turn reduces the content provider's incentive to improve quality. Our findings provide insights for content platforms (such as Youtube) on how and when the popularity score is beneficial for the platform and customers.

2 - Admission Pricing In Public Emergency Departments: Theory And Evidences From A Natural Experiment

Man Yu, Hong Kong University of Science and Technology, ISOM Department, HKUST, Clear Water Bay, Hong Kong, Hong Kong, Ji Chen, Tian Li

We study the pricing decisions of a medical service provider who operates both an emergency department and a non-emergency department with different priority schemes and admission fees. Effects of adjusting the admission fees are examined both in an analytical model and with empirical data from public hospitals in Hong Kong.

3 - Dynamic Service System Design With Flexible Servers And Priority Customers

Rui David Chen, The Chinese University of Hong Kong, Shenzhen, Shenzhen, 518172, China

We study non-preemptive queueing systems consisting multiple classes of customers with different waiting cost rates and multiple servers with heterogeneous service rates. We compare two common-in-practice systems (dedicated system and work-conserving flexible priority system) and characterize conditions for each one to be more favorable. Under the objective of minimizing discounted total waiting cost, we develop a Markov decision process formulation and analytically characterize the structure of the optimal dynamic server assignment policy. We prove that, the optimal policy is of a threshold type with intentional idleness. We also invent an approach to compute the optimal threshold values. Through numerical experiments, we quantify the advantage of the optimal policy.

■ VWA31

Virtual Room 31

Supply Chain Competition

Contributed Session

Chair: Neslihan Ozlu, Stockholm University, Stockholm, 18254, Sweden

1 - Chief Intellectual Officers: An Exploratory Analysis Of Their Emergence And Effects

Yoichiro Nishimura, Associate Professor, Chuo University, Tokyo, Japan, regression@hotmail.com, Masayo Kani

While many studies examine CFO, COO and CSO, little is known about CIPO. In this study, we examine the emergence of CIPO inside the firm and its effect on corporate IP strategy. We primarily relied on two perspectives to examine CIPO: contingency perspective and institutional perspective. We find that firm size and R&D size which represent the general & IP-related CEO's workload respectively are positively associated with the emergence of CIPO. Furthermore, we also show that the emergence of CIPO is affected by the institutionalization of the CIPO position in the industry. We also reveal that top executive who is appointed as CIPO is likely to adopt industry norm in terms of corporate IP strategy.

2 - Customer Segmentation, Pricing, And Lead Time Decisions: A Stochastic-user-equilibrium Perspective

Jun Ma, University of Calgary, Calgary, AB, Canada, Barrie R. Nault, Ding Zhang, Yiliu (Paul) Tu

We study a two-echelon supply chain network consisting of manufacturers and retailers facing customers that differ in their price- and time-sensitivity. We adopt a stochastic-user-equilibrium approach in a supply chain network by incorporating discrete choice theory and using a multinomial logit-based variational inequality to express equilibrium conditions. We find that price/lead time options provided by individual firms depends on multiple factors, including the mean and variance of customers' sensitivity coefficient distributions, time-cost relationship of firms, and supply chain management approaches.

3 - Competition Or Cooperation? Equilibrium Analysis In The Presence Of Process Improvement

Xuan Zhao, Professor, Wilfrid Laurier University, Waterloo, ON, Canada, Wei Li

Coopetition is a business phenomenon that dominates many supply chains. We aim to understand why and how coopetition occurs in supply chains with the presence of process improvement in upstream component production. An original equipment manufacturer (OEM) can purchase the component from either a non-competing supplier (NS) or a competing supplier (CS) that also sells substitutable products in the end consumer market. We demonstrate that without process improvement, coopetition does not exist. Two cases are considered in which process improvement is present: supplier-initiated investment and OEM-initiated investment.

4 - Effects Of Firm's Structural Position In Its Value Network On Competitive Intensity And Complexity

Yang Yang, Assistant Professor, University of Texas at El Paso, El Paso, TX, United States

Competition is fluid and dynamic, so firms must constantly create temporary advantages by frequently launching various competitive actions to sustain their competitive advantage. While research has shown that firms become increasingly dependent on their suppliers and customers to gain competitive advantage and has examined the impact of value network on firm performance (i.e., a result of a firm's competitive actions), no study has investigated how value networks could directly affect a firm's strategic competitive behavior. This study examines how firms' structural characteristics in value networks influence their competitive behavior in respect of competitive aggressiveness.

5 - Investigation Of Information Usage In A Retail Supply Chain

Abdurrezzak Sener, Assistant Professor, Penn State University, Beaver, PA, United States, Mutlu Y. Avcilar, Mehmet Barut

In this empirical study, we focus on how member relationships impact information sharing as well as the moderating impact of information quality on the relationship between acquiring information and processing information in a retail supply chain network.

6 - The Role Of Peer Experience And Learning In Operational Decisions

Neslihan Ozlu
Neslihan Ozlu, Stockholm University-Företagsekonomi, Stockholm, Sweden

Drawing on purchasing data from a European manufacturer, we investigate the purchasers-ordering behaviour under variable lead times. In particular, we examine the learning of the purchasers through their experiences with the suppliers from their peers. We also incorporate the specific versus all other purchasers as well as suppliers into the analysis. We mainly observe varying behaviours of purchasers depending on the relationships with the suppliers. Our results have both managerial and practical implications.

■ VWA32

Virtual Room 32

Emerging Topics on Supply Chains and Platforms

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Fang Xin, Singapore Management University

1 - Information, Inspection And Contract: An Analysis Of C2C E-commerce Platforms

Linqiu LI, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing, China, Xin FANG, Yunfong LIM

We consider a customer-to-customer platform that serves as a marketplace and provides an inspection service. An individual, who may not be a professional seller and is uncertain about the quality of his product, sells the product through the platform to a buyer. The inspection service of the platform can detect whether the product is of low quality with a probability. We find that with the inspection, the equilibrium of the signaling game between the seller and the buyer is completely different from that without the inspection. The platform's revenue is also larger with the inspection than that without the inspection.

2 - Mitigating Supply Disruption Risk With Endogenous Capacity Allocation Priority

Wenbin Wang, Shanghai University of Finance and Economics, Shanghai, 200433, China, Zhongzhong Jiang, Jiahua Zhang

This paper considers a supply chain where two manufacturers buys from a capacitated supplier. We design and compare different capacity allocation rules in mitigating the supplier's disruption risk

3 - Time-based Pricing at Grocery Stores? Transitioning Strategies under Retail Competition and Congestion Externality

Dongyuan Zhan, University College London, School Of Man. Gower Street, London, WC1E 6BT, United Kingdom, Christopher S. Tang, Onesun Steve Yoo

We examine whether (and, if so, how) retailers selling essential items (e.g., groceries) should transition to time-based pricing, or charging higher prices during peak hours in order to smooth demand and reduce the store congestion experienced by consumers. We incorporate consumers' congestion disutility in a two-stage dynamic game between two retailers. We find that, when the retailers are myopic, both choose an "immediate transition"; this choice does not affect consumer welfare. Otherwise, depending on the extent of retailer myopia and of consumers' aversion to congestion, there can be an equilibrium when both retailers choose a "cautious transition" or when one chooses an "immediatetransition" while the other chooses a "cautious transition"; each of these equilibria may be detrimental to consumer welfare.

4 - Incentivizing Farmer Adoption Of Agri-technology Products
Xiao Tan, Washington University in St. Louis, St. Louis, MO, 63130, United States

With the development of agriculture technology, new agri-technology products like UAV help farmers with seeding and fertilizing. However, it is of highrisk and uncertainty to use these products. We characterize farmers' behaviors in equilibrium when they engage in Cournot competition. Also, we study the firm's optimal effort and price regarding farmers' behaviors. The government may able to subsidize farmers or the firm. Our analysis will show which player should be subsidized under certain conditions.

■ VWA33

Virtual Room 33

Supply Chain Management IV

Contributed Session

Chair: Babiche Aerts, Antwerpen, 2060, Belgium

1 - Contingency Planning For Combined Adaptation Of Healthcare And Commercial Supply Chains For A Pandemic Response
Oleg Gusikhin, Ford Motor Company, Dearborn, MI, United States, Xingyu Li, Dmitry Ivanov, Kathryn E. Stecke

During the COVID-19 pandemic, severe shortages have been observed in healthcare production entailing ad hoc supply chain (SC) adaptation by using capacities of commercial companies. Time delays, high preparation efforts, and long shortage periods have been seen during these adaptations. We hypothesize that some collaborative preparedness to the contingent structural SC adaptation with development of upfront plans for combining commercial and healthcare SCs should result in higher efficiency and effectiveness. Using optimization and simulation methodology, the value of collaborative structural adaptation is examined in the context of different industrial infrastructures.

2 - The Choice Of Agricultural Cooperation Model In The Poverty Alleviation Supply Chain:contract Farming Vs Live Commerce
Zigong Cai, South China University of Technology, Guangzhou, China, Fei Ye

This article studies two agricultural models for cooperation between the farmer and e-commerce: contract farming (CF) and live commerce (LC). Under CF, e-commerce determines the contract price of crops, and the farmer produce according to the contract price. Under LC, the farmer directly sells crops online through the e-commerce platform to the market, and the e-commerce collects a certain platform commission from the farmer. In the model, the e-commerce actively assumes the corporate social responsibility of poverty alleviation and receives government subsidies.

3 - Coordination Strategy For An Eco-friendly Three-level Textile Supply Chain
Arnab Bisi, Associate Professor, Johns Hopkins Carey Business School, Baltimore, MD, United States, Arnab Adhikari

The design of a multi-level eco-friendly textile supply chain remains an interest for scholars. Existing scholarly works mostly incorporate a two-level apparel manufacturer-retailer setting. It motivates us to depict a multi-level eco-friendly textile supply chain using a three-level setting that comprises a textile firm, an apparel manufacturer, and an apparel retailer. We demonstrate the collaboration of textile supply chain members using greening cost-sharing, profit-sharing, and two-part tariff contracts. We propose a contract selection framework for greening quality, pricing, and supply chain member's profitability. Also, we devise the coordination mechanism.

4 - Multiechelon, Multicommodity Supply Chain Design With Uncertain Demand From A Climate Change Mitigation Perspective
Reza Alizadeh, University of Oklahoma, Norman, OK, United States, Janet K. Allen, Farrokh Mistree

According to the US EPA, companies with a supply chain (SC) generate about 42% of greenhouse gas. Thus, designing a green supply chain (GSC) is a reasonable solution to mitigate climate change. To design a GSC, we model the SC as a network of customers, stores, and warehouses. The number and location of stores are determined to find a low-cost and low emission configuration. A multi-echelon, multi-commodity SC with different warehouses and stores is designed. Using socio-spatial data, demand is predicted. The multi-echelon multi-commodity supply chain distribution and inventory systems are then considered in the proposed model for different carbon policies.

5 - Modeling And Solving The Replenishments Of The Forward Area For A B2C Warehouse In Order To Minimize Stock Outs
Babiche Aerts, University of Antwerp, Antwerp, Belgium, Trijntje Cornelissens, Kenneth Sörensen

In a B2C e-commerce warehouse where inventory is split over a reserve and forward area, replenishments to the forward area are crucial to avoid stock outs. Replenishments keep warehouse operations up and running, but despite their critical role, the planning of replenishment orders is studied to a minor extent. We present and solve a mathematical model for this replenishment problem, that allows to include different inventory policies, and takes into account limited replenishers and restricted replenishment time. For larger instances, we propose a heuristic approach. Preliminary results are discussed for different target stocks, replenishment levels and resource availability.

■ VWA34

Virtual Room 34

Economic and/or Environmental Implications of Innovative Business Models

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Safak Yucel, Georgetown University, Washington, DC, 20057, United States

1 - Reducing Food Waste In The Food Service Industry
Feng Tian, Ross School of Business, University of Michigan, Ann Arbor, MI, 77305, United States, Ekaterina Astashkina

Food waste is a global environmental problem that spans many industries including food service. We build a stylized model of a firm that serves consumers who decide on the amounts of food to buy in the presence of demand uncertainty. We identify key determinants of food waste and suggest potential solutions that lead to lower waste.

2 - Wastewater Recycling Capacity Investment In Urban Water Management
Qian Luo, Singapore Management University, Singapore, Singapore, Onur Boyabatli, Buket Avci

Wastewater plays a pivotal role in water sustainability by closing the urban water cycle and serving as another water source. This paper investigates a wastewater recycling capacity optimization problem considering rainfall and recycling cost uncertainties in the integrated urban water management system. We formulate the water utility's decisions as a two-stage stochastic problem and characterize the optimal water allocation schemes and the optimal recycling capacity. We also conduct sensitivity analysis to investigate the impacts of rainfall and recycling cost variabilities their correlation on the optimal expected cost and recycling capacity. In this paper, we also conduct a case study using publicly available data to calibrate the model and conduct extensive numerical analysis to complement the analytical results.

3 - Design Of Electricity Demand-response Programs
Vishal Agrawal, Georgetown University, Washington, DC, 20057, United States, Safak Yucel

Demand-response programs incentivize customers to reduce their electricity demand as compared to a baseline when utility firms face unusually high electricity demand and procurement cost. We investigate how the existence of the baseline affects demand-reduction decisions by customers, and in turn, the design of demand-response programs by utility firms.

4 - A Dynamic Structural Model of Renewable Energy Investment
Seyed Amin Seyed Haeri, Clemson University, Clemson, SC, United States, Ahmet Colak, Safak Yucel

In this study we look at investments in renewable energies from the dynamic structural modeling lens. We focus on one of the California's electricity market clean energy program (i.e., Renewable Portfolio Standard), that is the most ambitious program across the United States. We evaluate how this program may influences firms' strategic decisions such as market entry/exit, and capacity adjustments.

■ VWA35

Virtual Room 35

Renewable Energy

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Alexandra M. Newman, Colorado School of Mines, Golden, CO, 80401-1887, United States

1 - Estimating The Value Of Concentrating Solar Power Under New Costs Paradigm

Kehinde Abiodun, Colorado School of Mines, Golden, CO, 80401, United States

There is a gap in knowledge regarding the value of Concentrating Solar Power (CSP). Extant studies on the value of CSP are mostly outdated. This paper takes a price-taker approach to calculate the value of CSP based on recent cost information. The estimated value is based not only on the value from energy services and storage, but also on the provision of ancillary services, including spinning reserves and firm capacity. This paper uses price data from the CAISO market, zone SP15 in California, and National Renewable Energy Lab (NREL's) System Advisor Model (SAM).

2 - Experience Curves And The Relatedness Of Technologies: Offshore And Onshore Wind Energy

Christian Hernandez-Negron, University of Massachusetts-Amherst, Amherst, MA, United States, Erin Baker, Anna Goldstein

We look at the impact of modeling offshore wind as (1) a fully new technology, (2) a direct offshoot of onshore wind, and (3) a hybrid. We chart the cumulative installed capacity of offshore wind on a global scale against the LCOE starting in 2010, and we find that assumptions about its relatedness to onshore wind are equally important as assumptions about future growth scenarios. We contrast these experience curve models with expert elicitations, which appear to underestimate recent trends in cost reduction for offshore wind. The results are consistent with the idea that experts view offshore wind as a direct offshoot of onshore wind. This research highlights a previously neglected factor in experience curve analysis, which may be especially important for technologies, such as offshore wind energy, that are expected to contribute significantly to climate change mitigation.

3 - Multistage Adaptive Robust Optimization For The Management Of Hydroelectric Resources

Marcel Favereau, Pontificia Universidad Catolica de Chile, Santiago, Chile, Alvaro Lorca

The problem of hydrothermal scheduling seeks to use the water stored in reservoirs throughout time efficiently. This problem has been typically approached through multistage stochastic programming models that minimize the total expected operational cost over the planning horizon. We propose a multistage adaptive robust optimization model that minimizes the hydrological worst-case cost. To solve this model, we propose an efficient formulation based on full affine policies and vector autoregressive models to represent the hydro inflows uncertainty. Our experiments show the proposed model's efficiency for large-scale systems and the reliability that robust optimization models deliver.

■ VWA36

Virtual Room 36

Environment, Energy, and Natural Resources I

Contributed Session

Chair: Rebecca Ciez, Murrysville

1 - Predictive Multi-microgrid Generation Maintenance, Formulation And Impact On Operations & Resilience

Farnaz Fallahi, GRA, Wayne State University, Detroit, MI, United States, Murat Yildirim, Jeremy Lin, Caisheng Wang

This work proposes a framework that builds a seamless integration between sensor data and operational & maintenance (O&M) drivers in a multi-microgrid setting and demonstrates the value of this integration for improving multiple aspects of microgrids operations. The framework offers an integrated stochastic optimization model that jointly optimizes O&M. Operational uncertainty from renewables, demand, and market prices are modeled through scenarios. We use the model structure to develop a decomposition-based solution algorithm to ensure computational scalability. The model provides significant improvements in terms of reliability, costs, generation availability, & resilience.

2 - Hierarchical Parametric And Semi-parametric Bayesian Modeling Of Electric Outages

Luis J Novoa, Assistant Professor, James Madison University, Harrisonburg, VA, United States, Atilla Ay, Refik Soyer, Goran Vojvodic, Babak Zafari

When an electric outage occurs, it is important for utility companies to identify which device(s) failed and estimate repair times. This impacts the development of prevention policies and crew scheduling. We develop hierarchical parametric and semi-parametric bayesian models to assess the reliability of different devices in a power system and provide probabilistic statements about the reliability of each device as well as the overall power system, while considering different weather scenarios

3 - Assessing Wildfire Hazards Around Electric Grids

Fernando Marianno, IBM, Yorktown Heights, NY, United States, Wang Zhou, Levente Klein, Ildar Khabibrakhmanov, Rui Zhang, Johannes Schmude

Sparks generated by power lines touching vegetation often cause wildfires, and thus a continuous wildfire hazard assessment around electric grids is needed. Infrared signatures from satellites can identify fire events in near real time. We present a data and physical-model driven framework to assess dynamic wildfire hazards around electric grids. The framework, which accounts for terrain, available fuel, vegetation, and weather, continuously processes massive amounts of data that drive the physical and hazard models. The framework enables continuous calculation of the minimum distance between the wildfire location and power lines and proposes operational actions under extreme conditions.

4 - Predictive Analysis Of Green-ness Of U.s. Congress Members Using Machine Learning Techniques

Jiayu Fan, Clark University, Worcester, MA, United States, Jie Bian, Yue Gao

The League of Conservation Voters (LCV) tracks the voting records of Congress members on environmental issues in its National Environmental Scorecard. It is a nationally accepted index used to rate the 'green-ness' of U.S. congress members. In this study, we use a longitudinal sample over a 44-year period and employ machine learning methods to predict senators' LCV Scores, including nonlinear models, random forest, and XGBoost. The results demonstrate that Party affiliation, presidential election voting, the percentage of college-educated, and unionization rate have the most significant effects on the LCV scores. We discuss implications for policymakers, firms, and residents as well.

5 - Power-to-X: Evaluating Commodities For Long-duration Storage

Rebecca Ciez, Purdue University, West Lafayette, IN, United States, rciez@purdue.edu

Further incorporating the industrial sector into a net-zero emissions electricity system may also present opportunities to use commodities as an energy storage resource: by adjusting production based on seasonal electricity patterns and by consuming commodities themselves to produce energy. Here, we combine historical trends in commodities manufacturing capacity utilization and electricity demand in a two-stage optimization framework to construct and dispatch electricity and commodity production for a zinc processing facility.

■ VWA37

Virtual Room 37

From Uncertainty to RrobustInsights in Energy-Climate Scenarios

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Massimo Tavoni, Politecnico di Milano School of Management, Politecnico di Milano School of Management, Italy

Co-Chair: Giacomo Marangoni, Polytechnic University of Milan, Polytechnic University of Milan, Italy

1 - Sources Of Uncertainty In Long-term Global Scenarios Of Solar Photovoltaic Technology

Evelina Trutnevyte, University of Geneva, Renewable Energy Systems, Geneva, Switzerland, Marc Jaxa-Rozen

The deployment of solar photovoltaic (PV) technology has consistently outpaced expectations over the past decade. However, long-term prospects for PV remain deeply uncertain, as recent global scenarios span two orders of magnitude in installed PV capacity by 2050. Here we systematically compile an ensemble of 1,550 scenarios from peer-reviewed and influential grey literature, including IPCC and non-IPCC scenarios, and apply a statistical learning framework to link scenario characteristics with foreseen PV outcomes. We show that a large portion of the uncertainty in the global scenarios is associated with general features such as the type of organization, energy model and policy assumptions, without referring to specific techno-economic assumptions. IPCC scenarios consistently project lower PV adoption pathways and higher capital costs than non-IPCC scenarios.

2 - Determinants Of Uncertain Regional Technological Transitions In Global Decarbonisation Scenarios

Pei-Hao Li, University College London, Energy Institute, London, United Kingdom, Steve Pye

IPCC collated numerous global decarbonisation pathways to gain insights into how to reach the Paris Agreement targets. However, only simple descriptive statistics are applied to show the uncertain energy transitions at the global level in their reports. Influences of key determinants on regional technological transitions have not been systematically investigated to date. Thus, this study intends to fill the research gap by identifying key determinants of uncertain regional transitions in the global transition scenarios with machine learning techniques. Spectral Clustering will determine technological transition archetypes at the regional level. The Random Forest algorithm will then identify the key determinants of the regional transitions. Finally, policy implications for regional energy transitions will be drawn from the identified determinants.

3 - Net Zero-emission Pathways Reduce The Physical And Economic Risks Of Climate Change

Laurent Drouet, RFF-CMCC European Institute on Economics and the Environment (EIEE)

Mitigation pathways exploring end-of-century temperature targets entail varying degrees of temperature overshoot. The intertemporal consequences of overshoot have been typically evaluated from the point of view of mitigation. Here, we provide an assessment of the benefits of limiting overshoot via an ensemble of integrated assessment models. We compute physical and macroeconomic probabilistic indicators of temperature overshoot pathways. Temperature overshooting affects the full distribution of many critical physical impacts, such as those associated with heat extremes. We show that limiting overshoot reduces risk in the right tail of the distribution, in particular for low-temperature targets such as 1.5C.

4 - Clustering Performance and Feasibility Metrics of 2°C Scenarios

Giacomo Marangoni, Politecnico di Milano, Milano, 20156, Italy, Massimo Tavoni

What are climate mitigation strategies that perform well across a multitude of performance metrics and against a wide range of plausible alternative futures? Here, we take a large ensemble of available 2°C-consistent climate-energy-economy scenarios and derive from the underlying data a representative set of prototypical pathways towards climate stabilization. We extract and select the most informative features from the variables describing the scenarios and cluster them following multiple approaches to reach a parsimonious, yet exhaustive and robust, representation of the several ways to decarbonize our economy. We focus on a variety of metrics which cover technological, environmental, economic, land-use and energy demand dimensions, and identify solutions that balance all the metrics of interest well under multiple socio-technical assumptions.

■ VWA38

Virtual Room 38

OR and AI approaches for Biodiversity Conservation

Sponsored: ENRE/Environment and Sustainability

Sponsored Session

Chair: Bistra Dilkina, University of Southern California, Los Angeles, CA, 90089, United States

1 - Optimal Land Supply For BECCS Considering Biodiversity Conservation

Cindy Azuero, Georgia Tech, Atlanta, GA, United States,

Bioenergy with carbon capture and storage (BECCS) will play a major role in mitigation pathways toward the 1.5º and 2ºC scenarios. Estimated land requirements for BECCS are big, ranging from 200 Mha-1500 Mha, for a deployment between 3-30 Gt CO2 per year in 2100 (Creutzig et al., 2021). Current land allocation models used in Integrated Assessment Models (IAMs) do not consider biodiversity impacts when determining the location of the land supplied for bioenergy. Here, we integrate a linear optimization model with a biodiversity impact assessment model, to determine how to optimally supply land for BECCS considering (1) minimizing biodiversity impact subject to a budget constraint and (2) minimizing cost subject to a biodiversity threshold. A pareto frontier is constructed with which the trade-off between biodiversity and cost can be analyzed.

2 - Designing And Deploying Data-driven Decision Support Tools For Conservation Agencies

Amrita Gupta, Conservation Science Partners, University of Washington, Truckee, CA, 98119, United States
Amrita Gupta, Georgia Institute of Technology, Atlanta, GA, United States

The Analytics Lab at Conservation Science Partners develops computational models that enable us to answer complex questions about our natural world and society. We leverage Earth observation and other geospatial data, artificial intelligence, and domain expertise in ecology and social science to inform decision-making for conservation and natural resource managers. I will showcase some of the projects we have at Conservation Science Partners, highlighting the models we have built, the decision processes they are developed in service of, and the process of working hand in hand with experts and end-users to identify the most relevant inputs and outputs for actionable science.

3 - Embedding Conjugate Gradient In Learning Random Walks For Landscape Connectivity Modeling In Conservation

Yexiang Xue, Purdue University, West Lafayette, IN, 47907, United States, Pramith Devulapalli, Bistra Dilkina

Models capturing random walks on graphs have been widely adopted in wildlife conservation to study species dispersal. By exploiting the connection between random walks and circuits, we show that learning a random walk model can be reduced to finding the optimal graph Laplacian for a circuit. We propose a moment matching strategy that correlates the model's commuting times with those observed empirically. To find the best Laplacian, we propose a neural network capable of back-propagating gradients through the matrix inverse in an end-to-end fashion, where each neural net layer encodes one conjugate gradient iteration of the matrix inverse. We apply our computational framework to applications in landscape connectivity modeling. Our experiments successfully demonstrate that our framework effectively and efficiently recovers the ground-truth configurations.

4 - Interdiction Of Wildlife Trafficking Supply Chains: An Analytical Approach

Burcu B. Keskin, University of Alabama, AL, 35406-4062, United States, Bistra Dilkina, Aaron Ferber, Emily Barbee, Oakley Prell

Illicit Wildlife Trafficking (IWT) has a negative impact on the environment and communities, enabling the spread of diseases, land degradation, and biodiversity loss. IWT is a global issue, with almost 6,000 different species seized since the 90s and expanding to more than 150 countries. Traffickers operate complex and dynamic networks that require detailed strategies to disrupt. We model disrupting these networks as a network interdiction problem where authorities seek to interdict along specific routes to reduce the trafficker's profitability and force any resulting geographical displacement to be as costly as possible. We characterize the needed and available data in IWT, modeling assumptions, and network interdiction formulations that apply to this complex setting, and we evaluate the proposed methods in the context of global air travel networks.

■ VWA39

Virtual Room 39

Learning Methods for Planning and Operation of Energy Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Lesia Mitridati, ETH Zurich, ETH Zurich, Switzerland

Co-Chair: Antoine Lesage-Landry, Polytechnique Montréal, Polytechnique Montréal, QC, Canada

1 - Embedding Information On Power Systems Into Machine Learning Methods, A Physics-informed Approach To Planning And Operating Them

Laurent Pagnier, The University of Arizona, Tucson, AZ, United States,

With the increasing penetration of renewables in our energy mix, power systems become more prone to disturbances. To maintain their high reliability, it is paramount to have efficient tools to monitor and manage them. Machine Learning is likely to play a significant role to achieve these tasks, however grid operators are still reluctant to use ML methods for their operations and planning. This is mostly due to their lack of interpretability and to their unpredictable behavior in operational regimes unseen during training. Here, we focus on parameter and state estimations. We show that embedding the physical laws governing power systems into the ML methods allows to train them on smaller data sets, to make accurate predictions in rare regimes and to interpret learned parameters as features of grid elements. These physics-informed methods outperform standard ML methods.

2 - Fitted Q-iteration For Network-Safe Demand Response

Antoine Lesage-Landry, Polytechnique Montréal, Montreal, QC, Canada, Duncan S. Callaway

We propose a batch reinforcement learning-based demand response (DR) approach to account for distribution network constraints in unknown environments. We assume that the DR aggregator has no knowledge of the network and cannot communicate with the system operator. We consider frequency regulation provided by thermostatically controlled load aggregations. We use the fitted Q-iteration (FQI) algorithm and historical grid measurements to compute a network-safe control policy. We compare our method to a greedy, grid-agnostic approach in a case study using real load profiles. The average cumulative loss reduction and tracking root mean square error are 48% and 0.093 for FQI, and 78% and 0.060 for the grid-agnostic approach. Our simulations show that FQI reduces on average by 95% the number of rounds with constraint violations when compared to the grid-agnostic approach.

3 - Learning To Control In Power Systems: Design And Analysis Guidelines For Concrete Safety Problems

Patricia Hidalgo-Gonzalez, University of California, San Diego

Rapid progress in machine learning and artificial intelligence (AI) has brought attention to its applicability in power systems for new forms of control that help integrate higher levels of renewable generation and address increasing levels of uncertainty and variability. In this work we discuss these new applications and shine light on the most relevant new safety risks and considerations that emerge when relying on learning for control purposes in electric grid operations. We build on recent taxonomical work in AI safety and focus on four safety problems. We draw on two case studies, one in frequency regulation and one in distribution system control, to exemplify these problems and show mitigating measures. We then provide general guidelines to help people working on integrating learning capabilities for control purposes to make safety risks a central tenet of design.

4 - A Model-Based Reinforcement Learning Approach For Controlling Smart Buildings Integrating Renewable Energy Resources

Ehsan Rezaei, PhD Student, Polytechnique Montréal, Montréal, QC, Canada, Vincent Taboga, Hanane Dagdougui

Due to the limitations of classical identification and control approaches, the optimization of thermal behavior of buildings is one of the main challenges towards the implementation of smart buildings. In recent years, reinforcement learning (RL) has gained great popularity to solve some of these issues. In this work, we present a model-based RL method to minimize the power consumption of a building integrating with PV system and battery while preserving thermal comforts of its occupants. In this approach, a nonlinear model can be efficiently learned from observations. This approach makes the planning more efficient than model-free RL methods. The model-based RL agent is then used to control building's systems in a simulated environment to assess the efficiency of control. Due to its fast training process, the proposed model-based RL can be used for real-time applications

5 - Deep Statistical Solvers

Balthazar Donon, RTE

We introduce Deep Statistical Solvers (DSS), a new class of trainable solvers for optimization problems. The idea is to learn a solver that generalizes to a given distribution of problem instances. This is achieved by directly using as loss the objective function of the problem, as opposed to most previous Machine Learning based approaches, which mimic the solutions attained by an existing solver. Though both types of approaches outperform classical solvers with respect to speed for a given accuracy, a distinctive advantage of DSS is that they can be trained without a training set of sample solutions. Focusing on use cases of systems of interacting entities (e.g. power systems, discretized PDEs), the proposed approach is instantiated within a class of Graph Neural Networks. We experimentally validate the approach on linear problems and non-linear AC power grid simulations.

■ VWA40

Virtual Room 40

Data-Driven Analytics for Future Electricity Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Ali Daraeepour, Princeton University, NJ, United States

1 - Machine Learning for Determining Optimal Load-following Reserve Requirements in Systems With High Shares of Variable Renewable Electricity

Mauricio Hernandez, PhD Student, Duke University, Durham, NC, 27708, United States, Ali Daraeepour, Elnaz Daraei Pour, Dalia Patino-Echeverri, Xiaodong Zhang

Cost-effective integration of large shares of VRE requires grid assets to meet the necessary load-following capability (LFC) requirements. Multiple studies propose using stochastic unit commitment models to identify time-varying load-following needs dynamically. Although this approach effectively determines optimal targets, its computational complexity prevents it from being used in large-scale grids. This study proposes a machine learning approach that maps the system's operating conditions and the required LFCs to ensure cost-effective integration of VRE. It uses the Electricity Market Simulation Tool to identify necessary LFC for a scaled version of PJM under different conditions.

2 - Lyapunov-regularized Reinforcement Learning For Power System Transient Stability

Wenqi Cui, University of Washington, Seattle, WA, United States, wenqicui@uw.edu, Baosen Zhang

Transient stability of power systems is becoming increasingly important with the growing integration of renewable resources. Their power electronic interfaces can implement almost arbitrary control laws, which provide increased flexibility in frequency responses. To design optimal non-linear policy for these controllers, reinforcement learning (RL) has emerged as a powerful method. A key challenge is to enforce that a learned controller must be stabilizing. This paper proposes a Lyapunov regularized RL approach for optimal frequency control for transient stability in lossy networks. Because the lack of an analytical Lyapunov function, we learn a Lyapunov function parameterized by a neural network. The learned Lyapunov function is then utilized as a regularization to train the neural network controller by penalizing actions that violate the Lyapunov conditions.

3 - Grid-aware Learning For Distribution System Modeling And Monitoring

Shanny Lin, University of Texas at Austin, Austin, TX, United States, Hao Zhu

Feeder modeling aims to estimate the network line parameters from fast nodal samples based on a linearized model, while the goal of monitoring is to enhance the observability of grid-edge resources by utilizing heterogenous types of data. To address the limitation of data availability, both learning problems have leveraged unique spatio-temporal characteristics of residential loads and resources to improve the solution effectiveness.

4 - Enforcing Policy Feasibility Constraints Through Differentiable Projection for Energy Optimization

Bingqing Chen, Carnegie Mellon University, Pittsburgh, PA, United States, Priya Donti, Kyri Baker, J. Zico Kolter, Mario Berges

Real-world applications of reinforcement learning (RL) are limited due to the fact that the actions from such learned policies may not be feasible or safe. In this work, we propose a method, PROF, to integrate convex operational constraints into RL frameworks. Specifically, we incorporate a differentiable projection layer within a neural network-based policy to enforce that all learned actions are feasible. We then update the policy end-to-end by propagating gradients through this differentiable projection layer, making the policy cognizant of the operational constraints. We demonstrate our method on two applications: energy-efficient building operation and inverter control.

5 - Machine Learning Approaches To The Unit Commitment Problem

Yafei Yang, Stevens Institute of Technology, Hoboken, NJ, United States, Lei Wu

With the growing scale and complexity of modern power grids, it becomes more complicated to accurately formulate the physical power system and more difficult to efficiently solve the corresponding UC problems. As a matter of fact, plenty of historical power system operation records, as well as real-time data, could provide useful information and insights into the underlying power grid. To this end, machine learning methods could be valuable to help understand the relationship of UC performance to power system parameters, reveal the rationality behind such relationship, and finally address UC problems in a more efficient and accurate way. This talk discusses the current practices, challenges, and promising strategies of adopting machine learning approaches to effectively solve the mixed-integer linear programming-based UC problems.

■ VWA41

Virtual Room 41

mpi-sppy: Asynchronous Optimization under Uncertainty

Sponsored: Computing Society

Sponsored Session

Chair: David Woodruff, University of California Davis, CA, United States

1 - Asynchronous Projective Hedging: Introduction, Implementation, And Large-scale Computational Experiments Using Mpi-sppy

Jean-Paul Watson, Senior Research Scientist, Lawrence Livermore National Laboratory, Livermore, CA, United States, David L Woodruff, Jonathan Eckstein, Bernard Knueven

We describe a scenario-based decomposition algorithm - Asynchronous Projective Hedging, or APH - for multistage stochastic programming that resembles the progressive hedging method of Rockafeller and Wets, but is capable of asynchronous parallel operation without sacrificing theoretical convergence in the convex case. Perhaps more importantly, each iteration of the decomposition method may process only a subset of the possible scenarios. We discuss the implementation of APH in the mpi-sppy parallel library for stochastic programming, and detail large-scale computational experiments highlighting both the effectiveness of APH and the scalability (to tens of thousands of ranks) of mpi-sppy.

2 - Airport Infrastructure Planning Using Multi-stage Stochastic Programming

Devon Sigler, National Renewable Energy Laboratory, Golden, CO, United States

The Athena project, funded by the Department of Energy, has worked to identify the critical infrastructure at Dallas Fort Worth (DFW) Airport which influences mobility between the airport and the surrounding city of Dallas. Using scalable methods that can leverage HPC resources we have developed a multi-stage stochastic infrastructure expansion model for determining parking and curb modifications to the DFW Airport over a 20-year horizon. Additionally, we have explored the impacts of congestion pricing in conjunction with infrastructure modifications. Our multi-stage stochastic model is implemented using the mpi-sppy software and solved in parallel using progressive hedging on the National Renewable Energy Laboratory's HPC system Eagle. In this talk we present results from solving this model at scale.

3 - Bounds And Confidence Intervals In Mpi-sppy

David L. Woodruff, University of California-Davis, Davis, CA, 95616, United States, dl Xiaotie Chen, Bernard Knueven, Jean-paul Watson

mpi-sppy (https://github.com/Pyomo/mpi-sppy) is a software package to allow for optimization of Pyomo optimization models uncertainty. In thistalk we will overview design and performance considerations related to bounds and confidence intervals. Particular attention will be paid to issuesassociated with problems that have more than two stages and scenarios that do not exhibit stage-wise independence.

■ VWA42

Virtual Room 42

Computer Science - Applications to OR

Contributed Session

Chair: Arjun Balasingam, Massachusetts Institute of Technology, Cambridge, MA

1 - Exactly Solving Linear Systems via The Sparse Exact (SPEX) Framework: History and Theoretical Foundation

Erick Moreno-Centeno, Texas A&M University, College Station, TX, United States, Christopher Lourenco

Solving sparse linear systems has a central role in solving linear programs and other optimization problems. 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 problems, 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 a companion talk by Christopher Lourenco will focus on the recent developments and computational results.

2 - Exactly Solving Linear Systems via the Sparse Exact (SPEX) Framework: Moving Towards Exact Optimization

Christopher Lourenco, Assistant Professor, US Naval Academy, Annapolis, MD, United States, Erick Moreno-Centeno

Solving sparse linear systems, via LU, Cholesky, and other factorizations, is a fundamental subroutine in mathematical programming. Though most solvers operate exclusively in double precision; applications where more precision is needed are increasingly forcing solvers to move towards quad precision or even fully exact solutions. This talk presents a framework to exactly solve sparse linear systems like those in mathematical programming. Our presented algorithms operate exclusively in integer-arithmetic and we provide computational results showing that they outperform the alternate exact approaches of rational-arithmetic and exact iterative methods.

3 - A Study of Software Development Practice in Operations Research

Mesut Yavuz, University of Alabama, Tuscaloosa, AL, United States, Huseyin Ergin

Software is a crucial part of operations research (OR). In this talk, we present the results of two studies. The first explores all papers published in INFORMS Journal on Computing in the 5-year window (2016-2020) and the second one is a survey of 389 OR scholars. The results shed light on the current state of software development practice in OR, reveal the relationship of the OR scholars with research software, and present the expectations and concerns of them regarding code and data sharing practices.

4 - Throughput-fairness Tradeoffs in Mobility Platforms

Arjun Balasingam, Massachusetts Institute of Technology, Cambridge, MA, United States, Karthik Gopalakrishnan, Radhika Mittal, Venkat Arun, Ahmed Saeed, Mohammad Alizadeh, Hamsa Balakrishnan, Hari Balakrishnan

We study the problem of scheduling, routing, and allocating tasks from different customers to vehicles in shared mobility platforms (e.g., food and package delivery, ridesharing, and mobile sensing). We introduce Mobius, a system that uses guided optimization to navigate the inherent tradeoffs between fairness and throughput caused by shared mobility. Mobius supports spatiotemporally diverse and dynamic customer demands. Our evaluation demonstrates these properties, along with the versatility and scalability of Mobius, using traces gathered from ridesharing and aerial sensing applications.

■ VWA43

Virtual Room 43

Learning and Equilibria

Sponsored: Auctions and Market Design

Sponsored Session

Chair: John Dickerson, University of Maryland, College Park, MD, United States

Co-Chair: Stephanie Allen, College Park, MD, 20740, United States

1 - Using Inverse Optimization To Learn Cost Functions In Generalized Nash Games

Stephanie Allen, University of Maryland-College Park, College Park, MD, 20782-1159, United States

As demonstrated by Ratliff et al. (2014), inverse optimization can be used to recover the objective function parameters of players in multi-player Nash games. These games involve the optimization problems of multiple players in which the players can affect each other in their objective functions. In generalized Nash equilibrium problems (GNEPs), a player's set of feasible actions is also impacted by the actions taken by other players in the game. One example of such impact comes in the form of "coupled constraints" as referenced by Rosen (1965), Harker (1991), and Facchinei et al. (2007) which involve the other players' variables in some of the constraints of a player's feasible region. We extend the framework of Ratliff et al. (2014) to find inverse optimization solutions for this class of GNEPs. We validate our formulation on a simulated multi-player transportation problem.

2 - Tâtonnement beyond Constant Elasticity of Substitution

Denizalp Goktas, Brown University, Providence, RI, United States, Amy Greenwald, Enrique Areyán

We propose a new convex program that generalizes the dual of the Eisenberg-Gale program from the special case of utilities that satisfy constant elasticity of substitution (CES) to arbitrary continuous, concave, homogeneous utility functions. The main tools that enable this extension are the dual concepts of expenditure minimization and indirect utility maximization functions, which provide an intuitive interpretation of the dual of the Eisenberg-Gale program, which to our knowledge was not yet well understood. Additionally, we show that solving any quasilinear Fisher market can be reduced to solving a linear Fisher market, allowing known results for linear Fisher markets to be applied to quasilinear Fisher markets. We further show that solving our convex program with generalized gradient descent is equivalent to computing the equilibrium prices of a Fisher market via tâtonnement. This result allows us to establish the convergence of the discrete tâtonnement process at a rate of O(1/t) for Fisher markets with continuous, strictly concave, homogeneous (CSCH) utility functions representing locally non-satiated preferences—a class of utility functions beyond the class of CES utility functions, the largest class for which convergence results were previously known. CSCH Fisher markets include nested and mixed CES Fisher markets, thus providing a meaningful expansion of the relevant space of Fisher markets that is solvable via tâtonnement.

3 - The Survival Of The Strictest In An Uncertain World: Stable And Unstable Equilibria Under Regularized Learning With Partial Information

Emmanouil Vasileios Vlatakis Gkaragkounis, PhD Candidate, Columbia University, New York, NY, United States

Understanding the Nash equilibrium convergence properties of no-regret learning in general N-player games is a fundamental question in online learning and game theory. In this talk, we focus on the archetypal "follow the regularized leader" (FTRL) family of algorithms, and we consider a wide spectrum of uncertainty that the players may encounter - from noisy, oracle-based feedback,to bandit, payoff-based information. We present a succinct equivalence between the stability of a Nash equilibrium and its support: A Nash equilibrium is stable and attracting with arbitrarily high probability if and only if it is strictly pure (i.e., each equilibrium strategy has a unique best response). This talk is based on joint works with P. Mertikopoulos (InRIA), A. Giannou (Univ.Wisconsin) and L. Flokas (Columbia Univ.), T. Lianeas (NTUA), G. Piliouras (SUTD)

■ VWA44

Virtual Room 44

Deep Learning/Maching Learning V

Contributed Session

Chair: Emanuele Borgonovo, Bocconi University, Milano, 20136, Italy

1 - Deep Spatio-temporal Anomaly Detection In Laser Powder Bed Fusion

Sepehr Fathizadan, Arizona State University, Tempe, AZ, United States, Feng Ju, Yan Lu, Zhuo Yang

Parametric and regression-based anomaly detection methods often fall short when faced with high-dimensional data containing rich spatio-temporal correlations. The multitude of unrealistic assumptions renders the decisions made by such methods unreliable and prone to large errors. It has been shown that relying on a single melt pool image to detect anomalies in the process is usually misleading and can result in significant inflation of false alarm rates. In this study, we propose a configuration of convolutional long short-term memory auto-encoders to learn a deep spatio-temporal representation from the sequence of melt pool images and perform anomaly detection.

2 - A Comparison Of Hybrid Support Vector Machine Models For Analysis Of Work Zone Crash Injury Severity

Roksana Asadi, Research Assistant, NJIT, Newark, NJ, United States, Branislav Dimitrijevic

Crash severity models are often used in analyzing the adverse effects of highway work zones on traffic safety. This study applies two hybrid support vector machine (SVM) models for crash severity prediction: a genetic-algorithm-optimized SVM (GA-SVM), and greedy-search-optimized SVM (GS-SVM) models. The models are demonstrated using the work zone crash data for New Jersey from 2016 to 2018. The results revealed that the GA-SVM model outperformed both GS-SVM and the SVM with constant parameters in predicting the severity of work zone crashes.

3 - Learning A Continuous Search Space For Discrete Routing Problems Using Autoencoders

André Hottung, Bielefeld University, Bielefeld, Germany, Bhanu Bhandari, Kevin Tierney

Methods for automatically learning to solve routing problems are rapidly improving. However, most methods are unable to effectively utilize longer run times because they lack a sophisticated search component. We present a learning-based optimization approach that learns to map instance-specific routing problem solutions to points in a continuous space, thus turning a discrete search space into a continuous search space that can be explored using any unconstrained continuous optimization method (e.g., differential evolution). Our approach outperforms existing machine learning based approaches for the traveling salesperson problem and the capacitated vehicle routing problem.

4 - Post Hoc Explanations Through Probabilistic Sensitivity Measures

Valentina Ghidini, Bocconi University, Milan, Italy, Emanuele Borgonovo, Roman Simon Hahn, Elmar Plischke

Nowadays, Machine Learning models are ubiquitous; since they do not always intrinsically provide insights of their inner decision processes, the field of eXplainable Artificial Intelligence (XAI) is emerging. In this work, we first review the definition and the desiderata of an explanation; we then compare Sensitivity Analysis (SA) and XAI. Next, we define post-hoc explanations for machine learning models using probabilistic sensitivity measures. This method is applicable to alternative data formats. We focus on a classification task to illustrate the use and performance of the method, and we present a quantitative and automatic evaluation of the resulting explanations.

■ VWA45

Virtual Room 45

Analytics I

Contributed Session

Chair: Sayed Kaes Maruf Hossain, New Mexico State University, Las Cruces, NM, 88003, United States

1 - Detecting Bias In Jury Selection Using Optimal Trees

Daisy Zhuo, Interpretable AI, Cambridge, MA, United States, Jack W. Dunn

To support 2019 U.S. Supreme Court case Flowers v. Mississippi, there was a previous analysis using backward stepwise logistic regression to assess whether the State exhibited a racial bias in striking potential jurors. Their method is only a heuristic, and additionally cannot consider interactions between features. We apply Optimal Feature Selection to identify the globally-optimal subset of features and affirm significant evidence of racial bias. We also use Optimal Classification Trees to segment the juror population subgroups with similar characteristics and probability of being struck, and find that three groups exhibit significant racial disparity, pinpointing specific areas of bias.

2 - Visualizing The Intellectual Structure Of The Impact Of COVID-19 On E-learning

Hyaejung Lim, Kyungpook National University, Daegu, Korea, Republic of, Chang-Kyo Suh

E-learning platforms developed enormously over time since the appearance of the Internet. However, COVID-19 pandemic made the ways of e-learning change on another level. This study intended to explore the visualization of the intellectual structure of the e-learning field concentrated on the appearance of the COVID-19 pandemic using CiteSpace(Chen, 2017). In this research, we collected the articles through the Web of Science on e-learning field related to the COVID-19 crisis. We analyze the references of the papers through author-co-citation analysis. Then, we classify the major research domains and characteristics. The results and interpretation will be further discussed in the conference.

3 - A Study On Online Platform Customer Journey And Channel Management With Data Analytics And Deep Learning

Tzu-Chien Wang, National Taiwan University, Taipei, Taiwan, Chialin Chen, Ruey-Shan Guo

In the IoT era, customer journey analysis enables better understanding of customers' behaviors and interactions with an online platform. In this study, we utilize data analytics and deep learning to analyze customer journey on an online financial platform with a three-stage procedure. In the first stage, we perform cluster analysis to construct a user characteristic behavior model. In the second stage, we apply convolutional neural network and long short-term memory methods to predict customers' subsequent behaviors and the target conversion value. In the third stage, binary differential evolution is used to solve channel planning and revenue optimization problems under budget constraints.

4 - Enhancing Object Detection Using Wisdom Of The Crowd

Joshua Grassel, Arizona State University, Tempe, AZ, United States, Romena Yasmin, Adolfo Raphael Escobedo

Aggregating multiple human judgements to reach an informed decision that is superior to any individual's judgment is known as the wisdom of the crowd. An area of study where this concept has received little attention is object detection, where automated algorithms have exhibited key deficiencies. In this research, we define an approach to classify images by crowdsourcing object detection judgements. Participants evaluate an image through multiple methods of elicitation, whose responses are then aggregated using computational social choice and machine learning methods. The aggregation algorithms are customized to increase accuracy or reduce false negative (or false positive) rates.

5 - Extensions On Antminer Algorithms For Rule-based Classification

Sayed Kaes Maruf Hossain, PhD Candidate, New Mexico State University, Las Cruces, NM, United States, Sajia Afrin Ema, Hansuk Sohn

In this research, we have suggested multiple extensions on the AntMiner algorithms for rule-based classification. Firstly, we incorporated a strategy to dynamically balance the weight of exploration and exploitation during the rule discovery process. Secondly, we have suggested a probabilistic approach to improve the existing exhaustive rule pruning procedures. Thirdly, we performed a modular analysis to explore how the algorithm behaves for a range of probability functions. The early experimental results show competitive results for the proposed strategies over their counterparts.

■ VWA47

Virtual Room 47

Equilibrium Asset Pricing

Sponsored: Finance

Sponsored Session

Chair: Marko Weber, Columbia University, New York, NY, 10023-4207, United States

1 - Incomplete Market Equilibrium With Business Cycles And Heterogeneous Preferences

Marko Hans Weber, National University of Singapore, Singapore, 10023-4207, Singapore

We explicitly solve an equilibrium model in which several long-lived agents with heterogenous absolute risk-aversion and discount rates make consumption and investment decisions, trading an asset that pays a dividend whose growth rate randomly fluctuates over time. We analyze equilibrium consumption shares, stock price, risk-free rate, and optimal trading strategies. We study first-order effects of market incompleteness on equilibrium prices and policies.

2 - Equilibrium Existence in a Limited Participation Economy
Kim Weston, Rutgers University, Piscataway, NJ, United States

A limited participation economy models the real-world phenomenon that some investors have access to more of the market than others. Basak and Cuoco (RFS'98) introduced a continuous-time, running consumption model of limited participation with two (classes of) investors: an unconstrained investor with access to a complete market, and a constrained investor who cannot trade in the stock market and faces incompleteness. Equilibrium existence results have so far been limited to considering logarithmic constrained investors, in part due to the complications that arise with an endogenously-determined stochastic interest rate. In this talk, I will discuss an extension of Basak and Cuoco's model to the case of exponential investors. Equilibrium is described by a coupled system of semilinear PDEs, whose form relies on the presence of a traded annuity that is accessible to both the constrained and unconstrained investors. The equilibrium existence proof is based on Banach's fixed point theorem in Holder spaces.

3 - Disagreement And Control Rights: Implications For Debt Policy And Aggregate Dynamics
Steven D. Baker, University of Virginia, Charlottesville, VA, United States, Zhaohui Chen, Timothy C Johnson

We examine firm capital structure when heterogeneous agents optimally hold different claims, and control of the firm may change hands. When agents cannot commit to firm value maximization, controlling agents have the incentive to alter firm policy to maximize their preferred portfolio at the expense of other claim-holders. We consider settings that can include partial control rights to minority share-holders and/or debt-holders. In general equilibrium, the distortions relative to complete contracting are large even with small disagreement. However, it need not be the case that the distortions amplify the business cycle nor that stronger protection of debt holders mitigates the problem.

4 - Rogue Traders
Huayuan Dong, Dublin City University, Dublin, Ireland, Paolo Guasoni, Eberhard Mayerhofer

Investing on behalf of a firm, a trader can feign personal skill by committing fraud that with high probability remains undetected and generates small gains, but that with low probability bankrupts the firm, offsetting ostensible gains. Honesty requires enough skin in the game: if two traders with isoelastic preferences operate in continuous-time and one of them is honest, the other is honest as long as the respective fraction of capital is above an endogenous fraud threshold that depends on the trader's preferences and skill. If both traders can cheat, they reach a Nash equilibrium in which the fraud threshold of each of them is lower than if the other one were honest. More skill, higher risk aversion, longer horizons, and greater volatility all lead to honesty on a wider range of capital allocations between the traders.

■ VWA48

Virtual Room 48

Finance- Theory & Empirics

Contributed Session

Chair: Chi-Hong Ho, Henry M. Gunn High School, Palo Alto, CA, 94303, United States

1 - Not To Invest, It Should Be An Option: A Better Pursuit Of Maximum-sharpe Portfolio
Long Zhao, NUS Business School, Singapore, Singapore, Ziteng Wang

Conventionally, portfolio optimization faces the inevitable challenge of estimation errors in the expected returns, which is further amplified by the prevalent assumption that one must invest at all times. However, we propose that not to invest should be an option. With this option, portfolio optimization can become more manageable: it only needs to address the cases when estimation errors are tolerable; when the estimation errors are large, one does not invest. Taking the maximum-Sharpe (MS) portfolio optimization, we demonstrate that implementing the no-invest option is doable and beneficial.

2 - Zooming In Distress Anomaly: Bankruptcy Vs. Other Failures
Xiaorui Zhu, University of Cincinnati, Cincinnati, OH, United States, Yuhang Xing, Yan Yu

This paper reinvestigates the distress risk anomaly that financially distressed firms deliver abnormally low returns. We distinguish between bankruptcy and other-failure events and then utilizing the state-of-the-art adaptive Lasso variable selection method to identify predictors for these two types of risk. We obtain strikingly different predictors of bankruptcy and other-failure risk. In addition, both selected models gain better out-of-sample prediction performances than that of classical models in the literature. With the new risk measures, we find that the other-failure risk anomaly disappears while the anomalous return is persistently associated with the bankruptcy risk.

3 - Financial Valuation Of Disruptive Technologies With Supply Chain Dynamics
Zugang Liu, Penn State- Hazleton, Hazleton, PA, United States, Jia Wang

Disruptive technologies have been a major force behind the fasting-changing landscape of today's society and business world. This research studies the financial valuation of disruptive technologies with a focus on how supply chain relationships such as competition and partnership affect the values of different types of firms in disrupted industries.

4 - Multivariate Statistical Modeling Of Covid Vaccine Development Companies Stock Investment Strategy
Chi-hong Ho, Henry M. Gunn High School, Palo Alto, CA, ■

VM85-3

Virtual Room 85

Technology Showcase: Radical Simplification for the Creation of Optimization Models

Technology Showcase

1 - Radical Simplification for the Creation of Optimization Models
Segev Wasserkrug, IBM Reserach Lab, Haifa, Israel, Dharmashankar Subramanian

We will demonstrate a unique technology being developed by IBM to radically simplify and speed up the creation of optimization models. This is done through a combination of data driven and simplified modeling techniques, thereby also creating end-to-end data to decisions pipelines.When you interact with IBM, this serves as your authorization to INFORMS or its vendor to provide your contact information to IBM in order for IBM to follow up on your interaction. IBM's use of your contact information is governed by the IBM Privacy Policy

United States, Chi-Feng Ho

In 2020, wall street experienced a large market crash and the COVID-19 pandemic was the big factor. Author invested in vaccine developed companies after hearing good news. The idea of the project is to help investors to find the best biotech stocks for earning money. The author used a Financial Statement to find more potential stocks in 22 companies. The authors used those models: Outlier detection (robust regression & quantile range), PCA-SPC model, Eigenvalue & heating map, Confident Ellipse to help with determining the best timing and consider the risk of stock investment.

■ VWA49

Virtual Room 49

Theory and Application for Decision Analysis

Sponsored: Group Decision and Negotiation

Sponsored Session

Chair: Haiyan Xu, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China

Co-Chair: Shawei He, Nanjing, China

1 - Presenter
Haiyan Xu, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China

2 - Selecting International Flight Routes for Official Business Travel Using Logit Model: Case for Public Universities in China During Post-pandemic Period
Shawei He, PHD, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China, Xianmei Li, Tiwari Asmita

Official business travel follows specific regulations. During the post-pandemic period, the demands for official business travel will hopefully recover with the introduction of COVID vaccines. The selection of flight routes between cities in China and Europe is investigated using Logit model. With the data from booking websites and survey, the optimal flight route is selected among five candidates. Elastic analysis is carried out to suggest the impact of extended transfer time on the optimal route. This study indicates that the duration of transfer is the critical factor for official business travel and COVID vaccination could also affect the behavior of official business passengers.

3 - Efficiency and Competitiveness Evaluation of Medium-lift Launch Vehicle (MLV) Using Integrated DEA - TOPSIS Model

Rustam Ismatov, Master, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China, Xhen Wan, Haiyan Xu

Owing to the increasing launch demand and lack of satellite launch vehicles for commercial customers, the commercial launch market for transporting satellites into orbit by medium-lift launch vehicles (MLVs) is getting extremely popular and competitive. Understanding the efficiency and competitiveness of each MLV is particularly significant for countries who are planning to launch their own satellites. This paper presents a hybrid model that combines the data envelopment analysis (DEA) model, and technique for order performance by similarity to ideal solution (TOPSIS) to evaluate and then rank the efficiency and competitiveness of 19 MLVs that are currently operational in the world market.

4 - Best Possible Choice of Covid-19 Vaccines for Economically Weak Countries: Using AHP, TOPSIS and DEA Models

Binoy Barua, Master, Nanjing University of Aeronautics and Astronautics, Nanjing, 210016, China, Muhammad Ayaz

As of March 2021, there are 308 candidate vaccines at various stages of development. As no single vaccine has yet been found to be the most efficient so a need for decision making exists especially for economically weak countries. In this work, we identified a total of 10 criteria and we chose seven alternatives (vaccines). We used three mathematical tools that belong to MCDM (Multi-criteria decision-making methods). The tools were - AHP, TOPSIS and DEA. Among the 10 criteria, 8 criteria were chosen for AHP and TOPSIS. The weights of the criteria were calculated using AHP. Then, we ranked the COVID-19 alternatives using the TOPSIS method. The DEA model was used to evaluate the performance of each vaccine basing on 7 criteria. The aim of combining TOPSIS and DEA was to determine the vaccines that perform well in both TOPSIS and DEA.

5 - Sequential Price Negotiations For Big-ticket Items: Empirical Discovery And Estimation Of Predetermined Strategies

Abdullah Gokcinar, PhD Candidate, The University of Texas at Dallas, Richardson, TX, United States, Metin Cakanyildirim, Suleyman Karabuk

We empirically analyze negotiations between the seller and buyer over the price of a big-ticket item. In a negotiation, the seller and buyer take turns to accept the other's offer, make a concession from the previous offer, or exit. Empirical results suggest that a player makes concessions following a predetermined negotiation strategy towards a price, and he/she may accept or exit based on the other player's offers. Following these, we analytically model negotiations to estimate negotiation strategies along with acceptance and exit probabilities. These estimations can help us in revealing latent negotiation characteristics in different player subpopulations.

■ VWA50

Virtual Room 50

Economics and Supply Chain Modeling & Simulation

Sponsored: Simulation Society

Sponsored Session

Chair: Scott Rosen, MITRE, McLean, VA, 22102, United States

1 - Distributed Supply Chain Simulation: An Overview

Simon Taylor, Brunel University, Kingston Lane, Uxbridge, UB8 3PH, United Kingdom, Anastasia Anagnostou

Conventional approaches to supply chain simulation (SCS) involve building a model and using that model to predict the behaviour of the supply chain. There many be several problems with this. Is every enterprise happy with sharing their system details? Does the current version of the model reflect the current operating status of the company (e.g., data)? Who "owns" the supply chain model? Is it convenient to extend the SCS with new elements? Does the SCS run slowly and to speed it up does model detail need to be sacrificed? Distributed SCS (DSCS) presents a possibly solution to the above. We present an overview of DSCS, its benefits and barriers, a possible way forward, and other associated advantages.

2 - Modeling Supply Chain Resiliency For Determining Incentive Options Under Economic Shocks

Andrew Hong, PhD, MITRE, McLean, VA, 22102, United States

Economic shocks can stem quickly from many external causes with COVID-19 being a recent example. These shortages can propagate across the supply chain making it difficult to fully understand and control the impact of the degraded individual supply nodes. This research at MITRE is pursuing an integrated simulation framework to enable regional policy makers to gain a better insight in identifying the critical industries in their supply chain and where incentives should be allocated for sustained production. The long term goal is a supply chain decision support tool that helps assess the allocation of specific government benefits in local regions and industries to preserve supply chain resilience.

3 - Management Of A Distribution System Subject To zcSupply Disruptions

Kangye Li, Lehigh University, Bethlehem, PA, 18015, United States, Lawrence V Snyder

We study a periodic-review inventory system with a distribution system topology that is subject to supply disruptions. We assume that demand follows a Poisson process, each stage follows a base-stock policy and the allocation policy is first-come, first-served (FCFS). We propose two heuristics for this problem. Our heuristics combine a heuristic for serial systems subject to supply disruptions with the decomposition-aggregation (DA) heuristic for distribution systems without disruptions. We also consider the special case of a two-echelon distribution system and provide an explicit cost function using a "top-down" approach.

4 - Fairness Aware Dynamic Ridesharing

Xinglu Liu, Tsinghua University, Shenzhen, China, Minghua Chen, Wai Kin (Victor) Chan

In this work, the utility of each rider is computed by a nonlinear function of multiple factors. We formulate the problem into a mixed nonlinear integer programming, then we reformulate the proposed model with column generation. The pricing problem is solved by a polynomial-time algorithm. For the master problem, we develop a polynomial-time approximation method. The numerical experiments are conducted based on the NYC trip record. Results reveal that the proposed approach improves fairness significantly.

5 - AM Challenges in the Industry 4.0 Era

Yober J Arteaga Irene, Tsinghua University, Shenzhen, China, Wai Kin (Victor) Chan

Additive Manufacturing (AM) technology could revolutionize the way industry makes products. However, there are still challenges that must be overcome since these are slowing down AM adoption by industry. Therefore, this research aims to uncover these limitations based on a systematic literature review. The findings show that there are five global challenges that AM is currently dealing with, technical aspects, supporting technologies, management of operations, supply chain configuration, and legal innovation.

■ VWA51

Virtual Room 51

Revenue/ Yield Management

Contributed Session

Chair: Weimar Ardila, University of South Florida, Tampa, FL, 33613-4027, United States

1 - Omni-channel Partnerships To Manage Consumer Returns

Tolga Aydinliyim, Associate Professor of Operations Management, Baruch College, CUNY, New York, NY, United States, Monire Jalili

Motivated by partnerships between online and B&M retailers where the online retailer operates a micro-store within the B&M store (e.g., Amazon within Kohl's), we study consumers' purchase and returns channel choices and induced B&M store customer traffic implications as well as when such partnerships are profitable for the involved parties.

2 - Assortment Decisions With All-at-once Returns And Heterogeneous Customers

Sahika Sahan, Olin Business School, Saint Louis, MO, United States, Jacob Feldman

In this paper, we study the assortment problem in a setting where heterogeneous customers can return the products that they ordered. We consider a fixed return cost across products per customer type. Each customer chooses to order a subset of offered products that maximizes her expected utility. Then, once the customer receives the products, she keeps the highest utility product and returns the rest. 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.

3 - Improving Underwriting With AI

Simona C. Milea, Student, Saint Joseph's University, Philadelphia, PA, United States

While the number of car accidents have declined since 1996, every day 30 people die as a result of a drunk driving accident, that is one person every 50 minutes. One reason the number of car accidents have decreased since 1996 is because of usage-based car insurance which promotes safe driving. People with UBI are rated on how they drive, so they drive safer to get cheaper insurance rates. UBI can help combat drunk driving accidents, similar to the way it has prevented so many car accidents from occuring. Current UBI programs use AI to track variables to rate a driver's driving. For my research I analyzed three different datasets to determine variables that could help insurers predict drunk driving accidents.

4 - Limiting Average Variance Of A Markov Decision Process With Randomized Rewards

Andrew Benton, Rutgers University, New Brunswick, NJ, United States

We study the variance of the sum of rewards of a Markov decision process over an infinite horizon, focusing on problems with randomized rewards. Since this value is generally divergent, we focus on the limiting average variance. Closed forms are provided for the limiting average variance of finite unichain Markov chains with randomized rewards. Sufficient conditions for the convergence of the multichain problem are also discussed. These results are then applied in an inventory control setting. Finally, we formulate a linear programming solution to select the policy with minimal variance among expectation-optimal policies.

5 - Strengthening The Resilience Of Seaport Terminals For Disruption Management

Weimar Ardila, University of South Florida, Tampa, FL, United States, Alex Savachkin, Devashish Das, Daniel Romero

The implementation of resilience strategies is essential to ensure the regular operation of supply chains. Nonetheless, many actions that can increase resilience conflict with traditional business goals. The main research objective is to propose an initial approach for a Markov Decision Process (MDP) formulation to enhance a system's response by minimizing the cost of implementing actions that can reduce a system's total recovery time. A testbed based on the seaport terminals operation in Barranquilla (Colombia) will be used to validate and assess this approach's performance.

■ VWA52

Virtual Room 52

Business Analytics for Disaster Management

Sponsored: Social Media Analytics

Sponsored Session

Chair: Alfonso Pedraza-Martinez, Indiana University

1 - Business Analytics For Disaster Management: Research Opportunities And Challenges

Alfonso J Pedraza-Martinez, Indiana University, Kelley School Of Bus. Bloomington, IN, 47405-5308, United States, Lu (Lucy) Yan, Yu Kan

We discuss the state of the art of academic and practitioner business-analytics applications for disaster management. In doing so, we identify opportunities for future research in this area. Moreover, we present an empirical application that exemplifies our proposed agenda.

2 - The Role Of Volunteer Experience On Performance On Online Volunteering Platforms

Gloria Urrea, University of Colorado Boulder, Boulder, CO, 80303-1154, United States, Eunae Yoo

Online volunteering platforms allow humanitarian organizations (HOs) to recruit volunteers to work remotely on projects. We investigate the relationship between volunteers' experience levels and two performance metrics on these platforms: project completion and volunteer retention. To test these relationships, we collected a novel panel dataset from the Humanitarian OpenStreetMap Team Tasking Manager, on which volunteers contribute to mapping projects. Our dataset includes 5,162 online volunteering projects with 2,169,683 contributions by 96,450 volunteers. The results of our econometric analyses shed light on online volunteer management and offer operational insights for HOs as well as for online volunteering platforms.

3 - Does Gender Shape Organizers' Charitable Crowdfunding Success?

Kristin Kelley, Research Fellow, WZB Berlin Social Science Center, Berlin, Germany, Jorge Mejia, Alfonso J. Pedraza-Martinez

Men raise more money for entrepreneurship on crowdfunding platforms due to their higher status. The perception that women are better at promoting the welfare of others should offset men's advantages in communal, female-dominated contexts like charitable crowdfunding. We analyze data from 120,677 charitable crowdfunding campaigns to examine this possibility.

4 - Inventory Pre-positioning Decision Support For Humanitarian Relief In Nepal

Jason Acimovic, Penn State University, University Park, PA, United States

Humanitarian organizations typically work independently to pre-position stock in countries in preparation for a disaster. This lack of coordination leads to gaps and overlaps. Working with the Emergency Supply Prepositioning Strategy Group (ESUPS), we utilize inventory data they collected from various NGOs working in Nepal to formulate and solve an optimization problem suggesting where inventory should go. From this, we and ESUPS developed a decision support tool to help guide local NGOs working in Nepal. We will talk about the experience of implementing optimization problem solutions in actual humanitarian organizations, and the status of the project.

■ VWA53

Virtual Room 53

Crowdfunding and Platform Economics in Social Media

Sponsored: Social Media Analytics

Sponsored Session

Chair: Zhen Fang, University of Washington, Seattle, WA, 98105, United States

1 - Bargaining-based Subsidy Payment Negotiations In Sponsored Data Programs

Jialin Song, Microsoft, Redmond, WA, 61801, United States, Qiong Wang

Major Mobile Service Providers (MSPs) in U.S. have all introduced sponsored data programs that allow Content Providers (CPs) such as Facebook and Youtube to subsidize the data usage by consumers. The MSP and CP may need to negotiate the subsidy payment based on specific negotiation mechanism. We develop a model-based study to analyze different negotiation schemes. Specifically, we apply Nash bargaining theory to model the negotiation between a monopoly MSP and a set of CPs under the one-to-many bargaining framework. We analyze and compare two bargaining protocols: we build a multi-stage optimization model to solve the sequential bargaining problem; and apply Nash-in-Nash solution to solve the simultaneous bargaining problem. Our results show that the bargaining outcome leads to different welfare consequences under different bargaining protocols.

2 - Business Practice Of Social Media - Platform And Customer Service Adoption

Yang Gao, University of Rochester, Rochester, NY, 14611, United States, Shujing Sun, Huaxia Rui

Based on the full trajectory of 274 international airlines on Twitter, we propose a two-stage model to estimate the key drivers in the adoption of the platform and customer service on social media. Regarding peer influence, we show that firms pay close attention to their peers' moves and act correspondingly, as a firm is more likely to adopt the technology when the extent of peers' adoption increases. We also find evidence of knowledge spillover across firms, where firms are attracted by positive consumer voices but discouraged by negative voices following peers' adoptions. Regarding consumer pressure, we find that higher volume and sentiment directed at the firm itself positively contribute to both adoptions. While firms equally value positive and neutral voices in the platform adoption, only positive voices significantly contribute to customer service adoption.

3 - More Than Double Your Impact: An Empirical Study Of Match Offers On Charitable Crowdfunding Platforms

Zhen Fang, University of Washington, Seattle, WA, 98105, United States, Xue Tan, Shengsheng Xiao, Yong Tan

To promote charitable giving, charitable crowdfunding platforms adopted match offers, whereby leadership donors match the others' donations at a given rate. Our study seeks to understand how the suppliers (donors) evaluate projects with and without match offers differently, especially varying with their donation experience, and how the demanders (fundraisers) react to match offers. At an individual level, we find that, on average, donors derive a higher utility toward matched projects. Warm-list donors are three times more likely to contribute to matched projects, while cold-list donors are twice more likely to do so. New donors prefer unmatched projects. The market-level analysis shows that increasing the matched project ratio benefits both sides of the market. Our work connects micro-level and macro-level to disentangle the impact of match offers systematically.

■ VWA54

Virtual Room 54

Operations Research & Vulnerable Populations

Committee Choice: Public Sector OR

Committee Choice Session

Chair: Kayse Lee Maass, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Yaren Bilge Kaya, Northeastern University, Boston, MA, 02130-0000, United States

1 - Designing Policies For Allocating Housing To Persons Experiencing Homelessness

Bill Tang, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos, Cagil Kocyigit

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. We evaluate it on synthetic and real-world Homeless Management Information System data to illustrate practical usage of our methodology.

2 - Analytics To Improve The United States Immigration System

Geri Louise Dimas, PhD Candidate, Worcester Polytechnic Institute, Worcester, MA, 01602-1915, United States, Andrew C. Trapp, Renata Alexandra Konrad, Adam Ferrarotti

The United States immigration court system is extremely backlogged with 1.3 million cases waiting to be heard. Due to large influxes of immigrants together with limited design and resources, the court system struggles to manage this growing backlog, resulting in delays that unnecessarily tax governmental and community resources. We explore the intricacies of the court system, deconstructing different elements and their respective complexity through discrete event simulation. We study possible improvements to the simulated system by adjusting its properties, such as the assignment of cases to judges, queuing discipline, hearing medium (in person, or remote), and priority queues.

3 - Reducing Vulnerability To Human Trafficking By Improving Access To Housing And Support Services

Yaren Bilge Kaya, PhD Candidate, Northeastern University, Boston, MA, 02130-0000, United States, Kayse Maass, Renata Alexandra Konrad, Andrew C Trapp, Geri Dimas

Exposure to trauma, violence, and substance use, coupled with a lack of community support services, puts runaway and homeless youth at high risk of being trafficked. Access to safe housing and supportive services such as healthcare and education is known to be an effective answer to youth's vulnerability towards exploitation. However, in most communities in the U.S. the number of youths experiencing homelessness exceeds the capacity of the housing resources available. This study involves primary data collection and an integer linear optimization model to project the collective capacity required by service providers to adequately meet the needs of these vulnerable youth in NYC.

■ VWA55

Virtual Room 55

OR/MS and the Public Sector II

Contributed Session

Chair: Benjamin Lewis

1 - Operational Cost Savings From On-site Forensic Evidence Identification

Jamie R. Wieland, Associate Professor, Illinois State University, Normal, IL, United States, C. C. Mulligan, M. Gizzi

Forensic backlogs in the criminal justice system are indicative of the need for efficient methods for identification of evidence. New technologies show promise in meeting this need, with the capability to quickly identify evidence directly at the crime scene, eliminating the need for samples to be sent to off-site laboratories for evidence confirmation. Simulation is used to develop a fiscal impact model to estimate the operational costs associated with on-site evidence screening. Sensitivity analyses were conducted to determine which input variables most impacted cost per sample. Overall, significant cost-savings are associated with on-site identification of forensic evidence.

2 - Decision Support On Road Resurfacing Under Maintenance Cost Uncertainty

Zhuoyi Zhao, Iowa State University, Ames, IA, United States, zyzhao@iastate.edu, John Jackman, K. Jo Min

The maintenance cost of an asphalt road has been increasing on average and fluctuating over time. The decision-maker has an option to resurface the road after which the road condition is like new. In this paper, assuming the maintenance cost follows a geometric Brownian motion process and is reset to the initial value upon resurfacing, we model and analyze resurfacing decisions from a real options perspective leading to optimal threshold maintenance costs and expected duration until resurfacing. We also investigate how key factors such as volatility impact the resurfacing decision through numerical examples. Finally, managerial insights and economic implications are provided.

3 - Inmate Overcrowding And Prison Operations: A Review

Ben Lewis, Research Fellow, University of Michigan, Ann Arbor, MI, United States

Overcrowding has been an ongoing issue in federal and state prisons for decades, and many US prisons are still operating over capacity despite efforts to reduce prison populations in the wake of COVID-19. This systematic literature review aims to 1) highlight the individual, group, and societal impacts of inmate overcrowding, 2) illustrate the current landscape of prison operations literature, and 3) identify optimization approaches that could reduce overcrowding in prisons. Co-citation analysis suggests that overcrowding generally has negative impacts on prisoners and prison operations and that assignment and queuing approaches are best suited for minimizing prison populations.

■ VWA56

Virtual Room 56

SpORts V

Sponsored: spORts

Sponsored Session

Chair: Raymond Stefani, California State University, Long Beach, 25032 Via Del Rio, Lake Forest, CA, 92630-2633, United States

1 - Analyzing Home-Field Advantage Using COVID-19 Athletic Events

Elliott Tranter, Georgia State University, Atlanta, GA, United States, Frank Lee

Researchers across various areas have studied the home-field advantage in athletics and proposed numerous conceptual models. Previous research has primarily focused on particular events at particular times and identifying potential causes of the effect. This study aims to find the existence of the home-field advantage and determine the magnitude of this effect using the data from the recent COVID-19 athletic events played without an audience.

2 - The True Meaning Of The Olympic Motto Citius, Altius, Fortius Is Not That Records Have Been Broken, But How They Were Broken

Raymond Stefani, Professor Emeritus, California State University, Long Beach, CA, United States

At an Arcueil, France sports assembly in 1891, Father Henri Didon spoke what was to become the Olympic motto, Citius, Altius, Fortius. Following the true meaning of what Didon said, each set of young athletes enters sports under the prevailing conditions of their time and each athlete then tries to run faster, jump higher and become stronger than that athlete had done before. Simply trying to improve was Didon's mantra. The best of them do compete on sports teams, the best of them do compete on Olympic teams and the best of them do set records. Figures showing the accumulated improvement of Olympic male and female champions in throwing, swimming, jumping and running demonstrate the legacy of Didon's mantra.

■ VWA57

Virtual Room 57

Valuing External and Collaborative Innovation

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

Chair: Jochen Schlapp, Frankfurt School of Finance & Management gGmbH, Frankfurt Am Main, 60322, Germany

1 - Leveraging The Potential Of Outsourcing And Offshoring In Complex Product Development

Ole Frauen, Volkswagen AG, Okerstr. 15, Wolfsburg, 38100, Germany, Arnd H. Huchzermeier, Jurgen Mihm

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 conducted 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.

2 - An Entrepreneur's Innovation Dilemma: Learning-financing Tradeoff At Lean Startups

Onesun Steve Yoo, University College London, London, United Kingdom, onesun.yoo@ucl.ac.uk, K Sudhir

Using a Bayesian learning model of lean startup and a Nash bargaining game between the investor and entrepreneur, this paper examines entrepreneur's trade-off between optimizing learning for the startup's success relative to the need to convey market potential by producing observable success signal for early-stage investors. We find that depending on the entrepreneur's relative bargaining position, the entrepreneur may distort product development downwards or upwards to sacrifice learning relative to the one prescribed in the Lean startup method. The two types of distortions differently impact the innovation efficiency and innovation output. We examine how they could be mitigated and collectively improve the innovation economy.

3 - Optimal Presentation Of Alternatives

Zeya Wang, Georgia Institute of Technology, Atlanta, GA, United States, Morvarid Rahmani, Karthik Ramachandran

In many contexts such as healthcare, knowledge outsourcing, or product design and development, a provider may have multiple alternatives that could potentially solve the client's problem. A key decision for the provider is: how to present these alternatives to a client? In this paper, we develop a game-theoretic model where the provider chooses which alternative to present and in what sequence, and the client chooses which alternative to implement. We characterize the optimal strategies for the provider in equilibrium to determine which alternative the provider should offer and when to offer it. We study the effects of implementation ability, asymmetric implementation cost and correlation between options on these strategies.

4 - The Value Of Analytics Partnerships For Biopharmaceuticals

Niyazi Taneri, Cambridge Judge Business School, University of Cambridge Judge Business School, Tru, Cambridge, CB2 1AG, United Kingdom, Jiatao Ding, Michael Freeman

Through partnerships for analytics, biopharmaceutical firms aim to gain complementary capabilities and streamline their operations—e.g. improve the selection of drug candidates and speed up the drug development cycle. In an industry with notoriously low success rates and a patent cliff, improvements on these fronts translate to more products with longer periods of on-patent sales. We study the shareholder value implications of such partnerships and provide insights on when those partnerships add the most value.

■ VWA58

Virtual Room 58

Transportation-Operations III

Contributed Session

Chair: Ying Lian, Antwerpen, 2000, Belgium

1 - Transit Network Design With Passenger Assignment Constraints

Pramesh Kumar, University of Minnesota-Civil Egineering, Minneapolis, MN, United States, kumar372@umn.edu, Alireza Khani

The research proposes a bi-level optimization model for designing an efficient transit network. It considers both passengers' and operator's perspectives when deciding where to locate transit routes and determining their optimal frequency. It captures user behavior through the optimal strategy transit assignment model at the lower level. The overall model is a mixed-integer non-linear program that is solved using Benders decomposition.

2 - Simulation-based Optimization For The Planning Of Electric Airport Shuttle Systems: Case Study In Dallas Fort Worth International Airport

Zhaocai Liu, Postdoctoral Researcher, National Renewable Energy Laboratory, Lakewood, CO, United States, Qichao Wang, Devon Sigler, Andrew Kotz, Monte Lunacek, Caleb Phillips

To help operators of airport shuttle systems effectively deploy electric buses, this study proposes a simulation-based optimization modeling framework. An event-driven simulation model is first developed to evaluate the performance of an electric airport shuttle system from detailed day-to-day operations. A simulation-based optimization model is then proposed to determine the design of battery and charger for the bus system. A genetic-algorithm-based solution procedure is also proposed to effectively obtain near-optimal solutions. Based on a shuttle system at the Dallas Fort Worth International Airport, the proposed modeling framework is demonstrated with extensive numerical studies.

3 - Designing A MATSim Environment For A One-way Car Sharing System As A Transport Mode

Selin Ataç, EPFL, Lausanne, Switzerland, Nikola Obrenovi, Michel Bierlaire

Car sharing (CS) services have become popular due to their financial and environmental benefits. The CS operators have offered flexibility by allowing one-way trips which resulted in vehicle imbalance in the service area. They have then introduced rebalancing operations to reduce the imbalance thus, to increase the level of service. Since it is exhausting to collect the data to develop a demand model, this work makes use of the agent-based simulation MATSim in a one-way CS system. The results are used to explain the relation between the city structure, demand structure and the different rebalancing strategies.

4 - Mixed-integer Linear Programming (milp) Formulation For A Mast System

Reza Shahin, PhD candidate, University of Gustave Eiffel, villeneuve d'ascq, France, Pierre Hosteins, Pierre-Olivier Vandanjon, Paola Pellegrini

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. In this area, the system provides an on-demand service. We use Mixed-Integer Linear Programming to tackle the MAST system and consider often neglected realistic constraints, as those linked to vehicle capacity and fleet availability. We perform a sensitivity analysis to understand how the system performance varies as a result of changing client priorities.

5 - On-demand Bus Routing Problem With Prepositioning Under Stochastic And Dynamic Requests

Ying Lian, University of Antwerp, Antwerp, Belgium, Flavien Lucas, Kenneth Sörensen

The On-Demand Bus Routing Problem (ODBRP) is defined as large-scale dial-a-ride problem with bus stop selection, and each passenger can have alternative stops to board and alight. Contrary to dynamic ODBRP where buses are only dispatched to received requests, we also consider sending buses to potential ones, if the expected number of served requests are higher. A metaheuristic algorithm solves this problem, and experimental results with artificial data show the superiority of prepositioning under dynamic and stochastic requests.

■ VWA59

Virtual Room 59

Military Applications

Contributed Session

Chair: Vicky H Mak-Hau, Deakin University, Melbourne, 3125, Australia

1 - Optimization In Medium-term Planning For Military Aircraft Maintenance

Sergio Rebouças, Brazilian Air Force, Sao Jose dos Campos, Brazil, Dennys Wallace Imbassahy, Fernando Teixeira Abrahão

The assignment of military aircraft must be closely linked to the fleet maintenance plan. Optimization of maintenance activities and resources is crucial to maximize fleet availability and minimize the costs of air operations. Current optimization models generalize critical constraints that make their application in real-life difficult. This work proposes a new approach to medium-term optimization planning for military aircraft maintenance. Innovative constraints are defined and implemented through the Biased Random-Key Genetic Algorithm for optimization of the fleet maintenance plan, improving the model's adherence to the operational context.

2 - The Multiphase Course Timetabling Problem
Vicky H. Mak-Hau, Deakin University, Melbourne, Australia, Rasul Esmaeilbeigi, John Yearwood, Vivian Nguyen

We present a new MILP formulation and solution method for solving a highly complex military training scheduling problem. A lesson may require simultaneously a student from two or more different syllabi, along with an available instructor with minimum lesson specific qualifications. The constraints are imposed on students, instructors and resources. Lessons are broken down into four phases each potentially requiring different physical and human resourcing. In addition, a subset of lessons, when scheduled to occur consecutively, can achieve efficiencies in instructor utilisation by having combined preparation, briefing and debriefing times for the respective lessons and students.

■ VWA60

Virtual Room 60

Marketing II

Contributed Session

Chair: Tsutomu Sunaga, Kwansei Gakuin University, Hyogo, 662-8501, Japan

1 - Executives Social Media, Employee Organizational Identification And Customer Satisfaction: A Small-world Network Perspective
Giovanni Visentin, PhD Candidate, ESCP Business School, Paris, France, Fabrizio Zerbini, Sandrine Macé

Recent work subscribes to the view that top executives can use social media to better engage with employees and customers. However, most executives fear that online approachability may present cyber security threats and increase their job demands. Integrating social networks into organizational identification and customer-orientation theorizing, this study identifies the benefits that compensate for the risks of greater online approachability. Empirical analysis of a sample of CEOs that use Twitter reveals that small-world network exchanges increase employee organizational identification and, through that, customer satisfaction.

2 - Context Effects In Crossmodal Associations Between Music And Fine Art Paintings: Influences Of Initial Musical Pitch On Subsequent Perceptions And Associations
Tsutomu Sunaga, Kwansei Gakuin University, Hyogo, Japan, Mime Yabuno, Naoto Onzo

Despite most sensory information being received sequentially, little research on crossmodal correspondence has taken this context into account. Our study bridges this gap by investigating how initial exposure to relatively high-/low- frequency music affects consumers' crossmodal associations between subsequent music and fine art paintings. The results have demonstrated that participants first presented with high- (vs. low-) frequency music are more likely to perceive the subsequent music as matching cool, dark, and abstract paintings. We uncovered that the association with "spatial descending" mediated this process.

■ VWA62

Virtual Room 62

Emerging Traffic Management Techniques in Manned and Unmanned Aviation System

Sponsored: Aviation Applications

Sponsored Session

Chair: Ang Li, University of California-Berkeley, Berkeley, CA, 94720-2392, United States

1 - Trajectory Planning For Mission Survivability Of Autonomous Vehicles In Moderately To Extremely Uncertain Environments
Fanruiqi Zeng, Georgia Institution of Technology, Atlanta, GA, United States, Husni R. Idris, John-Paul Clarke

In this work, we propose a receding horizon control strategy with novel trajectory planning policies that enable dynamic updating of the planned trajectories of autonomous vehicles operating in environments where potential conflicts are, from a statistical perspective, either partially known or completely unknown. The proposed policies utilize two metrics: (1) the number of feasible trajectories; and (2) the robustness of the feasible trajectories. We measure the effectiveness of the suggested policies in terms of mission survivability. Our findings have significant implications for achieving safe aviation autonomy.

2 - Miles-in Trail Restrictions and Aviation System Performance: Chicago O'Hare Case Study
Ke Liu, PhD Candidate, UC Berkeley, Berkeley, CA, United States, Mark M. Hansen

This paper focuses on the improvement opportunities from the reduction of Miles-in-Trail(MIT). We design a model including estimation of planned arrival time and deterministic queuing diagram to assess the impacts of an MIT or a set of MITs. Our model is applied to ORD of 2018 as a case study. As results show, if all ORD-sourced MITs were eliminated, the overall queueing delay would increase by 3.3 hr per day on average while arrival delay would decrease by 14.7 hr per day. We found ORD during 8-9, 11-12 and 17:30-18:30 tends to experience more throughput loss when implementing MITs and those delayed flights are allocated into 9-10, 12-13 and 18:30-19:30 respectively. Our results strongly suggest that ORD-sourced MITs, while relieving some build-up of flights in the ORD terminal area, do so at a substantial penalty in the form of increased arrival delay and throughput shortfalls.

3 - Optimization Models For Flights Arrival Scheduling Incorporating Carrier Preferences
Yeming Hao, University of Maryland-College Park, 4326 Rowalt Dr Apt 201, College Park, MD, 20740-3161, United States, David J Lovell, Michael O. Ball, Sergio Torres

This study presents results of a simulation of strategies to incorporate business-driven airline preferences in Time-based Flow Management metering operations. Traffic flow systems that balance demand versus capacity at airports assign Controlled Times of Arrival (CTAs) to incoming flights. We evaluate optimization models and heuristics to assign these CTAs based on user-provided information and priority preferences in a way that minimizes the total CTA delay cost. We quantify potential savings by comparing the results with the default first-come-first-served (FCFS) scheme. Simulations under a variety of realistic scenarios show that our proposed heuristic could reduce CTA delay costs between 20% and 30% relative to the FCFS baseline scheme.

4 - Capacity-aware Traffic Flow Management For Urban Air Mobility Operation
Jungwoo Cho, Postdoctoral fellow, Korea Advanced Institute of Science and Technology, Daejeon, Korea, Republic of, Yoonjin Yoon

In urban areas where UAM demand is expected to be concentrated, the risk of contact between aircraft can frequently be at the highest level. To minimize such risk, there needs strategic planning to redirect traffic to lower-density or less-congested airspace. This study proposes a new approach that keeps traffic levels in urban airspace below the desired threshold while minimizing the total distance traveled by all aircraft. We first assume airspace is composed of hexagonal spatial units and then allocate a sequence of spatial units that each aircraft can reserve and use to avoid regions with expected traffic above specified thresholds. In doing so, we generate initial paths for all participating aircraft, calculcate the estimated occupancy of spatial units, and redirect traffic via delayed departure or rerouting.

5 - Using Flight Shifting to Mitigate Delay in Multiple Airport Regions
Ang Li, University of California-Berkeley, Berkeley, CA, 94720-2392, United States, Mark M. Hansen, Bo Zou

This study aims to improve operational performance of a multiple airport region (MAR) by analyzing interdependent capacity scenarios of that MAR airports and redistributing airport traffic to make more efficient use of the available capacity. We identify MARs based on temporal distance between airports. Capacity interdependence in MAR is demonstrated by conducting clustering analysis on daily capacity profiles. Flight shift models are proposed in both tactical and strategic levels to reduce flight delays of all flights serving airports in the same MAR. Results show that by rescheduling flight landing airport and landing time, the total flight delay in the New York MAR could be significantly reduced in both models.

■ VWA63

Virtual Room 63

Distributed Algorithms for Power System Operations I

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Kibaek Kim, Argonne National Laboratory, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - Leveraging GPU Batching For Scalable Nonlinear Programming Through Massive Lagrangian Decomposition

Youngdae Kim, Argonne National Laboratory, Lemont, IL, 60657-5499, United States, François Pacaud, Kibaek Kim, Mihai Anitescu

We present the implementation of a trust-region Newton algorithm ExaTron.jl for bound-constrained nonlinear programming problems, fully running on multiple GPUs. ExaTron solves a batch of the problems by employing a vast number of thread blocks on GPUs. Without data transfers between CPU and GPU, our implementation has achieved the elimination of a major performance bottleneck under a memory-bound situation, particularly when solving many small problems in batch. We discuss the design principles and implementation details for our kernel function and core operations. By using the application of distributed control of alternating current optimal power flow, we show that parallel computational performance of ExaTron scales linearly with respect to the batch size and the number of GPUs and outperforms performance on a single-core CPU by up to two orders of magnitude.

2 - On The Tightness And Scalability Of The Lagrangian Dual Bound For The Alternating Current Optimal Power Flow Problem

Weiqi Zhang, University of Wisconsin-Madison, Madison, WI, United States, Kibaek Kim, Victor Zavala

We study tightness and scalability properties of a Lagrangian dual (LD) bound for the nonconvex alternating current optimal power flow (ACOPF) problem. We show that the LD bound is as tight as that provided by the powerful and popular semidefinite programming relaxation. However, a key advantage of the proposed bound is that it can be computed in a parallel, decentralized manner. Specifically, in the proposed approach we partition the network into a set of subnetworks, we dualize the coupling constraints (giving the LD function), and we maximize the LD function with respect to the dual variables of the coupling constraints (giving the desired LD bound). The dual variables that maximize the LD are obtained by using a bundle method and we provide a proof of convergence for such method.We demonstrate our developments using PGLib test instances.

3 - A Privacy-preserving Distributed Control Of Optimal Power Flow

Minseok Ryu, Argonne National Laboratory, 1205 Beal Avenue, Lemont, IL, 48109-2117, United States, mryu@anl.gov

We consider a distributed optimal power flow formulated as an optimization problem that maximizes a non-differentiable concave function. Solving such a problem by the existing distributed algorithms can lead to data privacy issues because the solution information exchanged within the algorithms can be utilized by an adversary to infer the data. To preserve data privacy, in this paper we propose a differentially private projected subgradient (DP-PS) algorithm that includes a solution encryption step. We show that a sequence generated by DP-PS converges in expectation, in probability, and with probability 1. Moreover, we show that the rate of convergence in expectation is affected by a target privacy level of DP-PS chosen by the user. We conduct numerical experiments that demonstrate the convergence and data privacy preservation of DP-PS.

4 - Machine Learning For Distributed Power Systems

Mathieu Tanneau, ISyE Georgia Tech, Atlanta, GA, United States, Pascal Van Hentenryck, Terrence W. K. Mak, Minas Chatzos

This presentation considers distributed algorithms for optimal power systems, one of the fundamental problems in energy systems. It presents a machine-learning approach that has the potential to speed-up distributed (ADMM) algorithms significantly. Results on large test cases with thousands of buses will be presented and highlight how the potential benefits of machine-learning to improve the convergence speed of ADMM algorithms. Limitations of the approach and future research directions will also be discussed.

5 - Evaluating The Performance Of Distributed Optimization Algorithms With Nonideal Data Sharing

Mohannad Alkhraijah, Georgia Institute of Technology, Atlanta, GA, United States,

Distributed optimization allows independent power systems with local controllers to cooperatively solve an optimization problem by sharing the computation results through an iterative process. Data quality plays a major role in the performance of distributed algorithms as the independent systems continuously share the results of their computations. We investigate the impacts of different data quality issues due to communication errors and malicious attacks on the performance of distributed optimization algorithms in the context of DC Optimal Power Flow (DC OPF) problem. We compare and characterize the performance of three distributed optimization algorithms in terms of their convergence rates and solution quality with different communication noise models. We also investigate the impact of targeted attacks on the shared data and propose a detection method.

■ VWA64

Virtual Room 64

Advances in Discrete Optimization and Machine Learning

Sponsored: Opt/Machine Learning

Sponsored Session

Chair: Hussein Hazimeh, Massachusetts Institute of Technology, Cambridge, MA, 02139-4850, United States

1 - Tightened Single-neuron Relaxations For Neural Network Verification

Juan Pablo Vielma, Google, Cambridge, MA, 02142-1508, United States, Ross Anderson, Christian Tjandraatmadja, Will Ma, Krunal Patel, Joey Huchette

We improve the effectiveness of propagation- and linear-optimization-based neural network verification algorithms with a new tightened convex relaxation for ReLU neurons. While our description of the relaxation may require an exponential number of inequalities, we show that they can be separated in linear time and hence can be efficiently incorporated into optimization algorithms on an as-needed basis. Based on this relaxation, we design two polynomial-time algorithms for neural network verification: a linear-programming-based algorithm that leverages the full power of our relaxation, and a fast propagation algorithm that generalizes existing approaches. In both cases, we show that for a modest increase in computational effort, our strengthened relaxation enables us to verify a significantly larger number of instances compared to similar algorithms.

2 - Duality And Meaning In Computation

Ted K Ralphs, Lehigh University, Industrial And Systems Engineering, Bethlehem, PA, 18015-1518, United States

In this talk, we discuss notions of duality arising in algorithms for discrete optimization and machine learning problems and explore how such notions are related. We then describe how these notions can be exploited to better interpret the results of computations. The specific application we have in mind is explainability in machine learning, but the concepts apply more broadly.

3 - Binary Matrix Factorisation Via Column Generation

Reka Agnes Kovacs, University of Oxford, Oxford, United Kingdom, Oktay Gunluk, Raphael Hauser

Identifying discrete patterns in binary data is an important dimensionality reduction tool in machine learning and data mining. In this talk, we consider the problem of rank-k binary matrix factorisation (BMF) under Boolean arithmetic: given a binary matrix X of dimension n x m and a fixed positive integer k, find two binary matrices A and B of dimension n x k and k x m such that the discrepancy between X and the Boolean product of A and B is minimum. We describe a novel mixed integer linear programming formulation with exponentially many variables and use column generation technique to solve its LP relaxation. The dual bound provided by our formulation is stronger than the bound given by previously available models for BMF. Experimental results on real world datasets demonstrate that our proposed method is effective at producing highly accurate factorisations.

4 - Ecole: A Library For Learning Inside Milp Solvers

Antoine Prouvost, Polytechnique Montréal, Montreal, QC, H3C 3A7, Canada, Justin Dumouchelle, Maxime Gasse, Didier Chételat, Andrea Lodi

We describe Ecole (Extensible Combinatorial Optimization Learning Environments), a library to facilitate integration of machine learning in combinatorial optimization solvers. It exposes sequential decision making that must be performed in the process of solving as Markov decision processes. This means that, rather than trying to predict solutions to combinatorial optimization problems directly, Ecole allows machine learning to work in cooperation with a state-of-the-art a mixed-integer linear programming solver that acts as a controllable algorithm. Ecole provides a collection of computationally efficient, ready to use learning environments, which are also easy to extend to define novel training tasks.

5 - Subset Selection: From Linear Models To Neural Networks
Hussein Hazimeh, Massachusetts Institute of Technology, Cambridge, MA, 02139-4850, United States

Subset selection is a fundamental concept in machine learning, which is commonly used to improve model interpretability. We present two scalable methods for subset selection in linear models and neural networks. Our first method solves the L0-regularized regression problem to global optimality through a tailored branch-and-bound (BnB) algorithm. Our BnB can scale to problems with ~ 10^7 features, more than 1000x larger than what is possible using Gurobi and MOSEK. Our second method is aimed at training neural networks under a cardinality constraint. We propose a new reformulation that converts the cardinality constrained problem to an equivalent unconstrained problem based on binary variables. By smoothing the binary variables, we demonstrate how the neural network can be efficiently trained using first-order methods while enforcing the cardinality constraint.

■ VWA65

Virtual Room 65

Decision Diagram Methods

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Andre Augusto Cire, University of Toronto Scarborough, Rotman School. Toronto, ON, M1C 1A4, Canada

1 - "ddo" a Fast and Efficient Framework for Solving Combinatorial Optimization Problems with ■ VM85-3
Virtual Room 85

Technology Showcase: Radical Simplification for the Creation of Optimization Models

Technology Showcase

1 - Radical Simplification for the Creation of Optimization Models
Segev Wasserkrug, IBM Reserach Lab, Haifa, Israel, Dharmashankar Subramanian

We will demonstrate a unique technology being developed by IBM to radically simplify and speed up the creation of optimization models. This is done through a combination of data driven and simplified modeling techniques, thereby also creating end-to-end data to decisions pipelines.When you interact with IBM, this serves as your authorization to INFORMS or its vendor to provide your contact information to IBM in order for IBM to follow up on your interaction. IBM's use of your contact information is governed by the IBM Privacy Policy

Branch-and-bound MDD
Xavier Gillard, Grad. Student, UC Louvain, Louvain-la-Neuve, Belgium

In this talk I will present you "ddo" a free fast and efficient framework for solving combinatorial optimization problems with branch-and-bound MDDs. To that end, we will start modelling well known problems (Knapsack, Travelling Salesman with Time Window a.k.a TSPTW). Once the basic are in place, we will discuss some performance strategies. In particular, we will see how to easily exploit the available hardware on your platform. We will also see how to boost the performance of the solvers though the introduction of problem specific knowledge in the form of a rough upper bound. Finally, I will present some numerical results comparing the performance of "ddo" and Gurobi on the resolution of MISP (Maximum Independent Set Proble), MCP (Maximum Cut Problem) and MAX2SAT (Maximum 2 Satisfiability). These results show the relevance of using ddo as it may significantly outperform MIP.

2 - DD-based Reformulation For A Class Of Combinatorial Bilevel Problems
Leonardo Lozano, University of Cincinnati, Carl H. Lindner Hall Cincinnati, OH, 45246-2310, United States, David Bergman, Andre Augusto Cire

We study a class of challenging discrete bilevel problems and propose a reformulation based on decision diagrams that results in a single-level mixed integer program (MIP). The decision diagrams are to provide a convex representation of the discrete follower problem which is then appended to the leader problem via KKT conditions. In contrast to previous approaches from the literature that reformulate bilevel problems as nonlinear single-level MIPs and often transform the resulting problem into a linear MIP usually via big-M formulations, our approach exploits the structure given by the decision diagrams to provide a linear reformulation, thus avoiding any linearization or big-M constraints. Computational experiments on a bilevel project selection problem shows that our approach greatly outperform two state-of-the-art bilevel algorithms from the literature.

3 - Improving Decision Diagram Relaxations For Sequencing Problems
Isaac Rudich, Polytechnique Montréal, Montréal, QC, H3G 1A3, Canada

Relaxations of multivalued decision diagrams (MDDs) are effective for improving methods of solving sequencing problems. To strengthen the bounds generated by MDD relaxations, we used multiple metrics to improve merge rules and encoded a restricted MDD into the relaxed MDD. We evaluated our approach by comparing its performance to previous work done by Cire and van Hoeve on variations of the traveling salesman problem (TSP), such as the asymmetric TSP, TSP with time windows, TSP with precedence constraints, and the sequence ordering problem.

■ VWA66

Virtual Room 66

Network Optimization: Network games

Sponsored: OPT/Network Optimization

Sponsored Session

Chair: Tarannum Nisha, University of British Columbia, Vancouver, BC, V6R 1S9, Canada

1 - Network Connectivity Game
Darko Skorin-Kapov, Professor, R. B. Willumstad School of Business, Adelphi University, Garden City, NY, United States, Jadranka Skorin-Kapov

We investigate the cost allocation strategy associated with the problem of providing service between all pairs of network nodes. There is a cost associated with each link and the communication between any pair of nodes can be delivered via paths connecting those nodes. A cost efficient solution which provides service for all node pairs is a (non-rooted) minimum cost spanning tree. The cost of such a solution should be distributed among users (node pairs) who might have conflicting interests. The objective of this paper is to formulate the above cost allocation problem as a cooperative game, to be referred to as a Network Connectivity (NC) game, and efficiently find some core cost allocations.

2 - Decentralized Fictitious Play In Near-potential Games With Time-varying Communication Networks
Sarper Aydin, Texas A&M University, College Station, TX, United States, Sina Arefizadeh, Ceyhun Eksin

We study the convergence properties of decentralized fictitious play (DFP) for the class of near-potential games where the incentives of agents are nearly aligned with a potential function. Agents share information only with their current neighbors in a sequence of time-varying networks, keep estimates of other agents' empirical frequencies, and take actions to maximize their expected utility functions computed with respect to the estimated empirical frequencies. We show that empirical frequencies of actions converge to a set of strategies with potential function values that are larger than the potential function values obtained by approximate Nash equilibria of the closest potential game.

3 - A Game Theoretic Model For Strategic Coopetition In Business Networks
Segev Wasserkrug, IBM Research Lab, Haifa, Israel, Eitan Farchi, Nimrod Megiddo

Multi enterprise business networks, such as supply chain and transportation networks, are prevalent in today's world. Such networks combine both cooperative and competitive aspects: enterprises simultenously cooperate so as to obtain value beyond what each company can obtain on its own and compete to divide this value. We present a generic game theoretic characterization of such networks and demonstrate theoretical results defining the interplay between cooperation and competition in these networks. In addition, by building on results on stability in business networks (Ostrovsky, Hatfield et. al.) we show how such stable networks can be formed while maximizing the network value.

4 - Greedy Algorithms To Maximize Anti-coordination In Network Games
Soham Das, Texas A&M University, College Station, TX, United States, Ceyhun Eksin

In an anti-coordination network game, players are encouraged to differentiate their actions from their neighbors. Since, despite incentives, selfish agents may fail to do so, our goal is to eliminate all active coordination links by controlling a minimum set of players. We motivate the problem by an epidemic game where people (healthy and sick) decide to take the costly action, e.g. taking protective measures vs. free riding. The player selection problem is combinatorial with a submodular objective. Hence, we consider greedy algorithms that exploit behavior cascades on the network. Numerical experiments show that the greedy algorithms are near optimal and outperform centrality based heuristics.

5 - A Bilevel Programming Framework for Joint Edge Sertive Placement and Pricing

Tarannum Nisha, University of British Columbia, Vancouver, BC, Canada, Duong T. Nguyen, Vijay K. Bhargava

Due to the heterogeneity and limited capacities of edge resources, it is important to address the joint pricing and service placement problem in edge computing. To this end, we propose a bilevel optimization model where the edge infrastructure provider is the leader while each service is a follower. Given the resource pricing and provisioning decisions computed by the leader, the followers optimize their resource procurement and workload allocation strategies. We customize the column-and-constraint generation from robust optimization literature to solve the proposed integer bi-level model. Our model not only maximizes the profit of the provider but also minimizes the cost for every service.

■ VWA67

Virtual Room 67

Nonlinear Optimization in Cybersecurity

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Abdullah Al Omair, Ohio State Univ., Athens, OH, 45701-9291, United States

Co-Chair: Theodore T. Allen, Ohio State University, Columbus, OH, 43210-1271, United States

■ VWA68

Virtual Room 68

Advances in Derivative-Free Optimization II

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Lindon Roberts, The Australian National University

1 - A Progressive Barrier for Constrained Derivative-Free Multiobjective Optimization

Ludovic Salomon, Polytechnique Montreal, Montréal, QC, Canada, Sebastien Le Digabel, Jean Bigeon

The last decade has seen the development of new efficient convergent-based derivative-free and blackbox optimization algorithms for multiobjective optimization, most of them extensions of reliable single-objective methods. However, very few have been designed to take into account inequality blackbox constraints. This work presents an extension of the single-objective blackbox Mesh Adaptive Direct Search (MADS) algorithm with the progressive barrier to multiobjective blackbox optimization. It integrates the knowledge of inequality constraints. Numerical experiments on synthetic benchmarks and engineering applications show that this new method is competitive according to other state-of-the-art algorithms.

2 - Derivative Free Optimizers For Noisy Intermediate Scale Quantum Devices

Juliane Mueller, Lawrence Berkeley National Lab, Berkeley, CA, United State, Wim Lavrijsen

We present a performance comparison of derivative-free optimization algorithms applied to noisy intermediate scale quantum (NISQ) devices. The optimization objective function is black-box, computationally expensive to evaluate, and contains noise. Although a wide variety of derivative-free optimizers exist, few of them can properly deal with noise and get stuck in noise-induced local optima. In this talk, we examine when these optimizers break down and how to potentially alleviate their drawbacks by coupling them with a first optimization phase that uses non-interpolating surrogate models to guide the search for promising regions in the parameter space from which well-established local search methods can be started. We present the results of numerical experiments conducted on two simulation applications.

3 - Convergence Analysis of a Trust-Region Method under Noisy Settings

Liyuan Cao, Lehigh University, Bethlehem, PA, 18015-3704, United States

The convergence of a trust-region method is analyzed under the assumption that the local approximation models and function evaluations are only accurate with a sufficiently high probability. The objective function is assumed to have Lipschitz continuous gradients but non-convex. Two different definitions of approximation models being accurate are studied, and under both definitions the number of iterations needed for the algorithm to find a solution with ϵ accuracy is shown to be bounded by $O(1/\epsilon^2)$ with high probability.

■ VWA69

Virtual Room 69

Theory and Applications on Stochastic Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Haoming Shen, University of Michigan,Ann Arbor, MI, 48105-2404, United States

Co-Chair: Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109-2117, United States

1 - Adjustable Distributionally Robust Optimization With Infinitely Constrained Ambiguity Sets

Zhi Chen, College of Business, City University of Hong Kong, Rm 7-270 Centre For Academic Exchange 81 Tat Chee, Kowloon, Hong Kong, Chin Pang Ho, Haolin Ruan

We study adjustable distributionally robust optimization problems over a class of ambiguity sets that involve infinitely many expectation constraints. We adopt the extended linear decision rule approach to progressively improve the approximation to these problems and thus we can iteratively obtain a better here-and-now decision. Numerical examples are presented to showcase possible applications.

2 - Tight Conic Approximations For Two-Sided Chance-Constrained Optimization

Abolhassan Fathabad, University of Arizona, Tucson, AZ, United States, Jianqiang Cheng, Kai Pan, Boshi Yang

In this talk, we focus on developing tight conic approximations for two-sided chance constrained (TCC) programs with an application to AC optimal power flow problem. We present an efficient second-order cone programming (SOCP) approximation of the TCC programs under Gaussian Mixture (GM) distribution. As compared to the conventional normality assumption for forecast errors, the GM distribution adds an extra level of accuracy representing the uncertainties. Moreover, we show that our SOCP formulation has adjustable rates of accuracy and its optimal value enjoys asymptotic convergence properties. Finally, we demonstrate the effectiveness of our proposed approaches with both real historical data and synthetic data on the IEEE 118-bus system.

3 - A Study On Distributionally Robust Chance Constraints

Ruiwei Jiang, University of Michigan, Ann Arbor, MI, 48109-2117, United States, Haoming Shen

In this talk, we present a study on distributionally robust chance constraints (DRCC). We consider models and solution algorithms for DRCC and demonstrate them in examples and numerical case studies.

4 - Chance-Constrained Set Covering With Wasserstein Ambiguity

Haoming Shen, University of Michigan - Ann Arbor, Ann Arbor, MI, 48105-2404, United States, Ruiwei Jiang

We consider a distributionally robust chance-constrained set covering problem with a Wasserstein ambiguity set. This model involves binary-valued uncertainty and binary decision variables, leading to an inherently different reformulation from most existing models. We provide an exact two-stage reformulation and derive two families of valid inequalities. Numerical studies based on randomly generated test instances and real-life applications show the effectiveness of our reformulation and valid inequalities.

■ VWA70

Virtual Room 70

Distributionally Robust Optimization

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Grani Adiwena Hanasusanto, The University of Texas at Austin, Austin, TX, 78712, United States

1 - Wasserstein Robust Support Vector Machines With Fairness Constraints

Yijie Wang, University of Texas at Austin, Austin, TX, United States, Viet Anh Nguyen, Grani Adiwena Hanasusanto

We propose a distributionally robust support vector machine with a fairness constraint that encourages the classifier to be fair in view of the equality of opportunity criterion. We use a type-∞ Wasserstein ambiguity set centered at the empirical distribution to model distributional uncertainty and derive an exact reformulation for the worst-case unfairness measure. We establish that the model is equivalent to a mixed-binary optimization problem, which can be solved by standard off-the-shelf solvers. We further prove that the expectation of the hinge loss objective function constitutes an upper bound on the misclassification probability. Finally, we numerically demonstrate that our proposed approach improves fairness with negligible loss of predictive accuracy.

2 - Two-stage Data-driven Distributionally Robust Optimization With Random Recourse
Xiangyi Fan, UT Austin, Austin, TX, United States

We study two-stage data-driven stochastic optimization problems with random recourse where the adaptive decisions are multiplied with the uncertain parameters in both the objective and the constraints. We propose a scalable approximation scheme via piecewise linear and piecewise quadratic decision rules. The emerging decision rule problems can be reformulated as exact copositive programs, which admit tractable approximations in semidefinite programming. To address the inefficiency of solving large-size semidefinite programs, we design a decomposition algorithm where smaller-size subproblems can be solved in parallel. We further establish the performance guarantees of the proposed scheme and demonstrate its effectiveness through numerical examples.

3 - First-order Methods For Distributionally-Robust MDPs
Christian Kroer, Columbia University, Mudd Hall 500 W 120th St, New York, NY, 10027-6623, United States, Julien Grand-Clement

Markov decision processes (MDPs) are known to be sensitive to parameter specification. Distributionally robust MDPs alleviate this issue by allowing for ambiguity sets which give a set of possible distributions over parameter sets. The goal is to find an optimal policy with respect to the worst-case parameter distribution. We propose a framework for solving Distributionally robust MDPs via first-order methods and instantiate it for several types of Wasserstein ambiguity sets. By developing efficient proximal updates, our algorithms achieve convergence rates that are significantly better than existing value iteration methods. Numerical experiments show that our algorithm is significantly more scalable than state-of-the-art approaches across several domains.

4 - Optimal Transport Based Distributionally Robust Optimization
Soroosh Shafieezadeh-Abadeh, ETH Zurich, Zurich, Switzerland, Liviu Aolaritei, Daniel Kuhn, John Lygeros, Florian Dorfler

We show that the ordinary use of the Wassersyein type-p distance in DRO problems is not suitable even for simple loss functions. We then propose an optimal transport based DRO approach with a general transportation cost. In this general setting, the new DRO problem can be viewed as a zero-sum game. We prove that this zero-sum game admits a Nash equilibrium. We then proceed and explore the relationship between the distributional robustness and its regularization effect. In particular, we establish a link between the DRO setting and the use of high-order variation regularization, and then, we propose a simple dual formulation of the DRO problem for the class of generalized linear models using techniques in nonconvex optimization. This formulation enables us to both analyze the equivalency between the distributional robustness and its implicit/explicit regularization effect.

5 - On Data-driven Prescriptive Analytics With Side Information: A Regularized Nadaraya-watson Approach
Grani A. Hanasusanto, The University of Texas at Austin, ETC 5.120, 204, Austin, TX, 78712, United States, Prateek Raj Srivastava, Chin Pang Ho

We consider the stochastic optimization problem with side information, which aims to minimize the conditional expected loss in the presence of observable exogenous covariates. In general, the joint distribution of the side information and the loss function is unknown. Instead, only historical data is available. We propose an approximation based on the Nadaraya Watson estimator and derive out-of-sample performance guarantees based on moderate deviations theory. Our analysis leads to a variance-based regularization scheme, which is generally non-convex. We adopt ideas from distributionally robust optimization to obtain equivalent tractable formulations. We present numerical experiments for portfolio optimization and newsvendor problems.

■ VWA73

Virtual Room 73

Manufacturing I

Contributed Session

Chair: Zhenzhen Yan, Michigan State University, Lansing, MI, 48910, United States

1 - Resource Allocation Of Inspections In Genetic Manufacturing Systems By Using MDP Approach
Mohammad Maydanchi, Auburn University, Auburn, AL, United States, Gregory T. Purdy, Daniel F. Silva

Genetic Manufacturing System (GMS) is a new type of manufacturing with a genetic construct as the final product. In GMS, like other manufacturing systems, having a defective outcome increases the cost and time of the operation. Mid-process inspection is used to check the quality, but the type and number of inspections could adversely affect the time and cost of the product. This work deploys a Markovian Decision Process (MDP) approach to indicate preferred inspection strategies to minimize the total cost and improve the quality based on the non-conforming rate of operations and Type I and Type II error rates.

2 - Robust, Anomaly Detection of Melt-Pool Monitoring using Convolutional LSTM Network for Laser Power Bed Additive Manufacturing Process
Jaehyuk Kim, PhD Student/Pohang University of Science and Technology, Pohang, Korea, Republic of,

Laser Powder bed fusion (LPBF) is a widely used method in additive manufacturing. Despite the advanced development of LPBF, stability of the LPBF and the quality of the built part have been continually issued. To evaluate the status of LPBF, anomaly detection using melt pool from melt-pool monitoring has been studied. However, in previous studies, a definition of the anomaly melt-pool is unclear, and there is a limitation that only the melt pools generated in specific process parameters can be detected. Therefore, we propose a robust method for anomaly detection of melt-pool monitoring using convolutional LSTM Network.

3 - Design Of A Make-to-order (MTO) Multiproduct Batch Plant With Non-dedicated Storage Tanks, Under The Restriction Of A Targeted Delivery Lead Time
Amy Van Meir, University of Antwerp, Antwerp, Belgium, Trijntje Cornelissens, Johan Springael

Most design models of multiproduct batch plants are based on costs, while also responsiveness is a strategic key performance indicator. A metric for responsiveness is the lead time between ordering and delivery of a customer order. We integrate the targeted delivery lead time in the design of a make-to-order batch plant. Since orders are stored until transported, both number and capacity of production and storage tanks are determined, while minimizing total cost. By using the targeted delivery lead time as a constraint, the influence on cost and plant design is analyzed. The mathematical model is solved by mixed integer linear programming techniques and metaheuristics for larger instances.

4 - Manufacturing Localization And Its Performance Implications: An Empirical Study In The Automotive Industry
Zhenzhen Yan, PhD Candidate, Michigan State University, East Lansing, MI, United States, Sriram Narayanan, Tobias Schoenherr, Sourish Sarkar

Literature on manufacturing relocation focuses on the decision drivers while the decision consequences are understudied due to the difficulty of data collection. This study contributes to this stream of literature by investigating the performance implications of manufacturing localization, firms' decision of relocating manufacturing activities closer to the target market. Specifically, we use the automotive industry as an empirical context and apply a causal estimation to a uniquely assembled dataset across recalls, inventory, and other industry-specific proprietary data compiled over a 20-year period. Our findings provide practical insights to firms that consider relocation.

■ VWA81

Virtual Room 81

Routing Problems in Urban Transportation and Logistics

Sponsored: TSL/Urban Transportation Planning and Modeling

Sponsored Session

Chair: Chiwei Yan, University of Washington Seattle, Seattle, WA, United States

Co-Chair: Yu Yang, University of Florida, Gainesville, FL, 32607-3510, United States

1 - An Efficient Adaptable Exact Solution Framework For The Capacitated Multi-trip Vehicle Routing Problem With Time Windows And Its Variants
Yu Yang, University of Florida, Gainesville, FL, 32607-3510, United States

We consider the capacitated multi-trip vehicle routing problem with time windows (CMTVRPTW), where vehicles are allowed to make multiple trips. The ability to perform multiple trips reduces the number of vehicles and drivers needed, thus, the operating costs for carriers. Nevertheless, CMTVRPTW is substantially more challenging to solve than the CVRPTW. To the best of our knowledge, all state-of-the-art exact methods struggle in solving Solomon instances with 50 customers. By contrast, our proposed efficient adaptable exact solution framework (EAESF) can solve All test instances with up to 70 customers to optimality and obtain a near-optimal solution with an average optimality gap less than 0.3% within a 3-hour time limit when there are 80 to 100 customers. The EAESF can be easily adapted to solve four CMTVRPTW variants and achieve exceptional performance.

2 - Trading Flexibility for Adoption: Dynamic versus Static Walking in Ridesharing

Julia Y Yan, University of British Columbia, Vancouver, BC, 02143-3569, Canada, Sebastien Martin

On-demand ridesharing aims to fulfill riders' transportation needs whenever and wherever they want. Although this service level is appealing for riders, overall system efficiency can improve substantially if riders are willing to be flexible. Riders' flexibility in time has previously been studied through time windows and rider queues; here, we explore riders' flexibility in space via walking to more accessible pickup locations. We discuss two possible ways of incorporating walking in ridesharing: dynamic walking, which jointly optimizes rider-driver assignment with rider pickup locations; and static walking, which communicates a predetermined pickup location to the rider, and then optimizes rider-driver assignment. On its surface, dynamic walking appears to be the gold standard; the flexibility of optimization as compared to the restriction of a predetermined pickup location makes the viability of static walking far from a foregone conclusion. However, we find that static walking performs surprisingly competitively with dynamic walking: on Lyft data in Manhattan,we found static pickup locations that achieved up to 94-95% of the value of dynamic walking. Static walking can therefore overcome dynamic walking's advantages with just a modest relative increase in rider adoption of as low as 5-6%. We further support our simulations with empirical evidence of reduced pickup times from hundreds of thousands of Lyft rides.

3 - A Unified Branch-and-Benders Cut Framework For Two-Stage Stochastic Routing Problems

Yossiri Adulyasak, HEC Montréal, 3000 Cote-Sainte-Catherine, GOL department, Montreal, QC, H3T 2A7, Canada, Arthur Maheo, Simon Belieres, Jean-Francois Cordeau

Two-stage stochastic routing problems with routing recourse decisions are very challenging to solve due to the presence of combinatorial (discrete) decisions in the second stage. Nevertheless, traditional Benders decomposition is not directly applicable to tackle such problems due to the fact that it requires the second-stage variables to be continuous. We propose a unified Benders decomposition-based framework which can be used to solve large-scale two-stage routing problems with routing recourse decisions. We present an application of this framework on the two-stage traveling salesman problem arising in the context of service delivery with uncertain customer requests. We discuss how this framework can be readily leveraged for other similar applications involving routing recourse decisions.

4 - Statistical Efficiency Of Travel Time Prediction

Dawn Woodard, Uber, San Francisco, CA, 94103, United States, James Johndrow, Chiwei Yan

We conduct the first theoretical analysis on the statistical efficiency of travel time prediction methods. Our main focus is to compare the segment-based approaches versus the trip-based approaches that are commonly used in the literature and practice, yet not well understood from a theoretical lens. Under a Bayesian setting with general priors, we characterize the optimal estimator and compare their efficiencies under both finite-sample and asymptotic settings. We supplement our analysis with real data from a major ride-hailing platform.

5 - Dynamic Optimal Parking Allocation Model For Heterogeneous Vehicle Types

Abdelrahman Ismael, PhD Candidate, Rensselaer Polytechnic Institute, Troy, NY, United States, Jose Holguin-Veras

This research proposes a time-expanded formulation to find the optimal allocation of parking for passenger cars, delivery and service trucks through time using small steps of 5-30 minutes within a neighborhood. The objective of the model is to reduce congestion, emissions and illegal parking, and eliminate cruising. The model considers destinations, parking duration, arrival times and value of times along with information about the network and current parking situation. It can model operational characteristics for trucks from delivering to multiple establishments on multiple stops. The model can serve as a core of a decision system managed by cities for parking assignment within smart cities.

■ VWA83

Virtual Room 83

Physics Informed Machine Learning Techniques for Traffic State Estimation

Sponsored: TSL/Intelligent Transportation Systems

Sponsored Session

Chair: Saif Eddin G Jabari, New York University Abu Dhabi, Abu Dhabi, United Arab Emirates

Co-Chair: Sharon Di, Columbia University, New York, NY, 10027, United States

1 - Incorporating Kinematic Wave Theory Into A Deep Learning Method For Traffic Speed Estimation

Bilal Thonnam Thodi, PhD Student, New York University Abu Dhabi, Abi Dhabi, United Arab Emirates, btt1@nyu.edu

We present a kinematic waves-based Deep Convolutional Neural Network (Deep CNN) for estimating high-resolution traffic speed fields using sparse probe vehicle trajectories. Two key notions incorporate traffic physical constraints into the learning framework. Firstly, the use of anisotropic traffic kernels in the Deep CNN model - an architecture modification aimed to explicitly capture the space-time correlations in free-flow and congested traffic. These correlations are guided by the Kinematic Wave Theory of traffic flow. Secondly, simulation-based training - the use of simulated data as a surrogate to real-world data for training. This implicitly honors traffic physical constraints underlying the simulated data, and hence the simulation model. Speed field estimations for two real-world datasets show promising results.

2 - Physics Regularized Gaussian Process For Traffic State Estimation

Xianfeng (Terry) Yang, University of Utah, Salt Lake City, UT, 84112, United States, Yun Yuan

This study presents a new modeling framework, named physics regularized machine learning (PRML), to encode classical traffic flow models into the ML architecture and to regularize the ML training process. More specifically, leveraging the Gaussian process (GP) as the base model, a stochastic physics regularized Gaussian process (PRGP) model is developed and a Bayesian inference algorithm is used to estimate the mean and kernel of the PRGP. A physics regularizer, based on macroscopic traffic flow models, is also developed to augment the estimation via a shadow GP, and an enhanced latent force model is used to encode physical knowledge into the stochastic process. Based on the posterior regularization inference framework, an efficient stochastic optimization algorithm is then developed to maximize the evidence lower-bound of the system likelihood.

3 - Physics-Informed Deep Learning for Traffic State Estimation: A Hybrid Paradigm

Sharon Di, Columbia University, New York, NY, 10027, United States

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.

Wednesday, 7:45AM - 9:15AM

■ VWB01

Virtual Room 01

Participatory Specification of Trustworthy Machine Learning

Sponsored: Data Mining

Sponsored Session

Chair: Kush R Varshney, IBM Research, IBM Research, Yorktown Heights, NY, 10598, United States

1 - Paving An Intentional Path Towards Inclusive Practices In AI Development

Tina M. Park, Research Fellow (Methods for Inclusion), Partnership on AI, San Francisco, CA, United States,

Partnership on AI believes that working with communities affected by the deployment of AI/ML technologies is integral to their responsible development and mitigation of harm. To deepen our understanding of how inclusive public engagement approaches can help developers and researchers, PAI launched the Methods for Inclusion project. Multidisciplinary in nature, Methods for Inclusion draws from fields outside of computer science and technology, such as public planning & policy, education, public health, sociology, and community organizing which have grappled with questions of participation and inclusion for many decades. Drawing on semi-structured interviews with developers, data scientists, and researchers, as well as community advocates, the project explores the challenges present in conducting participatory design processes inclusively and equitably.

2 - Fair Performance Metric Elicitation
Gaurush Hiranandani, Student, UIUC, Urbana, IL, United States, Narasimhan Harikrishna, Oluwasanmi Koyejo

What is a fair performance metric? We consider the choice of fairness metrics through the lens of metric elicitation -- a principled framework for selecting performance metrics that best reflect implicit preferences. The use of metric elicitation enables a practitioner to tune the performance and fairness metrics to the task, context, and population at hand. Specifically, we propose a novel strategy to elicit group-fair performance metrics for multiclass classification problems with multiple sensitive groups that also includes selecting the trade-off between predictive performance and fairness violation. The proposed elicitation strategy requires only relative preference feedback and is robust to both finite sample and feedback noise.

3 - Addressing The Design Needs Of Implementing Fairness In AI Via Influence Functions
Brianna Richardson, University of Florida, Gainesville, FL, United States, Kush R. Varshney

The steady rise in machine learning applications is commensurate with the rise in efforts towards responsible and trustworthy AI. Despite the plethora of tools that exist to encourage interpretable, explainable, and fair AI, recent research depicts a lack of implementation by the practitioners who are meant to employ them. Utilizing findings and practices from participatory design research, this work introduces a novel explainable fairness methodology: influential fairness. Influential fairness employs state-of-the-art methods from robust statistics and fairness research to provide local, sample-specific explanations for group fairness metrics. Through task-based user studies, this work demonstrates the gaps in current fairness results and utilizes participatory design to maximize the insight and usability of influential fairness implementation.

4 - Empowering People To Design AI Systems For Their Own Contexts
Min Kyung Lee, UT Austin, Austin, TX, United States,

I present two participatory methods for AI design and their case studies in on-demand food rescue and algorithmic work scheduling: i. WeBuildAI is a participatory framework for stakeholders to build algorithmic community policies, such as determining efficiency and equity trade-offs; and ii. Well-being elicitation methods enable workers to build computational well-being models for the optimization and evaluation of algorithmic work.

■ VWB02

Virtual Room 02

Data Analytics for Social Media and Online Platforms

Sponsored: Data Mining

Sponsored Session

Chair: Changseung Yoo, McGill UniversitMontreal, QC, H3A 1G5, Canada

1 - Machine Learning Based Product Design: The Case Of Mobile Apps
Aditya Karanam, McCombs School of Business, UT Austin, Austin, TX, United States

Traditionally, firms update their products by innovating or imitating their competitors. Developers can also obtain user feedback, which may include suggestions of novel features or features from the competing apps. We build a deep learning model to identify four types of app features - developer initiated and user suggested - innovative and imitative features, and evaluate their impact on demand. Our results suggest that only developer-initiated innovative and user-suggested imitative features help increase the demand. We also find that the user-suggested innovative features have a higher impact on demand when they are implemented as-is. To the best of our knowledge, this is the first study to compare the efficacies of user and expert product ideas. We also develop a deep learning model for mining user suggestions.

2 - Internet Celebrity, Celebrity, And Online Endorsement
Dongliang Sheng, McGill University, Montreal, QC, Canada,

Internet celebrities are ordinary people who gain fame through the Internet, especially social media, and they provide brands another possibility of product endorsement. Traditional celebrity and Internet celebrity are different in audience reach, content creation, expertise, and credibility. Facilitated by source credibility model and source attractiveness model, this study aims to quantify and compare the effect of product endorsement from both celebrity and Internet celebrity on product sales. Both entities' endorsements are found to have a positive effect on product sales, but endorsement from celebrity is more effective compared with Internet celebrity.

3 - Human Vs. Ai: Will Ai Allow Humans To Do Tasks That Are Best Suited To Them?
Donghyuk Shin, Arizona State University, W. P. Carey School of Business, Dept. of Informati, Tempe, AZ, 85287, United States

The explosion of AI technologies is fundamentally reshaping how we work, transforming numerous occupations and industries. We investigate whether AI technology reinstates labor with new tasks, and how AI technology frees people up, allowing them to concentrate on what they can do best. To empirically test these questions, we use individual-level data from QANDA, a leading math problem-solver application, which provides both an AI-driven search engine and human tutor services. We find that, as the search engine quality improves, the search engine serves more common and basic questions, leaving only those that are more challenging to the human tutor. This study adds to the emerging economics of AI literature by calling further attention to future researchers to explore the substitutable vs. complementary role between human and AI.

4 - A Reinforcement Learning Algorithm for Online Personalized Tutor Recommendation
Mohamad Kazem Shirani Faradonbeh, University of Georgia, Athens, GA, United States

Intelligent computerized education reduces costs of tutoring by learning from the trajectories of the students. We present a data-driven algorithm implemented on an online platform for recommending personalized tutoring to students. To do so, multiple important challenges are addressed. First, the experiments for collecting data need to be diverse for exploring student responses, while at the same time they must focus on the immediate weakness of each student. Moreover, there are many tutoring items, but each student provides an extremely small data. Further challenges as well as employed methods that utilize student backgrounds for combining the data will be discussed.

■ VWB03

Virtual Room 03

Statistical Learning for Systems Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Xiaolei Fang, North carolina state university, North Carolina State University, Raleigh, NC, 27607, United States

1 - Domain Knowledge-oriented Deep Learning For The Remaining Useful Lifetime Prediction Of System With Multiple Failure Modes
Yuqi Su, North Carolina State University, Raleigh, NC, United States, Xiaolei Fang

Remaining useful lifetime (RUL) prediction is an important aspect of system prognostics and health management (PHM). Over the past decade, deep learning has been thriving and produced many outstanding results in various fields including PHM. In real-world applications, complex system always operates under multiple failure modes, while most previous studies rely heavily on prior knowledge of the system. To fill this gap, we propose a domain knowledge-oriented deep learning framework that is distributional accessible to depict the degradation process and to adapt RUL prediction when multi-sensors and multiple failure modes exist. The experimental results show the proposed method improves RUL prediction performance comparing with other benchmark architectures especially under the consideration of asymmetric preference that penalties more on late prediction.

2 - Fast And Reliable Metamodeling Of Large-scale Nonlinear Time-dependent Problems
Xinchao Liu, University of Arkansas, Fayetteville, AR, United States,

This research proposes a reduced-order surrogate learning framework for nonlinear structural dynamics governed by unequivocal physics principles. Motivated by the nonlinear spatio-temporal surface displacement process due to aircraft-UAV collisions, this paper shows (i) how the reduced-order physics models (including physics of motion,fundamental material laws and finite element framework) can be obtained from the Proper Orthogonal Decomposition; (ii) how the reduced-order physics models can be accelerated by gradient boosted ensemble trees; (iii) how the input (force) uncertainty in nature is incorporated into deterministic finite element results; and (iv) how the error is controlled and modelled for governing-equation-based reduced-order models.

3 - An Integrative Hierarchical Process Monitoring Approach For Detecting Defects And Anomalies In Additive Manufacturing
Wei Yang, Georgia Institute of Technology, 22 14th St Nw Unit 1811, Atlanta, GA, 30309-4696, United States, Marco Grasso, Bianca Maria Colosimo, Kamran Paynabar

Additive Manufacturing, also called 3D printing, is an emerging technology which enables the creation of complex shape with strong structural properties. Due to its unique manufacturing process, defects and anomalies might occur within each layer, across whole layer and throughout the whole sample, an accurate and responsive detection of various types of anomalies is essential for ensuring the quality and integrity of the manufactured product. In this paper, an integrative hierarchical process monitoring approach, namely, a three level monitoring strategy, is proposed to monitor within layer, between layer and across sample anomalies. The proposed approach learns the low-rank core tensor structure from normal process and incorporate Hotelling's T-squared statistics to implement the three level monitoring strategies.

4 - Human-machine Interaction System Reliability Model With Multiple Dependent Degradation Processes
Yuhan Hu, NC State University, Raleigh, NC, United States, Rui Wang, Mengmeng Zhu

Human factors greatly affect the performance of the machine. However, most system reliability models neglect the impacts of human factors. We thus propose a new human-machine interaction (HMI) system reliability model, in which the health state of the machine is not only affected by internal and external factors but also human behaviors. The human behaviors in this paper are illustrated by human situation awareness (HSA). Time and automation levels are chosen to model HSA. Also, the proposed model considers random shocks and multiple dependent degradation processes of the machine. This dependency is solved by the copula method. The impacts of HSA and random shocks will be reflected on the system as incremental change and sudden jump on degradation rate. The proposed model is firstly demonstrated by a simulated case, then by a battery management system in electric vehicles.

■ VWB04

Virtual Room 04

Discover Success Factors in Service Operations

Sponsored: Data Mining

Sponsored Session

Chair: ShiKui Wu, Lakehead University, Lakehead University, Thunder Bay, ON, P7B 5E1, Canada

1 - Using Virtual Learning Environment Data To Predict Learner Attrition And Inform Proactive Interventions
Wesley Floriano Willick, Lakehead University, Thunder Bay, ON, Canada, Kem Z Zhang

Increased usage of virtual learning environments (VLEs) in post-secondary institutions, especially in light of the COVID-19 lockdowns, has allowed for novel approaches to handling learner attrition. This research examines the VLE data of a small Canadian university to create predictive models of learner attrition. Further, we investigate student experiences in the 2020/2021 school year through a university-wide survey. A concurrent triangulation mixed-methods approach is then used to analyze both data sources to reach an integrative understanding about the impacts of VLEs on students.

2 - Case Mix Methodologies in Dementia Patients' Treatments at Long-Term Care Institutions: An Analytical Study
Hai Huynh, Lakehead University, Thunder Bay, ON, Canada, Michael Dohan, ShiKui Wu, Joshua Armstrong

The purpose of this research is to use analytic techniques to assess the accuracy of case mix methodologies for residents with dementia living in Long Term Care (LTC) institutions. The methodology outlines the details of the data sources and a three-phase data analysis process. The results of this research is expected to uncover some changes or additions that can be made to the current case mix methodologies which would better accommodate residents with dementia.

3 - Property Listing Popularity: The Case Of Airbnb In Canada
Bronte J Smith, Lakehead University, Thunder Bay, ON, Canada, Kem Z.K Zhang, ShiKui Wu

Airbnb is one of the most transformative developments in the tourism sector. Most literature tends to focus on consumers instead of the hosts that bridge the company to its consumers. Using a sample of multiple Canadian cities, this research will adopt a data-driven approach to explore the key determinants of host success in recent years. This research will increase insights into variables affecting host performance and thus guiding their practice, especially demonstrating how it is impacted by the Covid-19 pandemic

4 - Contributing Factors to the Success of Students in a Business Analytics Graduate Program
Dmitry Gimon, Park University, Kansas City, MO, United States

Business Analytics has been an emerging field in higher education in recent years. It is often being treated as a cross-disciplinary field combining learning outcomes from business degrees (including information systems), math and computer science. We found a gap in literature in studying factors contributing to students' success in business analytics education. In addition, the rapidly growing online education environment requires better understanding the role of students and their instructors in student success. We studied multiple factors, such as student backgrounds, dynamics of their progress through a degree as well as the faculty contributions.

■ VWB05

Virtual Room 05

The Role of Data Mining in Social Justice Research

Sponsored: Data Mining

Sponsored Session

Chair: Zhasmina Tacheva, Syracuse University, Syracuse, NY, 14210-2527, United States

1 - Can Data Mining Help Fight Injustice?
Zhasmina Tacheva, Syracuse University, Syracuse, NY, 14210-2527, United States

This paper seeks to present a framework of practical principles for the use of data mining techniques in elucidating and countering instances of online hate speech in the context of the ratification of the Istanbul Convention by European Union member states.

2 - Data Is People: Ethical Considerations for Data Mining
Casey Fiesler, University of Colorado-Boulder, Boulder, CO, United States

Digital traces like tweets, blog posts, photos, and dating profiles are all being used for science. Though some research stems from social science and purposefully engages with the human aspects of online content, sometimes it simply becomes “data”—particularly for the creation of training datasets for machine learning algorithms. So what kind of ethical metrics, beyond "publicness," should we use to determine whether and how we mine data from the internet?

■ VWB06

Virtual Room 06

Reinforcement Learning with Engineering Applications I

Sponsored: Data Mining

Sponsored Session

Chair: Mohammad Dehghanimohammadabadi, Northeastern University, Boston, MA, 02115-5005, United States

Co-Chair: Sahil Belsare, Boston, MA, 02120-2175, United States

1 - The Increased Applicability Of Reinforcement Learning In Engineering Applications
Sahil Belsare, Northeastern University, Boston, MA, United States,

In recent years, Reinforcement Learning (RL) has attracted the significant attention of optimization theorists, researchers, and industries because of its noteworthy successes in solving sequential decision-making problems. This is evident by the steady rise in publications displaying the applicability of RL for complex optimization problems in domains like operations research, supply chain, autonomous vehicles/drones, Industry 4.0, finance, health science, and many more. This presentation aims to highlight RL’s growing prominence by talking about RL’s used cases, scalability, benchmarking, the evolution of Deep RL, and future scope. Along with that, the parallel goal is to encourage researchers to work on the challenges addressed for applying RL in engineering applications.

2 - UAVs For Search And Rescue: A Reinforcement Learning Approach

Leren Qian, Northeastern University, Boston, MA, United States, Peiqi Wang, Dinghao Ma, Mohammad Dehghanimohammadabadi, Mehdi Behroozi, Emanuel Melachrinoudis

Reinforcement Learning (RL) is becoming an emerging field of research and a powerful tool to solve complex problems. This study applies RL to solve a team orienteering problem (TOP) of UAVs with charging stations. In this problem, a fleet of UAVs need to visit a subset of service nodes with the objective of maximizing the total collected service rewards. To increase UAVs reliability and reachability, UAVs can access charging stations along their routes. The problem is solved with a two-phase solution approach where the nodes are decomposed into clusters before using RL to find the best policy. A non-decreasing tree search updating strategy is designed to deal with the natural complexity of the combinatorial optimization problem during the state-action value update. Experiments show the approach outperformed the state-of-the-art commercial solver dealing with this task.

3 - Integrating Reinforcement Learning with a Discrete Event Simulation Environment for Queueing Networks

Sahil Belsare, Northeastern University, Boston, MA, 02120-2175, United States, Mohammad Dehghanimohammadabadi

In this project, RL is applied to solve a M/M/C queuing system in a simulated environment. To conduct this, SimPy, a discrete event simulation (DES) library in Python, is integrated with RL algorithms. This integration provides a unique platform to link a DES environment with RL techniques and enable a new approach to solve traditional simulation-optimization problems.

■ VWB07

Virtual Room 07

Reaching Global Optimum in Non-Convex Optimization Problems

Sponsored: Data Mining

Sponsored Session

Chair: Igor Molybog, University of California-Berkeley, University of California-Berkeley, Berkeley, CA, 94709, United States

1 - Nonconvex-nonconcave Minimax Optimization With Moderate Accuracy

Meisam Razaviyayn, University of Southern California, Los Angeles, CA, 90089-1057, United States

We studied the problem of solving general smooth nonconvex min-max optimization problems to moderate accuracy levels.

2 - On The Absence Of Spurious Local Trajectories In Time-varying Nonconvex Optimization

Cedric Josz, Columbia University, New York, NY, 94270, United States,

We study the landscape of a time-varying nonconvex optimization problem, for which the input data vary over time and the solution is a trajectory rather than a single point. A motivating example will be the alternating current optimal power flow problem where the demand varies throughout the day. To understand the complexity of finding a global solution of such a problem, we introduce the notion of spurious (i.e., non-global) local trajectory as a generalization to the notion of spurious local solution in nonconvex (time-invariant) optimization. We provide sufficient conditions for local trajectories to escape spurious local minima due to time variations. This joint work with Fattahi, Ding, Mohammadi, Lavaei and Sojoudi: https://arxiv.org/abs/1905.09937

3 - When Does MAML Objective Have Benign Landscape?

Igor Molybog, University of California-Berkeley, Berkeley, CA, 94709, United States, Javad Lavaei

The paper studies the landscape of the optimization problem behind the Model-Agnostic Meta-Learning (MAML) algorithm. The goal of the study is to determine the global convergence of MAML on sequential decision-making tasks possessing a common structure. We investigate in what scenarios the benign optimization landscape of the underlying tasks results in a benign landscape of the corresponding MAML objective. For illustration, we analyze the landscape of the MAML objective on LQR tasks to determine what types of similarities in their structures enable the algorithm to converge to the globally optimal solution.

4 - General Low-rank Matrix Optimization: Geometric Analysis And Sharper Bounds

Haixiang Zhang, University of California=Berkeley, Berkeley, CA, United State, Yingjie Bi, Javad Lavaei

We consider the global geometry of general low-rank matrix optimization problems via the non-convex factorization approach. For the rank-1 case, we prove that if the rank-2 RIP constant is less than 1/2, there is no spurious second-order critical point. Combining with a counterexample with the RIP constant equal to 1/2, we show that the bound is the sharpest possible. For the arbitrary rank-r case, the same property holds if the rank-2r RIP constant is at most 1/3. For any problem with RIP constant between 1/3 and 1/2, we prove that all second-order critical points have a positive correlation to the ground truth. Finally, the strict-saddle property, which can lead to the polynomial-time global convergence of various algorithms, is established if the rank-2r RIP constant is less than 1/3. The results of this work significantly extend several existing bounds in the literature.

5 - Local And Global Linear Convergence Of General Low-rank Matrix Recovery Problems

Yingjie Bi, University of California, Berkeley, Berkeley, CA, United States, Haixiang Zhang, Javad Lavaei

We study the convergence rate of gradient-based local search methods for solving low-rank matrix recovery problems with general objectives in both symmetric and asymmetric cases, under the assumption of the restricted isometry property. First, we develop a new technique to verify the Polyak-Lojasiewicz inequality in a neighborhood of the global minimizers, which leads to a local linear convergence region for the gradient descent method. Second, based on the local convergence result, we present two new conditions that guarantee the global linear convergence of the perturbed gradient descent method. The developed local and global convergence results provide much stronger theoretical guarantees than the existing results.

■ VWB08

Virtual Room 08

Innovation/ Entrepreneurship I

Contributed Session

Chair: Marc Eulerich, University Duisburg-Essen, Hagen, 58099, Germany

1 - Black-owned Small Businesses In Englewood, Chicago: Documenting The Effects Of COVID-19 And The Black Lives Matter Movement In 2020

Sophie Boorstein, Northwestern University, Evanston, IL, United States,

The present study assesses impacts of 2020 crises on Black-owned small businesses in Englewood, Chicago. The research examined SafeGraph foot traffic data to identify customer visitation patterns relative to COVID-19 stay-at-home orders and BLM protests. Through semi-structured interviews with Black-identifying entrepreneurs (n=8) in Englewood, the research further elucidated mechanisms by which the pandemic, protests, and looting disproportionately influenced minority-owned businesses. Amid unique foot traffic trends in Englewood and other majority-Black neighborhoods, business owners managed their retail enterprises with complex merchandise, staffing, and health decisions.

2 - The Ultimate, Most Revolutionary Paper Ever! How Bragging Affects New Product Success

Daniel Blaseg, Assistant Professor of Entrepreneurship, ESADE Business School, Sant Cugat, Spain, Christian Schulze

When new firms introduce a new product to the market, they face an important decision: Should they be modest, or should they brag? We investigate bragging (the use of superlatives) by studying 360,412 new products launched on Kickstarter. We find that the relationship between bragging and new product success follows an inverse U-shape. Ideally, about one in thirteen words should be a superlative. The right amount of bragging can help new firms increase product success by up to 66%. Competitive intensity moderates the results. The greater the competition and their bragging density, the higher the optimal bragging density. Contrary to conventional wisdom, it is not optimal to "stand out".

3 - How To Sell Videogames? Analyzing The Drivers Of Successful Video Game Sales

Marc Eulerich, Professor for Internal Auditing, University Duisburg-Essen, Duisburg, Germany, Anna K. Eulerich

The video game industry has an enormous economic, cultural, and social influence on today's society. Oddly enough, this field of research is far from exhausted. It is for this reason, that our study contributes to the existing literature by addressing a quite fundamental question, namely which factors drive video game sales. Using an unique data set, we perform a comprehensive analysis of different influencing factors in order to develop an in-depth understanding of the video game industry's success when it comes to sales figures. By combining information from different data sources, we are able to examine the impact of various market- and game-specific factors as well as cultural effects.

■ VWB09

Virtual Room 09

Healthcare Policy and Regulation

Sponsored: Health Applications Society

Sponsored Session

Chair: Yixin Iris Wang, University of Illinois at Urbana-Champaign, Champaign, IL, 61820-6915, United States

Co-Chair: Anqi Wu, University of Illinois, Champaign, IL, 61821, United States

1 - The More Monitoring, The Better Quality? Empirical Evidence From The Generic Drug Industry

Anqi Wu, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Yixin Iris Wang

With growing concerns on drug safety issues, FDA has implemented major moves to allocate more inspections to high-risk manufacturers. The actions of FDA implicitly assume that the frequent inspections at low-quality facilities could reduce the drug safety concerns. However, whether more monitoring guarantees better quality remains unclear. In this study, we directly examine the validity of this assumption in the generic drug industry and test the impact of inspection frequency on the manufacturing quality. Overall, we do not find evidence that supports the link between more frequent inspections and fewer recall events, suggesting that the current risk-based inspection model alone might not help bring down the quality failures in drug products. We propose two explanations for the results - the organizational culture and the inherent quality levels.

2 - The Impact Of Uncertainty Avoidance Culture On Patient Engagement During The Covid-19 Pandemic

Kellas Cameron, Assistant Professor, University of South Florida, Tampa, FL, 33602, United States, Lu Kong

National Cultures have played an undeniable role in how different countries have been able to effectively tackle the Covid-19 pandemic. We posit the countries that exhibit a higher uncertainty avoidance index had better responses due to their population's willingness to adapt to new social and health directives, as this risk averse nature has been associated with higher patient engagement. Our model demonstrates how these dimensions of national culture - as opposed to individual preferences - directly impacted the implementation of novel mitigation processes to lower infections rates. We outline ways in which those in health operations can leverage these cultural norms to maximize positive patient health outcomes.

3 - Impact Of Environmental And Safety Violations On Quality

Gopesh Anand, University of Illinois-Urbana Champaign, Champaign, IL, 61820-6915, United States, Christian Blanco, John Gray, In Joon Noh

In this research, we study how violations in environmental and safety regulations, revealed through adverse facility inspection outcomes by the EPA and OSHA, impact process and product quality in pharmaceutical manufacturing, assessed using inspection outcomes by the FDA. We use the attention-based view to address the question of whether, in general, there is a comprehensive attention to compliance with regulations, or whether the attention to compliance gets divided among multiple regulations.

4 - Healthcare Reimbursement Policy Impact On Multiple-provider Readmission Reduction Programs

Jon M. Stauffer, Texas A&M University, College Station, TX, 77843, United States, Jonathan Eugene Helm, Kurt M. Bretthauer

We examine the transition from Fee-for-Service to alternative reimbursement plans, such as bundled payments and the Hospital Readmission Reduction Program, and how this impacts the motivation for providers to reduce readmissions. Results show that bundled payment plans do motivate cost-effective readmission reduction effort from hospitals, but if post-discharge providers are included in the gain-sharing contracts they may perform insufficient or excessive effort. We discuss two redesigned structures (single-controlling provider and risk-adjusted) for bundled payment plans to address these readmission reduction effort misalignment issues.

■ VWB10

Virtual Room 10

Prediction and Optimization of Health States and Outcomes in Vulnerable Populations

Sponsored: Health Applications Society

Sponsored Session

Chair: Nan Kong, Purdue University, West Lafayette, IN, 47907-2032, United States

Co-Chair: Mingyang Li, University of South Florida, Tampa, FL, 33647-5133, United States

1 - Nonlinear State Space Modeling And Control For Monitoring, Identifying And Minimizing Risk Of Chronic Conditions In Patients With Multiple Chronic Conditions

Syed Hasib Akhter Faruqui, University of Texas at San Antonio, San Antonio, TX, United States, Adel Alaeddini, Jing Wang, Susan P. Fisher-Hoch, Joseph B. Mccormick

Understanding the interactions between multiple chronic conditions (MCC) and their evolution with time is an important and challenging problem. Graphical Models like Bayesian networks are often deployed to model their interactions and predict their future pathways toward developing new conditions. However, these interactions are often dynamic in nature and time-varying (non-linear). As a result, the underlying structure of the network also varies with time. To meet these challenges, this work utilizes a functional continuous-time Bayesian network to model the time-varying nature of MCC. In addition, we also adopted Model Predictive Control, an online, recursive inference procedure to examine the impact of various behavioral changes on the emerging trajectories of MCC and control the progression of chronic conditions in a patient with MCC.

2 - Physical And Cognitive Outcomes Modeling Of A Heterogeneous Population Of Older Adults: A Bayesian Non-parametric Approach

Yulun Xu, University of South Florida, Tampa, FL, United States, Suiyao Chen, Hongdao Meng, Nan Kong, Mingyang Li

Older adults suffered from multi-functional (e.g., physical and cognitive) declines tend to utilize varied healthcare settings, such as hospitals and nursing homes, differently over time. Accurate modeling their multi-functional declines will serve as the essential basis for accurate service demand forecasting and proactive healthcare resource planning. Conventional longitudinal outcomes modeling approaches often have restrictive assumptions, e.g., homogeneity assumption, univariate modeling and pre-specifying a fixed sub-population number in advance. We propose a Bayesian non-parametric modeling framework with effective estimation algorithm to characterize multi-dimensional longitudinal outcomes data to overcome all the above modeling limitations. A real case study is provided to illustrate the proposed work and demonstrate its effectiveness.

3 - Explainable Machine Learning-based SpO2 Estimation Using Neck Photoplethysmograms

Yuhao Zhong, Texas A&M University, College Station, TX, United States,

Conventional sensors for measuring blood oxygen saturation (SpO2) are limited by either accuracy or measuring sites. This study addresses the estimation of SpO2 at a non-standard measuring site and a concomitant identification of consistent subject inclusion-exclusion criteria, using a combination of unsupervised clustering, supervised learning, and global interpretations. A novel wearable device was developed to collect reflective photoplethysmograms from the neck arteries of 33 subjects. The approach identified the device settings and the characteristics of the subject clusters (i.e., inclusion criteria) that can lead to SpO2 estimation with a maximum absolute error ≤ 1.5%.

4 - Repeat Fall Prediction And Intervention For Older Adults At Emergency Department: A Causal Bayesian Network Model

Wenjun Zhu, University of Wisconsin-Madison, Madison, WI, 53705-2814, United States, Sujee Lee, Allie Delonay, Brian Patterson, Maureen Smith, Carayon Pascale, Jingshan Li

In the United States, more than 30% of older adults aged 65 years and older fall annually and older adult falls are the most common reason for unintentional injury-related emergency department (ED) visits. Evaluation of repeat fall risk for older patients and interventions for reducing repeat falls after ED care have significant importance in reducing morbidity and mortality among senior population. To achieve this, this studies introduces a causal Bayesian network model to study repeat fall prediction for older patients in EDs, which enables us to make causal inferences about the effect of manipulating variables on repeat falls. Based on the inferences, analysis of post-discharge intervention to reduce repeat fall probability can be carried out.

■ VWB11

Virtual Room 11

Addressing Healthcare Challenges in the Face of Uncertainty

Sponsored: Health Applications Society

Sponsored Session

Chair: Lauren Czerniak, University of Michigan, Ann Arbor, MI, 48105-2610, United States

1 - COVID Response: Sanitizer Deployment

Steven Foster, Clemson University, Clemson, SC, United States, Tyler O'Brien, Emily L Tucker, Sudeep Hegde

COVID-19 has forced universities to create strategies to combat infections in their student populations. To allow students to return to traditional instruction, Clemson University has deployed hand-sanitizing dispensers across campus to reduce viral transmissions, limit outbreaks, and promote adherence to CDC health guidelines. This study integrates optimization modeling and human factors methods to maximize usage of these hand-sanitizing dispensers. The facility location model presented uses door-access data to determine optimal dispenser locations within 37 buildings across campus. Interviews are used to define behavioral uncertainty and stakeholder decision-making to better direct the model to enhance future dispenser allocation.

2 - Analytical Study Of The Effects Of Drug Shortages On Hospital Pharmacy Operations During Covid-19

Noah Chicoine, Northeastern University, Boston, MA, United States, Jacqueline Griffin, Min Gong, Ozlem Ergun

The impact of COVID-19 has been well documented in the press, yet there remains a limited understanding of how these drug shortages were managed at the hospital level and the multitude of effects it had on operational decision making. We present our findings from an analysis of the operations of a top hospital pharmacy throughout the COVID-19 pandemic, with an emphasis on the results from analytics applied to data about inventories, information, and demand.

3 - Improving Simulation Optimization Run Time To Solve For Hospital Pharmacy Inventory Policies

Lauren L Czerniak, University of Michigan, Ann Arbor, MI, 48105-2610, United States, Mark S. Daskin, Mariel S. Lavieri, Burgunda V. Sweet, Jennifer Erley, Matthew A. Tupps

To guard against both drug waste and shortages in a hospital pharmacy inventory system with supply disruptions, we create a simulation-optimization model and implement a Binary Grid-Search algorithm to quickly solve for periodic review inventory policies. The numerical results show our modeling framework solves for the policies 21 times faster than an exhaustive search, without compromising solution accuracy. Our partner hospital stocks over 2,500 drugs, making this quick solution time vital in their inventory system.

4 - The Impact of Interventions on COVID-19 Transmission in K12 Schools in Fall 2021

Yiwei Zhang, North Carolina State University, Raleigh, NC, United States, Karl Johnson, Zhuoting Yu, Akane Fujimoto, Kristen Hassmiller Lich, Julie Simmons Ivy, Pinar Keskinocak, Maria Mayorga, Julie Swann

The study analyzes the potential impact of COVID-19 transmission within K12 schools as students return to in-person learning in the fall, as well as the possible interventions that can be applied to mitigate such impact. We develop a deterministic SIR model to estimate the infections under different intervention scenarios such as mask-wearing and randomized testing. We find that mask-wearing and regular testing can greatly reduce new infections among students. We test the sensitivity of these results to different parameters, such as the level of incoming protection among students.

■ VWB12

Virtual Room 12

Empirical and Behavioral Research in Healthcare

Sponsored: Health Applications Society

Sponsored Session

Chair: Hyun Seok (Huck) Lee, Korea University Business School, Corvallis, OR, 97333-3235

Co-Chair: Junghee Lee, y, Tulane University, New Orleans, LA, 70118-5669, United States

3 - The Impact of Transparency on Drug Innovation

Hanu Tyagi, University of Minnesota, Minneapolis, MN, United States, Rachna Shah

Operational transparency in supply chains has shown benefits to firms in varied contexts and settings. However, there is little research on the impact of transparency on a firm's propensity for product innovation. Using a uniquely curated dataset of pharmaceutical drug launches over a long period of time, we show how transparency in clinical trials leads to between- and across-firm knowledge spillovers thereby impacting drug innovation.

4 - Effects Of Telehealth And Ehr

Seung Jun Lee, Chung-Ang University, Seoul, Korea, Republic of, sjlee1@cau.ac.kr, Yerin Heo, Inn Joonhwan, Yongwon Seo

Due to the pandemic situation, the modern healthcare system is widely adopting various treatment services to improve care quality. One of the approaches relates to the telehealth, which refers to the use of electronic services to support a wide range of remote services, such as patient care, education, and monitoring service. Although such telehealth service may provide improved operational performance, few extant literature explore the marginal impact of the telehealth service., Thus, this study discovers the impact of telehealth service on hospital performance.

5 - Path Dependency In Physician Decisions

Lawrence Jin, National University of Singapore, Singapore, Singapore, lawrencejin@gmail.com, Rui Tang, Han Ye, Junjian Yi, Songfa Zhong

We examine path dependency in physician decisions. In both emergency department visits and childbirth deliveries settings where the ordering of patients is conditionally random, we find that physicians' treatment decision for the current patient is positively correlated with their decision for the previous patient. The estimated path dependency is stronger when consecutive patients share greater similarity, and when the current patient is associated with larger medical uncertainty. Our findings are consistent with memory and attention-based anchoring and adjustment mechanism, whereby treatment decision for the previous patient is used as a shortcut by physicians to make future treatment decisions.

6 - Learning In Drug Shortages

Hyun Seok (Huck) Lee, Korea University Business School, 3643 SE Shoreline Drive, Seoul, 97333-3235, Korea, Republic of, Junghee Lee, In Joon Noh

In this study, we investigate whether pharmaceutical manufacturing plants learn from their own drug shortage instances. Specifically, we examine if more drug shortages recovery at a plant lead to quicker recovery from its subsequent shortages. We also investigate factors that might affect this learning. Our findings will have policy implications for the FDA and will also contribute to the academic literature on learning.

■ VWB13

Virtual Room 13

Health Care, Modeling and Optimization V

Contributed Session

Chair: Lotte Verdonck, Hasselt University, Hasselt, 3500, Belgium

1 - Dynamic Divergence Among Physicians Emerging From Customers' Perception And Physicians' Experiential Learning

Hesam Mahmoudi, Virginia Tech, Blacksburg, VA, United States, hesam@vt.edu, Navid Ghaffarzadegan

Over-utilization bias and practice variation are two major contributors to suboptimal medical decisions. We do not seek to reject the common static explanations for bias and variation; instead, we offer an alternative and dynamic one. Our case is obstetricians' decision between C-section and natural deliveries. Simulation results show that skill accumulation together with conditional feedback availability are enough to endogenously cause bias and variation. The dynamics of patients' matching their preferences with the obstetricians' reputation interacts with the experiential learning dynamics, exacerbates the bias, and pushes the physicians to settle in their preferred delivery method.

2 - A Hybrid Simulation Model To Analyze Care Team Workflow And Data Generation In Intensive Care Unit

Farnaz Babaie Sarijaloo, University of Florida, Gainesville, FL, United States, Aditya Mahadev Prakash, Jaeyoung Park, Xiang Zhong, Ogie Gajic, Brian Pickering, Yue Dong

The intensive care unit (ICU) plays an important role in every hospital because patients with life-threatening conditions and comprehensive care need would be admitted to ICU. In this study, we developed a hybrid simulation model to analyze the processes in an ICU facility and the interaction between care providers and patients. The proposed model can capture the impact of resources on the patients' length of stay and data generation procedures within an ICU environment. The results provide insights into the staff leveling and capacity planning of a medical ICU to optimize resource utilization. Using this model, we are also able to assess the impact of COVID-19 pandemic on ICU capacity management.

3 - A Simulation-optimization Staffing Model To Improve Patient Flow And Patient Safety In The Emergency Department.

Vishnunarayan Girishan Prabhu, Clemson University, Clemson, SC, United States, Kevin M. Taaffe, Ronald G. Pirrallo, William Jackson, Michael Ramsay

Approximately 145 million patient visits are made to Emergency Departments (EDs) in the US annually. The diverse nature and overwhelming volume of patient visits to EDs make it predisposed to crowding, leading to reduced quality of care. This research focused on developing a simulation-optimization model to identify optimal physician staffing levels to minimize the combined cost of patient wait times, handoffs and physician shifts in the ED. By generating shift schedules using the optimization model and testing them in the validated simulation model, we observed that patient time in the ED and handoffs can be reduced by as much as 27% and 26% compared to the current practices.

4 - An Inventory-Routing Problem For Cooperative Hospital Supply Chain Operations

Silia Mertens, Hasselt University, Hasselt, Belgium, Lotte Verdonck, Lien Vanbrabant

A high amount of capital is tied up in hospital inventories because of the unpredictable demand and the severe consequences of a stock-out in critical materials. A way to reduce the amount of inventory while maintaining a high service level is inventory pooling. It requires re-engineering the traditional hospital SC into a cooperative SC consisting of a central warehouse that operates for multiple hospitals and replaces the central warehouse of each individual hospital. The aim of this research is to provide hospitals with new insights on how to improve the efficiency of their logistics processes, and on the optimal shaping and operational implementation of a cooperative hospital SC.

■ VWB14

Virtual Room 14

Data-driven Frameworks, Methods, and Applications in OM

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ningyuan Chen, University of Toronto, Mississauga, ON, L5L 1C6, Canada

1 - Data Aggregation And Demand Prediction

Renyu Zhang, New York University Shanghai, Shanghai, China, Maxime Cohen, Kevin Jiao

We study how retailers could use clustering techniques to improve demand prediction accuracy. A typical retail setting involves predicting demand for hundreds of products simultaneously. In this paper, we propose a practical method—referred to as the Data Aggregation with Clustering (DAC) algorithm—that balances the tradeoff between data aggregation and model flexibility. The DAC allows us to predict demand while optimally identifying the features that should be estimated at different aggregation levels. We analytically show that the DAC yields a consistent estimate along with improved asymptotic properties relative to the standard approaches. Using both simulated and real data, we demonstrate the improvement in prediction accuracy obtained by the DAC relative to several common benchmarks. Our results also yield useful managerial insights.

2 - Learning And Optimization With Seasonal Patterns

Longlin Wang, Tsinghua University, Beijing, China, Ningyuan Chen, Chun Wang

The stationarity assumption of Multi-armed Bandits (MAB) can be restrictive in the business world as decision makers often face an evolving environment with time-varying mean rewards. In this paper, we consider a non-stationary MAB model in which the mean rewards vary over time in a periodic manner. The unknown periods of the arms can be different and scale with the length of the decision horizon T polynomially. For this setting, we propose a two-stage policy that combines the Fourier analysis with a UCB-based learning procedure. In stage one, the policy correctly estimates the periods of all arms with high probability. In stage two, the policy explores the periodic mean rewards of arms using the periods estimated in stage one and exploits the optimal arm in the long run. We show that our policy achieves the rate of regret \tilde{O}(√{T ∑_{k=1}^K Tk}), where K is the number of arms and Tk is the length of period of the k-th arm. This rate of regret matches the optimal one of the classic MAB problem O(√{TK}) if we regard each phase of an arm in the period as a separate arm.

3 - Nonparametric Estimation Of Mixing Distributions In The Presence Of Endogeneity

Ashwin Venkataraman, University of Texas at Dallas, Jindal School of Management, Richardson, TX, 75080, United States, Srikanth Jagabathula, Sandeep Chitla

We propose a novel methodology for dealing with endogeneity in discrete choice models, that is nonparametric: does not make any assumption on the mixing distribution (addressing the classical BLP estimator's limitation) but still allows for coefficients that are fixed across customers (addressing the limitations in prior nonparametric estimators that use the control function approach); and versatile: can capture a wide class of regularization constraints on the mixing distribution. Our method relies on reformulating the estimation problem as a constrained convex program and leverages the conditional gradient algorithm to generate the support of the underlying mixing distribution. Numerical experiments on synthetic data show that our method recovers a better approximation of the true mixing distribution compared to both the BLP and control function approaches.

4 - Revenue Maximization And Learning In Products Ranking

Shuoguang Yang, Hong Kong University of Science and Technology, Hong Kong, China, Ningyuan Chen, Anran Li

We consider the revenue maximization problem for an online retailer who plans to display a set of products differing in their prices and qualities and rank them in order. The consumers have random attention spans and view the products sequentially before purchasing a "satisficing" product or leaving the platform empty-handed when the attention span gets exhausted. We show a nested structure of the optimal product ranking as a function of the attention span when the attention span is fixed and design a 1/ ;-approximation algorithm accordingly for the random attention spans. When the conditional purchase probabilities are not known and may depend on consumer and product features, we devise an online learning algorithm that achieves O(sqrt{ ;}) regret relative to the approximation algorithm.

■ VWB15

Virtual Room 15

Choice, Data and Optimization for Assortment and Pricing

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Ruxian Wang, Johns Hopkins University, Carey Business School, Kensington, MD, 20895, United States

Co-Chair: Chenxu Ke, Nanjing University, Nanjing University

1 - Product Price, Quality and Service Decisions under Consumer Choice Models

Chenxu Ke, Nanjing University, Nanjing, China, chenxu.ke@nju.edu.cn, Ruxian Wang, Shiliang Cui

In this paper, we develop an integrated framework to study a firm's joint decisionson product price, quality and service duration in a variety of monopolistic and competitive scenarios. We find that with multiple substitutable products being offered, it is sufficient for a firm to provide only two maximally differentiated service durations at optimality. The quality of each product should be set at a level such that the marginal utility to consumers equals the marginal cost to the firm, independent of the decisions on other products, whereas pricing decision should take into account all products.

2 - Assortment And Price Optimization Under The Threshold Utility Model

Zhuodong Tang, Hong Kong University of Science and Technology, New Clear Water Bay Road Kowloon Bay Kwun Tong, Hong Kong, NO, China, Guillermo Gallego, Ruxian Wang

We consider pricing and assortment optimization problems arising from the threshold utility model (TUM) under which consumers purchase all products whose net utility exceeds non-negative product-specific thresholds selected to maximize the total expected consumer surplus subject to a bound on the number of products purchased in expectation. For the monopolistic problem, we identify the conditions under which the multi-product price optimization can be efficiently solved. In the oligopolistic setting, we establish the existence of a Nash equilibrium under price competition and market share competition. We also investigate sequential games under which the threshold is updated periodically. The assortment optimization problem is NP-hard in general. We characterize polynomial-time solvable cases and develop efficient approximation schemes for general TUM.

3 - A Multi-choice Model With Context Effects

Xin Chen, UIUC, Transportation Bldg 104, Urbana, IL, 61801-2925, United States, Reza Yousefi Maragheh

Most of the existing papers in operations management assume a single-choice outcome when modeling choice selection behavior. In this paper, we develop a utility-based extension of the logistic regression, the Contextual Logit (CL) to model the choice selection of customers while allowing for multi-choice. Using the CL model, one can capture various complex contextual interactions among both complementary and substitute products. The predictive performance of this model is validated by comparing it with recent benchmark multi-choice models on 70 real data sets selected from diverse categories of products. We prove the NP-hardness of the Assortment Optimization Problem (AOP) under the CL model, and show that when some types of contextual interactions are dominant in data, the AOP is tractable. Efficient heuristics are proposed to solve the AOP under the general CL model.

■ VWB16

Virtual Room 16

Decision Making and Learning

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Garud N. Iyengar, Columbia University, New York, NY, 10027, United States

Co-Chair: Min-hwan Oh, Seoul National University, New York, NY, 10027, United States

1 - Doubly Robust Thompson Sampling With Linear Payoffs

Wonyoung Kim, Seoul National University, Seoul, Korea, Republic
Myunghee Paik, Gi-soo Kim

A challenging aspect of the bandit problem is that a stochastic reward is observed only for the chosen arm and the rewards of other arms remain missing. Since the arm choice depends on the past context and reward pairs, the contexts of chosen arms suffer from correlation and render the analysis difficult.We propose a novel multi-armed linear contextual bandit algorithm called Doubly Robust (DR) Thompson Sampling that applies the DR technique used in missing data literature to Thompson Sampling with contexts (LinTS). The proposed algorithm improves the bound of LinTS by a factor of $\sqrt{d}$, where \(d\) is the dimension of the context, under some regularity assumptions.A benefit of the proposed method is that it uses all the context data, chosen or not chosen, thus allowing to circumvent the technical definition of unsaturated arms used in theoretical analysis of LinTS.

2 - Contextual Pareto Bandit Under Covariate Shift

Apurv Shukla, Columbia University, New York, NY, 10025-1868, United States

We consider the contextual bandit problem under covariate shift and vectorial rewards. We propose a tree-based policy that maintains separately discretizes action and covariate spaces. For vectorial feedback, we use Contextual Pareto regret as the performance metric of the proposed policy. We establish an upper bound on the performance of the proposed policy for multiple-models of covariate shift including single, multiple and smoothly varying context distributions. Finally, the efficacy of the proposed policy is described on a suite of numerical experiments.

3 - Taylor Expansion Policy Optimization For Scalable Off-policy Reinforcement Learning

Yunhao Tang, Columbia University, United States

In this talk, I will focus on a model-free off-policy reinforcement learning (RL) framework called Taylor Expansion Policy Optimization (TayPO). TayPO is a principled framework with important theoretical insights: it generalizes prior work on trust region policy search and draws close connections to operator-based off-policy evaluation. TayPO also entails empirical performance gains on large-scale distributed RL agents, such as R2D2 and IMPALA, when evaluated on Atari-57 games.

4 - Sparsity-Agnostic Lasso Bandit

Min-hwan Oh, Seoul National University, Seoul, 08826, Korea, Republic of, Garud N. Iyengar, Assaf Zeevi

We consider a stochastic contextual bandit problem where the dimension d of the feature vectors is potentially large, however, only a sparse subset of features of cardinality s d affect the reward function. Essentially all existing algorithms for sparse bandits require a priori knowledge of the value of the sparsity index s. This knowledge is almost never available in practice, and misspecification of this parameter can lead to severe deterioration in the performance of existing methods. The main contribution of this paper is to propose an algorithm that does not require prior knowledge of the sparsity index s and establish tight regret bounds on its performance under suitable regularity conditions. We also numerically show that it consistently outperforms existing methods, even when the correct sparsity index is revealed to them but is kept hidden from our algorithm.

■ VWB17

Virtual Room 17

Operations Research at Facebook

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Amine Allouah, Columbia University, New York, NY, 10027, United States

Co-Chair: Okke Schrijvers, Facebook Inc, Menlo Park, CA, United States

1 - Max-weight Matching With Product Weights: The Ad Types Problem

Julian Mestre, Facebook Core Data Science, Menlo Park, CA, United States

The Ad Types Problem (without gap rules) is a special case of the assignment problem in which there are k types of nodes on one side (the ads), and an ordered set of nodes on the other side (the slots). The edge weight of an ad i of type to slot j is vi time a discount factor where vi is an advertiser-specific value and each ad type has a discount curve over the slots. We present two contributions for this problem: 1) we give an algorithm that finds the maximum weight matching that runs in O(n2(k+logn)) time for n slots and n ads of each type---cf. O(kn3) when using the Hungarian algorithm---, and 2) we show to do VCG pricing in asymptotically the same time, namely O(n2(k+logn)), and apply reserve prices in O(n3(k+logn)).

2 - Optimal Spend Rate Estimation And Pacing For Ad Campaigns With Budgets

Bhuvesh Kumar, Georgia Institute of Technology, Atlanta, GA, United States, bhuvesh@gatech.edu, Okke Schrijvers, Jamie Morgenstern

Online ad platforms offer budget management tools for advertisers that aim to maximize the number of conversions given a budget constraint. As the volume of impressions, conversion rates and prices vary over time, these budget management systems construct a spend plan and run a pacing algorithm to find a bidding strategy which follows the spend plan. We introduce a dynamic, episodic model of impressions and competition, and present the first learning theoretic guarantees on both the accuracy of spend plans and the resulting end-to-end budget management system. We give sample complexity bounds for the spend rate prediction problem and extend the algorithm of Balseiro and Gur [2019] to operate on varying spend rates and we show that the resulting combined system of optimal spend rate estimation and online pacing algorithm has sublinear - regret using $\tilde{O}(-3)$ samples.

3 - The Parity Ray Regularizer For Pacing In Auction Markets

Andrea Celli, Bocconi University, Milano, Italy

Internet advertising platforms typically offer advertisers the possibility to pace the rate at which their budget is depleted, through budget-pacing mechanisms. We focus on multiplicative pacing mechanisms in an online setting in which a bidder is repeatedly confronted with a series of advertising opportunities. Building on recent work, we study the frequent case in which advertisers seek to reach a certain distribution of impressions over a target population of users. We introduce a novel regularizer to achieve this desideratum, and show how to integrate it into an online mirror descent scheme with optimal order of sub-linear regret when inputs are drawn independently, from an unknown distribution. We demonstrate its effectiveness through numerical experiments on real-world data.

■ VWB18

Virtual Room 18

Information Systems III

Contributed Session

Chair: Sina Zare, Arkansas State University, United States

1 - Bridging Network Effects: Product Interactions For Ride-hailing Platforms

Jinan Lin, Paul Merage School of Business, UC Irvine, Irvine, CA, United States, Tingting Nian,
Bo (Rambo) Tan, Cheng Gong

We investigate the impacts of Didi carpool with interactions to Didi solo rides, under strong network effects from a leading ride-hailing platform. Our study provides supporting evidence that Didi carpool lifts overall spending, and reduces unit cost significantly for riders, whereas drivers' earnings also increase after the introduction of Didi carpool. We also test the cannibalization effects between carpool and solo rides. Carpool improves the platform efficiency by reducing geographic dispersion of drivers and encourage riders to explore city landscape. We discuss extensive heterogeneous effects from freelance drivers, high-rating drivers, entrant riders and bi-product riders.

2 - Understanding Differential Effects Of Social Network Capital On The Crowdsourced Answering Process In Stack Overflow
Orcun Temizkan, Ozyegin University, Istanbul, Turkey, Ram Kumar

Virtual Question and Answer (VQ&A) communities are becoming increasingly important in today's knowledge intensive environment. They represent a crowdsourced knowledge creation process that involves volunteer participants, and thus they are large repositories of online knowledge. A knowledge creation process may require different types and degree of social network capital of participants based on the complexity of the VQ&A process. We develop and empirically test models of the differential effects of social network capital on the VQ&A process. Empirical results based on data from Stack Overflow will be presented. Research and managerial implications will also be discussed.

3 - Team Alliance Strategies In Crowdsourcing Platforms
Sina Zare, Arkansas State University, Jonesboro, AR, United States,

Various factors play crucial roles in team alliance that may originate from the tendency to work with those who have similar technical backgrounds. On the contrary, the lack of specific expertise may initiate alliance and collaboration across teams. This study investigates alliance strategies and motivations in crowdsourcing platforms.

■ VWB19

Virtual Room 19

Learning and Optimization in Decision Making

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: David Simchi-Levi, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

Co-Chair: Xiaoyue Gong, MIT, Cambridge, MA, 02139-4301, United States

1 - On Adaptivity and Confounding in Contextual Bandit Experiments
Chao Qin, Columbia University, Daniel Russo

Multi-armed bandit algorithms minimize experimentation costs required to converge on optimal behavior. They do so by rapidly adapting experimentation effort away from poorly performing alternatives as feedback is observed. But this desirable feature makes them sensitive to confounding. We highlight, for instance, that popular bandit algorithms can't address the problem of identifying the best action when day-of-week effects may confound inferences. In response, this paper proposes simple, but critical, modifications to the Thompson sampling algorithm. Theoretical guarantees suggest the new algorithm strikes a delicate balance between adaptivity and robustness to confounding. It attains asymptotic lower bounds on the number of samples required to confidently identify the best action --- suggesting optimal adaptivity --- but also satisfies strong performance guarantees in the presence of day-of-week effects and delayed observations --- suggesting unusual robustness. These issues are explored through a very general model of contextual bandit experiments. The paper includes several new results that advance previous theory of Thompson sampling in such problems, which may be of independent interest.

2 - Chasing Convex Bodies Optimally
Mark Sellke, Stanford University

I will explain our recent understanding of the chasing convex bodies problem posed by Friedman and Linial in 1993. In this problem, a player receives a request sequence K_1,...,K_T of convex sets in d dimensional space and moves online into each requested set. The player's movement cost is the length of the resulting path. Chasing convex bodies asks to find an online algorithm with cost competitive against the offline (in hindsight) optimal path. This is equivalent to a competitive analysis view on online convex optimization. Obtaining any finite competitive ratio for this problem was open until 2018. We give an optimal algorithm based on an object from classical convex geometry known as the Steiner point.

3 - Simultaneous Learning Of Consumer Preference Over Different Markets.
Fabricio Previgliano, University of chicago, Chicago, IL, United States

We study the ranking and selection problem faced by a company that wants to identify the most prefered product among a finite set of alternatives when consumer preferences are unknown over different markets that may have similar characteristics. The company is able to sequentially display a subset of products to different customers on each market and ask them to report their top preference over the displayed set. The objective of the firm is to design a display policy that minimizes the expected number of samples needed to identify a top product on each market with a fixed high probability.

4 - Dynamic Planning And Learning Under Recovering Rewards
Feng Zhu, MIT IDSS, Boston, MA, United States, David Simchi-Levi, Zeyu Zheng

Motivated by emerging applications in promotions and recommendations, we introduce a general class of multi-armed bandit problems that satisifies: (i) at most K out of N different arms are allowed to be pulled in each time period; (ii) the expected reward of an arm immediately drops after it is pulled, and then non-parametrically recovers as the idle time increases. To maximize expected cumulative rewards over T time periods, we propose and prove performance guarantees for a class of "Purely Periodic Policies". For the offline problem when all model parameters are known, our proposed policy obtains an asymptotically tight approximation ratio that is at the order of 1-O(1/K1/2). For the online problem when the model parameters are unknown and need to be learned, we design an Upper Confidence Bound (UCB) based policy that has O(NT1/2) regret against the offline benchmark.

5 - Multi-armed Bandits With Temporal Structure
Qinyi Chen, Massachusetts Institute of Technology, Cambridge, MA, 02139, United States, Negin Golrezaei, Djallel Bouneffouf

Existing online learning algorithms are tailored to environments that are either stationary and predictable or adversarial and completely unpredictable. However, in many practical applications, including dynamic pricing and financial recommendation systems, the underlying environments are non-stationary but exhibit certain temporal structures. In our work, we design learning algorithms that take advantage of the underlying temporal structure. In particular, we study the multi-armed bandits problem with autoregressive rewards, and devise an algorithm that displays near-optimal performance with respect to the best dynamic policy. We establish a regret lower bound result that encapsulates the temporal structure, and in addition show that our algorithm attains a regret upper bound that almost matches the lower bound.

■ VWB20

Virtual Room 20

Markets and Service Systems

Sponsored: Applied Probability Society

Sponsored Session

Chair: Krishnamurthy Iyer, University of Minnesota, Saint Paul, MN, 55114-1380, United States

1 - Spatiotemporal Disease Transmission In Queueing Systems
Sherwin Doroudi, University of Minnesota, Minneapolis, MN, 55455-0150, United States, , Kang Kang, Mohammad Delasay, Alexander Wickeham

Motivated by the ongoing COVID-19 pandemic, we draw upon existing models of disease transmission to introduce a new framework for assessing the risk of infections in service facilities (e.g., grocery stores) that can be modeled as queueing systems. In our framework, the likelihood of disease transmission from one customer to another depends on both (i) the physical distance between these customers over time and (ii) the amount of time they spend together in the system. We leverage our framework to assess the impact of the choice of physical queueing layout design on transmission risks.

2 - SRPT In Multiserver Queues With Abandonment
Rouba Ibrahim, University College London, 1 Canada Square, School of Management, Level 38, C, London, E14 5AB, United Kingdom, rouba.ibrahim@ucl.ac.uk, Jing Dong

The shortest-remaining-processing-time (SRPT) scheduling policy hasbeen extensively studied, for more than 50 years, in single-server queues with infinitely patient jobs. Yet, much less is known about its performance in multi-server queues. In this paper, we present the first theoretical analysis of SRPT in multi-server queues with abandonment.

3 - Behavior-Aware Queueing
Raga Gopalakrishnan, Assistant Professor of Operations Management, Smith School of Business at Queen's University, Kingston, ON, Canada, Yueyang Zhong, Amy R. Ward

Service system design is often informed by queueing theory. Traditional queueing theory assumes that servers work at constant speeds. That is reasonable in computer science and manufacturing contexts. However, servers in service systems are people, and, in contrast to machines, both systemic and monetary incentives created by design decisions influence their work speeds. We study how server work speed is affected by decisions concerning (i) how many servers to staff, (ii) payment per service completion to servers, 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. This talk is complementary to Amy Ward's talk in Session ID 912.

4 - The Cost Of Decentralized Persuasion
Niloufar Mirzavand Boroujeni, University of Minnesota-Twin Cities, Minneapolis, MN, United States, Krishnamurthy Iyer, William L Cooper

We consider the problem of optimal information sharing in a multi-agent system offering service to an arriving customer. We study centralized signaling mechanisms in which the system sends a single signal containing information about the state of all agents and decentralized signaling mechanisms in which each agent sends a single signal containing information only about her localized state to the customer upon her arrival. We consider the relative gap between the expected utility of these two settings, and derive bounds on that gap for systems with an arbitrary number of symmetric agents. We obtain additional results in the special case of 2-agent systems with uniformly distributed states and linear customer pay-off function.

■ VWB22

Virtual Room 22

IISE Transaction Invited Session

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Judy Jin, University of Michigan, University of Michigan, A nn Arbor, MI, 48109-2117, United States

1 - Moderator
Judy Jin, University of Michigan, Ann Arbor, MI, 48109-2117, United States

2 - Panelist
Xiaoyu Chen, Assistant Professor, University of Louisville, Louisville, KY, 24060-2575, United States, xiaoyuch@vt.edu

3 - A Hybrid Transfer Learning Framework For In-plane Freeform Shape Accuracy Control In Additive Manufacturing
Kai Wang, Assistant Professor, Xi'an Jiaotong University, Xi'an, China

4 - A Bayesian Deep Learning Framework For Interval Estimation Of Remaining Useful Life In Complex Systems By Incorporating General Degradation Characteristics
Minhee Kim, University of Wisconsin-Madison, Madison, WI, 53706-1539, United States

■ VWB23

Virtual Room 23

Data-driven Methods for Systems Engineering

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Jialei Chen, Georgia Tech, Georgia Tech, Atlanta, GA, 30339-2258, United States

Co-Chair: Hongyue Sun, University at Buffalo, Buffalo, NY, 14260-2000, United States

1 - An Adaptive Data-driven Kernel for Blind Image Deblurring
Sajjad Amrollahi Biyouki, The University of Tennessee, Knoxville, TN, United States, Hoon Hwangbo

Blind Image deblurring tries to estimate blurriness and recover a latent image out of a blurred image. This process, as being an ill-posed problem, requires imposing restrictions either on the latent image or a blur kernel representing blurriness. Different from recent studies that impose some priors on the latent image, this research explicitly formulates the structure of the underlying kernel where the structure itself is adaptive to data, which enables modeling nearly non-parametric shape of blurriness. When applied to the recovery of satellite images, the recovered images show the superiority of the proposed method to other state-of-the-art approaches.

2 - Emulation Model For Personalized Bio-manufacturing
Jialei Chen, Georgia Tech, Atlanta, GA, United States, Roshan V Joseph, Chuck Zhang

We proposed a multiple-output emulation model, and its application to personalized biomanufacturing.

3 - Surface Temperature Monitoring In Liver Procurement Via Time-vertex Signal Processing
Sahand Hajifar, University at Buffalo, Buffalo, NY, United States, sahandha@buffalo.edu, Hongyue Sun

Accurate evaluation of liver viability during its procurement is a challenging issue. Recently, people have started to investigate the non-invasive evaluation of liver viability during its procurement using the liver surface thermal images. However, existing works attempt to evaluate quality of the liver by extracting either temporal temperature variation or spatial temperature variation. The objective of this study is to jointly extract spatiotemporal (belonging to both space and time) variations to evaluate quality of the liver. To achieve this objective, we use techniques from time-vertex signal processing. In particular, we use joint Fourier transform (JFT) to extract features that contain information from both time and space domains. Then, we use a high-dimensional control chart to monitor the features and estimate the change point.

4 - Active Learning For Image Classification Of 2d Mos2 With Deep-reinforcement-learning-based Query Strategy
Zebin Li, University at Buffalo, SUNY, Buffalo, NY, United States, Fei Yao, Hongyue Sun

Molybdenum disulfide (MoS2) is one of the promising 2D materials that has nice properties and broad applications, especially in semiconductor devices. The commonly fabricating technique for 2D MoS2 is through chemical vapor deposition (CVD). However, the evaluation of the CVD-synthesized 2D MoS2 via optical images is time-consuming and heavy for researchers. In this work, we proposed an active learning image classifier with a deep-reinforcement-learning (DRL)-based query strategy. The classifier can reach a high accuracy with fewer labels required from researchers, which is able to reduce the workload of researchers. Compared with the uncertainty-based query strategy, the DRL-based query strategy improves the acquisition of effective information. This work shows the effectiveness of applying DRL in active learning and demonstrates a good integration of them.

5 - Inkjet Printing Droplet Evolution Prediction via Tensor Time Series
Luis Javier Segura, University at Buffalo, Buffalo, NY, United States, Zebin Li, Luis Javier Segura, Hongyur Sun

Droplet behaviors substantially determine the quality of the produced products in the Inkjet Printing (IJP). The droplet formation mechanism (i.e., droplet evolution) understanding is fundamental for the process performance. This work investigates droplet evolution prediction via Tensor Time Series analysis. The method learns the spatial-temporal relationships by joining the force of Tensor Graph Convolutional Network (TGCN) and Tensor Recurrent Neural Network (TRNN). The method is tested in experimental and simulated droplet evolution data in the IJP process.

6 - Suspicious Machine Selection In A Serial-parallel Multistage Manufacturing Process: Production Log Data-based Approach
Seung-Hyun Choi, Postech, Pohang, Korea, Republic of, cshyun102@postech.ac.kr, Dong-Hee Lee, Eun-Su Kim, Young-Mok Bae, Young-Chan Oh, Kwang-Jae Kim

Serial-Parallel multistage manufacturing process consists of multiple process stages, each of which has several alternative machines. Performance of machines in a process stage is not identical and faulty machine tends to produce more defective products. In order to reduce efforts for diagnosing faulty machines, it is desirable to first find machines that are suspected of being faulty, called suspicious machines. This study proposes a method to select suspicious machines using production log data, which record a sequence of operating machines for each product. The proposed method is illustrated using a case study on a ring-shaped pattern of defectives in semiconductor manufacturing process.

■ VWB24

Virtual Room 24

Advances in Analytics for Additive Manufacturing

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Cesar Ruiz,

1 - Surface Morphology Analysis Using Robust Autoencoder In Additive Manufacturing With Laser Engineered Net Shaping
Zhangyue Shi, Oklahoma State University, Stillwater, OK, 74074-2619, United States, Chenang Liu

Additive manufacturing (AM) has gained increasing popularity in various quality critical applications. However, the relatively poor layer-wise surface quality may lead to compromised property and functionality of AM products. Therefore, it is critically needed to analyze surface morphology in AM and further correlate morphology features with machine parameters. In practice, there are two major challenges: (1) surface profiles are usually highly nonlinear; and (2) a large fraction of outliers and missing regions may exist in measured surface profile. To address these challenges, this paper applies a robust autoencoder-based approach to extract informative features from surface profile. The case studies demonstrated that this approach is very promising for surface morphology analysis and quality assurance in AM.

2 - Smart Sensor Fusion of Infrared and Ultrasonic Characterization for Additive Manufacturing Quality Control

Christian Zamiela, Mississippi State University, MS, United States, cez39@msstate.edu, Wenmeng Tian, Linkan Bian

The objective is to develop a deep fusion methodology for porosity detection using in-situ infrared and ex-situ ultrasonic images. A core problem with Laser-based additive manufacturing (LBAM) is that lack of fusion between successive layers of printed metal can lead to porosity and abnormalities in the printed component. We developed a deep fusion methodology that fills the gap in fusing in-situ images with ex-situ images to improve porosity detection. An ultrasonic infrared fusion network (UIF-Net), a deep fusion methodology for feature extraction of ultrasonic and infrared data is presented in this study. This is the first work for fusing in-situ infrared images and ex-situ ultrasonic scans using deep learning. The method is validated using real-world experiments, and the results show significant improvement in prediction accuracy via data fusion.

3 - A Prediction-oriented Optimal Design for Visualizaation Recommender Systems

Yingyan Zeng, Virginia Tech, Blacksburg, VA, United States, Xinwei Deng, Xiaoyu Chen, Ran Jin

A good visualization method can greatly enhance human-machine collaboration. Visualization recommender systems have been developed to provide the right visualization method to the right person in target contexts. A visualization recommender system often relies on a user study to collect data for personalized recommendations. However, a user study without an effective experimental design is expensive in terms of time and cost. In this work, we propose a prediction-oriented optimal design to determine the user-task allocation in the user study for the recommendation of visualization methods. The proposed optimal design will not only encourage the learning of the similarity embedded in the recommendation responses (i.e., users' preference) but also improve the modeling accuracy of the similarities captured by the covariates of contexts (i.e., task attributes).

4 - Calibration And Validation For Lpbf Process Based On Models And Limited Experimental Data

Zhimin Xi, Rutgers University-New Brunswick, Piscataway, NJ, 08854, United States

To date, modeling techniques for the SLM process are either computationally expensive based on finite element (FE) modeling or economically expensive requiring significant amount of experiment data for data-driven modeling. We propose the combination of FE and data-driven modeling with systematic calibration and validation framework for the SLM process based on limited experiment data. The data-driven modeling is conducted based on virtual experiment data from the FE modeling instead of the real experiment data, and its accuracy is later improved based on limited real experiment data through the calibration and validation framework. The proposed work enables the development of highly efficient and accurate models for melt pool prediction of the SLM process under various configurations.

5 - Digital Twin To Enable Closed Loop Control Of Additive Manufacturing Processes

Jun Zeng, HP Labs, 1501 Page Mill Road, Palo Alto, CA, 94304, United States

While additive manufacturing sees accelerated applications in volume production, higher production yield competing with mainstream manufacturing will demand more sophisticated process control to deliver final products in both geometry and function with precision. We develop Digital Twin that replicates virtually the dynamics of manufacturing processes and product evolution. It exploits processing and sensing dataset collected to ensure prediction specificity overcoming process variations. It is deployed as closed loop control of additive manufacturing process flow in the form of automated product design correction and automated process tuning.

■ VWB25

Virtual Room 25

Robust Prescriptive Analytics

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Qinshen Tang, Nanyang Techonological University, Singapore, 639798, Singapore

1 - Vehicle Repositioning under Uncertainty

Yu Zhang, Southwestern University of Finance and Economics, Northeastern University, Wenhua Road,, Heping Dis, Chengdu, 110819, China, Melvyn Sim, Qinshen Tang, Minglong Zhou

We consider a general multi-period repositioning problem in vehicle-sharing networks. This problem is subject to uncertainties along multiple dimensions and faces several operational constraints such as the service level and cost budget. We propose a robustness optimization model to tackle these uncertainties; thus we aim to satisfy operational constraints under a reference distribution yet also to protect against ambiguity in the true distribution. This paper is the first, as far as we know, to incorporate various time-dependent uncertainties. We then reformulate the model and efficiently obtain solutions by solving a sequence of mixed-integer linear optimization problems. Extensive simulation studies demonstrate that our model yields remarkable performance in various settings and is computationally scalable.

2 - The Analytics Of Robust Satisficing

Minglong Zhou, NUS, 1 Business Link, Singapore, 117592, Singapore, Melvyn Sim, Qinshen Tang, Taozeng Zhu

While there are many prescriptive analytics tools for maximizers, it is not the case for satisficers, who are content with attaining a reasonable target. We develop a new optimization framework called robust satisficing to help a satisficer achieve her target expected reward under risks and prediction uncertainty. We extend the robustness optimization framework to incorporate predictions. We adopt linear regression as the predictive model and propose a estimator uncertainty and residual ambiguity set. We present useful robust satisficing models and provide approximations for adaptive linear optimization problems. Simulation studies elucidate the benefits of our framework in helping the firm attain the target expected profits, mitigate shortfalls, and limit target surplus. Paradoxically, maximizers can also benefit from the analytics of robust satisficing.

3 - Robust Capacity Management With Multiple Demand Classes

JUN Jiang, National University of Singapore, Singapore, Zhenyu Hu, Long He

We consider the demand matching problem of one product and multiple demand classes where demand distributions are from Type-∞ Wasserstein ambiguity set. We provide a conic programming formulation for the single-period Distributionally Robust Optimization (DRO) model under the Hurwicz criterion and show that the optimal policy for the multiple-period DRO model is a rationing-level policy when demands are assumed to be temporally independent and ambiguity sets are rectangular. Efficient solution approaches are provided when distance of demands are defined in 1-norm or ∞-norm.

4 - Joint Prediction And Optimization For Multiproduct Pricing And Inventory Management

Qinshen Tang, Nanyang Techonological University, Division of IT & Operations Management, 50 Nanyang, Singapore, 639798, Singapore, Ying Rong, Xun Zhang

We adopt the robust satisficing (RS) framework in Sim et al. (2021) to explore the multiproduct pricing and inventory management problem with covariate information. The RS model is reformulated into a second order conic programming problem. Our extensive numerical studies demonstrate that the RS model can be solved efficiently, and the RS model outperforms the empirical optimization model.

■ VWB26

Virtual Room 26

Blockchain in OM

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Dmitrii Sumkin, INSEAD, INSEAD, Singapore, 138676, Singapore

1 - Pricing In Service Platforms: Who Should Set The Prices?

Tolga Dizdarer, Wharton School of Business, Jon M. Huntsman Hall 3730 Walnut St 533.1, Philadelphia, PA, 19104-3615, United States, dizdarer@wharton.upenn.edu, Gerard P. Cachon, Gerry Tsoukalas

Motivated by emergence of blockchain-based decentralized service platforms and Uber's recent 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 - On The Financial Inclusion And Sustainability Benefits Of Blockchain Adoption In Agriculture

Basak Kalkanci, Georgia Institute of Technology, 800 W Peachtree St Nw, Atlanta, GA, 30308-1149, United States, basak.kalkanci@scheller.gatech.edu, Saed Alizamir, Foad Iravani

An emerging financial innovation enabled by the Blockchain technology 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 find that tipping capability can make farmers and consumers worse off in expectation, or may increase income disparity among farmers.

3 - Blockchain-Enabled Deep-Tier Supply Chain Finance
Fasheng Xu, Syracuse University, 721 University Avenue, Syracuse, NY, 13244-4418, United States, Lingxiu Dong, Yunzhe Qiu

For many supply chains, deep-tier suppliers, due to their small sizes and lack of access to capital, are most vulnerable to disruptions. In this paper, we study the use of advance payment (AP) as a financing instrument in a multitier supply chain to mitigate the supply disruption risk and compare the traditional system (deep-tier financing with limited visibility) with the blockchain-enabled system (financing with perfect visibility). The main goal of this paper is to shed light on how blockchain adoption impacts agents' operational and financial decisions as well profit levels in a multitier supply chain.

4 - Optimal Cash Management With Payables Finance
Xiaoyue Yan, Cornell University, Ithaca, NY, United States, xy393@cornell.edu, Li Chen, Xiaobo Ding

Payables finance provides a supplier with the option to receive a buyer's payables early while allowing the buyer to extend its payment due date. Its recent adoption of blockchain technology has made the process more efficient and secure. In this paper, we study the supplier's optimal cash management policy under such a "frictionless" payables finance arrangement, based on which we quantify the value of payables finance to the supplier and also determine the equilibrium payment term extension for the buyer. Our work extends the classic cash management models to allow all interest gains and costs to accrue together with the cash balance. Our analysis reveals that the optimal cash policy has a cash balance-dependent (L, M, U) structure. We show that it is the cash liquidity enabled by payables finance to hedge cash flow uncertainty that generates value to the supplier.

■ VWB27

Virtual Room 27

Sustainable Operations

Contributed Session

Chair: Ying Cao, Penn State Erie The Behrend College, 6390 Pond Vw, Fairview, PA, 16415, United States

1 - Examining The Sustainability Frontier: Sustainability Performance Versus Efficiency
Meltem Denizel, Associate Professor, Iowa State University, Ames, IA, United States, mdenizel@iastate.edu, Yiming Zhuang, Frank Montabon

Sustainability undertakings require efficient use of resources to achieve the desired performance. This leads to the question of how efficient companies are in their sustainability practices. Relying on data from CSRHub, we employ DEA to evaluate the sustainability efficiency of 1141 large U.S. manufacturing companies from 2009 to 2018.

2 - Responsible Sourcing Traceability
Jen-Yi Chen, Cleveland State University, Cleveland, OH, United States, j.chen27@csuohio.edu

This paper aims to answer two questions: first, why some companies would rather risking great and costly reputational damage than trace the provenance of their projects and thus not fully comply with transparency regulations while the other companies of similar kinds would do the opposite? Second, what can external stakeholders, like government agencies, NGOs or investors, do to not just encourage more supply chain transparency but more importantly more responsible supply chains?

3 - Green Tech, Social Media And Uncertainty
Wenqing Zhang, University of Minnesota Duluth, Duluth, MN, United States, Prasad Padmanabhan, Chia-Hsing Huang, Rajesh Rajaguru

There has been increased pressure by a variety of internal and external stakeholders to persuade firms to invest in green technologies. For example, firms face social media pressures to adopt policies that promote non-financial objectives of the community. The adoption of green technologies by firms may provide benefits that do not exceed the costs of adoption many may seek alternate non-green methods that can provide output that can achieve a satisfying level of strategic performance. We use a game theoretic model to see how social media affect the green technology adoptions.

4 - Acquisition Of Used Products For Remanufacturing
Akshay Mutha, University of Vermont, Burlington, VT, United States, akshay.mutha@uvm.edu, Saurabh Bansal

We develop models to analyze the process of acquiring used products for remanufacturing. We perform numerical analyses to show the applicability of our models.

5 - Selecting Remanufacturing Technology From The Perspective Of Assortment Planning
Ying Cao, Assistant Professor, Penn State Erie The Behrend College, Erie, PA, United States, yxc673@psu.edu, Kai Meng, Xianghui Peng

In a closed-loop supply chain, manufacturers are often exposed to various remanufacturing method alternatives. Choosing a subset of the potential options is a crucial decision for both profit and environment. We study the selection of remanufacturing technologies from the perspective assortment planning. We explore different demand models and develop properties of the optimal solution and managerial insights. In addition, we study the impact on the manufacturer's profit from influencing the collection rate of end-of-life (EOL) product(s).

■ VWB28

Virtual Room 28

Healthcare Research and Innovation at Mayo Clinic

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Behrooz Pourghannad, University of Minnesota, University of Minnesota, Rochester, MN, 55901-4841, United States

Co-Chair: Kalyan Pasupathy, Mayo Clinic, Mayo Clinic, Rochester, MN, 55905, United States

1 - Partially-partitioned Templating Strategies For Outpatient Specialty Practices
Miao Bai, University of Connecticut, 2100a Hillside Rd Unit U1041, Storrs, CT, 06269-1041, United States, miao.bai@uconn.edu, Bjorn Berg, Esra Sisikoglu Sir, Mustafa Y Sir

Templating strategies specify policies on capacity allocation and appointment booking in outpatient specialty practices. In the widely-used partitioned templating strategy, appointment slots are allocated exclusively to each patient group, which often results in utilization challenges. We propose partially-partitioned templating strategies that cluster patient groups into access classes and allocate appointment slots to these classes. We formulate a two-stage stochastic optimization model to optimize decisions in the strategy design and develop an efficient solution algorithm based on Benders' cuts and an anticipatory approximation. Numerical experiments show that the proposed strategies outperform benchmark strategies through maintaining a balance of high capacity utilization and providing timely access for priority patients.

2 - Presenter
Kalyan Pasupathy, University of Illinois at Chicago, 200 First Street SW, Harwick 2-43, Chicago, IL, 55905, United States, kap@uic.edu

This session features various topics in the area of Information and Decision Sciences. Join the session to learn about the history and background of Learning Laboratories and the journey of projects from concept through translation and implementation.

3 - Predicting Risk Of Surgery In Patients With Small Bowel Crohn'S Disease
Narges Shahraki, Mayo Clinic, Rochester, MN, 55901-4841, United States, Akitoshi Inoue, Mohammad Samie Tootooni, Kalyan Pasupathy, David Bruining, Joel Fletcher

We develop a predictive model to assist physicians and patients in decision-making regarding the likelihood of response to medical therapy versus moving quickly to surgery, especially for Crohn's patients with probable strictures. The predictive model incorporates CTE/MRE imaging findings and patient symptoms to predict the risk for near term surgery (e.g., within 2 years). We use logistic regression and the Least Absolute Shrinkage and Selection Operator (LASSO) to make the predictions. The model demonstrate an accuracy of 91% in the training set and 75% accuracy in the validation set.

4 - Feature Importance Characterization of Diagnostic Error Cases in the Emergency Department
Moein Enayati, Mayo Clinic, Rochester, MN, 65211, United States, Daniel Cabrera, Nasibeh Zanjirani Farahani, Fernanda Bellolio, Hardeep Singh, Prashant Singh, Kalyan Pasupathy

Background: Diagnostic decision-making in emergency departments (ED) is a complex process that involves uncertainty and susceptibility to errors.Method: We aimed to identify variables associated with diagnostic errors in the ED by applying trigger algorithms on the EHR data. An emergency physician reviewed all T-positive cases to verify instances of errors or missed diagnoses.Results: Among the total of 341 reviewed charts, 91 were T-positive with 12 of them verified for diagnostic errors. Statistical comparison to recognize important feature variances showed T-positive patients have 3 times higher mortality rate, 91% higher LOS in the hospital, whereas their LOS in the ED was almost the same.

■ VWB29

Virtual Room 29

Practice-Based Empirical Research

Sponsored: MSOM/iForm

Sponsored Session

Chair: Annick Nusselder, MSD Animal Health, Boxmeer, Netherlands

1 - Operations Research Improves Biomanufacturing Efficiency At MSD

Annick Nusselder, MSD Animal Health, Boxmeer, Netherlands, annicknusselder@gmail.com, Tugce Martagan, Geert-Jan Van Houtum

Biomanufacturing methods use living organisms to generate active ingredients, and this leads to challenges that are different to those incurred by other industries. We present a portfolio of optimization models and decision support tools to reduce biomanufacturing costs and lead times. Real-world implementation at MSD resulted in 50 million savings.

2 - ONLINE LEARNING AND EDUCATIONAL INEQUALITY

Zhanzhi Zheng, Tianjin University, Tianjin, China, zzz15241179@tju.edu.cn, Ruomeng Cui, Shenyang Jiang

Online learning changes the learning environment compared to the brick-and-mortar learning at schools. The COVID-19 pandemic has forced students to face the sudden transition to online learning, leading to significant changes in home and school learning environments. How such huge and sudden changes in the learning environment affect educational inequality between students in high-resource and low-resource areas is an interesting and important research question. In this research, we use the performance of high schools in China at the national college entrance examination (NCEE) from 2018 to 2020 to answer this question. Results suggest that after transitioning to online learning, learning outcomes of students in low-resource areas have increased 20.44-percent relative to students in the high-resource areas, reducing educational inequality.

3 - Simulating Patient Backlog Mitigation Strategies For Non-emergency Procedures Under Reduced Capacity During The Covid-19 Pandemic

Aidan Haase, University of Michigan, Department Of Ioe 1205 Beal Ave, Ann Arbor, MI, 48109-2117, United States, haasea@umich.edu, Adam VanDeusen, Amy Cohn, Sameer Saini, Jacob Kurlander

COVID-19 impacted the healthcare system in many ways, including the cancellation or deferral of non-urgent appointments due to reducing capacity to keep patients safe and abide by governmental orders. This capacity reduction led to a backlog of patients waiting for appointments. We developed a discrete-event simulation to model how a clinical facility may triage patients to either alternative or delayed appointment options. Our model considers tiered reopening stages, in which appointment capacity is incrementally added back as restrictions are loosened. We applied our model to outpatient endoscopy procedures at a Veterans Affairs (VA) clinic in Ann Arbor, Michigan. We considered patients at different risk levels who arrive each week and are seen by providers, with the highest priority patients being seen first and lower priority patients waiting in a queue.

■ VWB30

Virtual Room 30

Transformation of Urban Mobility and Its Implications

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Hale Erkan, United States

1 - Toward Sustainable Cities: Bike Lane Planning With Endogenous Demand And Traffic Congestion

Jingwei Zhang, University of California-Los Angeles, 785 Weyburn Ter Apt C35, Los Angeles, CA, 90024-7212, United States, jingwei.zhang.phd@anderson.ucla.edu, Sheng Liu, Auyon Siddiq, Keji Wei

We study an urban bike lane planning problem considering endogenous demand and traffic congestion. Building bike lane attracts commuters to cycling and reduces traffic congestion, but narrows driving lanes and worsens traffic congestion. To investigate the net effect of bike lane construction on traffic congestion and improve cycling adoption, we formulate the network design problem as a bilevel programming problem. As model input, we structurally estimate travel time and mode choice model based on traffic equilibrium using data collected from multiple sources in downtown Chicago. As a result, we provide prescriptions on bike lane construction in the existing road network.

2 - Free Rides In Dockless, Electric Vehicle Sharing Systems

Bobby Nyotta, UCLA Anderson School of Management, 25369 Avenida Ronada, Los Angeles, CA, 91355-3203, United States, bobby.nyotta.1@anderson.ucla.edu, Fernanda Bravo, Jacob Feldman

We study free-ride policies as a mechanism to incentivize users of a dockless or free-floating electric vehicle sharing system (EVSS) to park vehicles at charging stations in order to maintain a charged fleet.

We develop an infinite horizon dynamic program to analyze free-ride policies. We build on this initial formulation to construct a mixed-integer program that outputs intuitive, battery-threshold rules for when to offer free rides.

In a discrete-event simulation model using real data from an EVSS, we compare the performance of this simple policy against other sophisticated policies, including the commonly used fine-based policy. Our simulation reveals this three-dimensional trade-off between customer satisfaction, revenue, and operational complexity. Our results are robust under many demand patterns and under a variety of network settings.

3 - Hyperlocal-Imbalance In Dockless Bike-Sharing Systems

Shivam Mishra, University of Maryland-College Park, College Park, MD, United States, smishra8@umd.edu, Ashish Kabra

Dockless bike/scooter-shares (e.g. Lime) have grown in popularity worldwide in recent years. While convenient for users, this free-floating model introduces operational challenges. We introduce a phenomenon that we term "hyperlocal imbalance" that stems from the user's behavior. In this talk, we demonstrate the extent of this phenomenon and its drivers.

■ VWB31

Virtual Room 31

Supply Chain Management I

Contributed Session

Chair: Hu Huang, Hong Kong, 000, China

1 - Information Updates In Supply Chains: Roles Of Blockchain

Xiutian Shi, Nanjing University of Science and Technology, Nanjing, China, xtshi@njust.edu.cn, Yajun Cai, Tsan-Ming Choi, Suresh Sethi

Today, emerging technologies such as data analytics and blockchain can improve supply chain operations by updating information to reduce demand uncertainty and improving data quality. We conduct a theoretical exploration of the values provided by such technologies in the context of a newsvendor supply chain facing a normally distributed demand with an unknown mean. We use Bayesian learning to reduce demand uncertainty based on the observation data, and discuss the expected value of information. We then study the "asymptotically perfect coordination" challenge and extend the analysis to examine the case when blockchain is used for product information disclosures.

2 - Manufacturer Selection In Multinational Supply Chain Based On Tariffs And Lead Time Compression

Feiyang Huang, Tongji University, Shanghai, China, shiningfeiyang@163.com, Jian Zhou, Chunyan Duan

Under the background of increased tariffs and uncertain market demand, this study establishes the newsvendor model consisting of a retailer and two multinational manufacturers. By quantifying tariffs and lead time, the impact on the selection of manufacturers is analyzed with simulation. The results show that, for short-life cycle products, compressing the lead time can offset the impact of tariffs and bring more benefits.

3 - Information Sharing In The Online Marketplace When Competing Sellers Make To Stock

Hu Huang, School of Business and Management, Hong Kong University of Science and Technology, Hong Kong, Hong Kong, Hongtao Zhang

We investigate the incentives for information sharing in a marketplace where multiple sellers distribute their partially substitutable products through a common online platform. The platform has information about the market state and may choose to share it with the sellers when they make stock decisions. Our analysis shows that the platform's information sharing decision depends on the stock cost, commission rate, and competing intensity. The platform should share information with more sellers when the stock cost is high, the commission rate is low, or the competing intensity is low. Besides, information sharing always benefits the informed seller while hurts the uninformed one.

■ VWB32

Virtual Room 32

Innovative Business Models in Supply Chain Management

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Xiaoyang Long, University of Wisconsin-Madison, University of Wisconsin-Madison, Madison, WI, 53706-1324, United States

1 - Brand Spillover As A Marketing Strategy

Xiaole Wu, Fudan University, Room 534, Siyuan Building, 670 Guoshun Road,, Shanghai, 200433, China, wuxiaole@fudan.edu.cn, Fuqiang Zhang, Yu Zhou

When a weak-brand firm and a strong-brand firm source from a common contract manufacturer, the weak-brand firm may advertise this relationship to promote its own product. This paper investigates whether the weak-brand firm should use such brand spillover as a marketing strategy and how this decision depends on the firms' characteristics and market conditions.

2 - Green Packaging Or Greenwashing? Implication Of Bring-your-own-container

Yunlong Peng, Tsinghua University, Beijing, China, pengyl.17@sem.tsinghua.edu.cn, Fei Gao, Jian Chen

Bring your own container/cups, i.e., BYOC has become a new prevalent trend among eco-conscious consumers in the restaurant industry. In response to consumers' environmental concerns, restaurants can make a choice between offering the green foodservice packaging or just engaging in greenwashing. In this paper, we develop a stylized model to study the impacts of BYOC on a firm's foodservice packaging decisions. We further study the scenario where greenwashing is stopped. Firstly, we find that the emergence of BYOC might promote rather than discourage the firm to choose green packaging or greenwashing, Secondly, with the existence of BYOC, stopping greenwashing might increase the profit of greenwashing firms but decrease the profit of green firms. Finally, stopping greenwashing could generate a negative impact on the environment when consumers' hassle cost is moderate.

3 - Retail Power: A Double Edged Sword For Suppliers

Shuya Yin, University of California-Irvine, Paul Merage School of Business, Irvine, CA, 92697-3125, United States, Yuhong He, Saibal Ray

In distribution channels, growing power of downstream firms (retailers) is a cause of both pleasure and pain for their upstream partners (suppliers). On one hand, suppliers rely on these key retailers to generate sales. On the other hand, these retailers may have the standing to negotiate vigorously on issues like sharing of channel revenues. We use an analytical model to explore how the level of product competition (whether they are differentiated or similar), the correlation between popularity of the retailers and their bargaining powers and intensity of competition from other channels shape a supplier's perspective about retail power: specifically, her preference about the structure of downstream retail distribution channel for her own product variants.

4 - Needs Title

Xingyu Fu, Hong Kong University of Science and Technology, Kowloon, Hong Kong, xfuai@connect.ust.hk, Ying-Ju Chen, Guillermo Gallego, Pin Gao

We study how a revenue-maximizing platform implements a new policy, from which a representative retailer also experiences a private externality. Our analysis suggests that: (1) when the policy is highly valuable for the platform's own interest, the platform may charge a fee from the retailer and then promise a less aggressive policy coverage; (2) when the policy is considerably expensive, in order to implement it, the platform may compensate the retailer and then share the full pie of the latter's revenue; (3) when the policy is mediocre to the platform, a hybrid occurs, where the platform may either charge a fee from the retailer or compensate to capture a portion of the retailer's realized revenue. Lastly, we carry out a series of comparative statics to show the impact on policy implementation when the externality distribution and the platform's self-interest change.

■ VWB33

Virtual Room 33

Supply Chain Management V

Contributed Session

Chair: Juzhi Zhang, University of Science and Technology of China, Hefei, 230026, China

1 - Empirically Predicting And Preventing Modern Slavery In Supply Chains

Joshua Schumm, Iowa State University, Ames, IA, United States, jschumm@iastate.edu, Frank Montabon, Kristin Rozier

Modern slavery in supply chains warrants attention (New, 2015), but few papers on modern slavery exist in supply chain literature. Techniques are needed to detect forced labor and predict how likely a given product, sourced from a given place, was made using slave labor. To this end, we apply a new methodological approach to preventing modern slavery in supply chains.

2 - Coordination Of A Green Industry 4.0 Supply Chain

Peral Toktas-Palut, Dogus University, Istanbul, Turkey, ppalut@dogus.edu.tr

Due to the deteriorating environmental conditions, eco-friendly production is gaining more importance. This awareness has also affected the consumers so that the demand for green products is increasing. Industry 4.0 technologies are also expected to have positive effects on the environment. This study analyzes the coordination of a green Industry 4.0 supply chain serving a green-conscious market. A two-part tariff contract is developed for this purpose. The results denote that the economic and environmental sustainability of the supply chain increases through coordination.

3 - A Dynamic Model Considering Consumer Green Awareness And Environmental Subsidy

Xin Liu, Elon University, Elon, NC, United States, xliu3@elon.edu, Xiaoya Han, Moutaz J Khouja

We optimize a firm's green level decisions considering consumer green awareness in a dynamic environment. The firm has the option of committing to a green level above the minimal regulatory green level (ARGL) and receive governmental subsidy depending on how much its green level in each period exceeds the ARGL.

4 - Supply Chain Management And COVID-19: Scientometric Analysis

Olga Biedova, Assistant Professor, College of Charleston, Charleston, SC, United States, biedovao@cofc.edu, Maryam Mahdikhani

Supply Chain Management (SCM) has matured in a well-researched and highly esteemed field. The ongoing pandemic intensifies interest in this field from the general public as well as various academic groups. In this study, we address the patterns in the SCM publications prior to and after the COVID-19 pandemic. In addition, we propose a novel method that utilizes supervised machine learning algorithms for predicting publication citation scores based on unsupervised latent topic analysis.

5 - Pareto Optimality And Contract Dependence In Supply Chain Coordination With Risk-averse Agents

Juzhi Zhang, University of Science and Technology of China, Hefei, China, Suresh P. Sethi, Tsan-Ming Choi, Edwin Cheng

This paper studies supply chain coordination (SCC) with risk-averse agents. We first explore the existing related literature and find that various definitions of SCC have been proposed to investigate SCC with risk-averse agents, among which the one based on the concept of Pareto optimality (PO) stands out. We then discuss the challenges of coordinating a supply chain under the PO criterion, notably the contract dependence of the achievability of PO. Finally, we provide methods and suggestions for SCC when it is impossible to establish PO.

■ VWB34

Virtual Room 34

Data Driven Perspectives on Gender in Production and Distribution

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Kamalini Ramdas, London Business School, London Business School, London, NW1 4SA, United Kingdom

Co-Chair: Amrita Kundu, Stanford Graduate School of Business, Stanford Graduate School of Business, London, NW1 4SA, United Kingdom

1 - Unmasking Sex Trafficking Supply Chains With Machine Learning

Pia Ramchandani, Wharton School, 3730 Walnut Street, OID Dept, Fl 5, Philadelphia, PA, 19104, United States, piar2@wharton.upenn.edu, Hamsa Sridhar Bastani, Emily Wyatt

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 in tandem with a novel machine learning framework to unmask recruitment-to-sales pathways, thereby providing the first global network view of sex trafficking supply chains. Key challenges to inferring supply chain relationships include extreme data imbalance and objective mismatch; our framework addresses these issues through natural language processing, active learning, and domain expertise.

2 - Why Do Women Struggle To Climb The Corporate Ladder? Evidence From Retail Frontline Managers

Lauren Xiaoyuan Lu, Dartmouth College, 100 Tuck Hall, Hanover, NH, 03755-9000, United States, lauren.x.lu@tuck.dartmouth.edu, Ruoran Chen, Susan F. Lu, Simin Huang

Today women are still struggling to climb the corporate ladder. While existing gender studies have focused on individual workers or C-suite executives, why men climb the corporate ladder faster than women remains a mystery. To fill this void in the literature, we explore gender differences and disparities in low-level management by empirically investigating the performance of frontline managers in a large sportswear retail chain. We observe a substantial performance gap between male and female managers. After matching stores based on sales-potential characteristics, the performance gap becomes quantitatively and statistically insignificant. These results suggest that the seemingly large gender gap in managerial performance reflects the fact that store assignment is inequitable across genders.

3 - Browsers Don't Lie? Gender Differences In The Effects Of Covid-19 Lockdowns On Digital Activity And Time Use

Amalia R. Miller, University of Virginia, Charlottesville, VA, United States, Kamalini Ramdas, Alp Sungu

We study gender differences in the impact of the initial COVID-19 lockdown in India on internet activity. Our data combines survey data with URL-level internet browser history. Browser data provide an objective measure of online activity before and during the lockdown without reporting or recall biases. Online activity, as measured by time or clicks, increased substantially for both men and women, but men increased their activity levels by significantly more. The gender gap in response to the lockdown is present overall and within categories, such as production, leisure, and job search. It is driven mainly by parents. In our survey, men and women both report substantial increases in time devoted to domestic production. Surprisingly, men report significantly larger increases in childcare time than women do. Female respondents do not report the same about their spouses.

4 - The Last Crack To Break The Glass Ceiling - Examining How The CEO Influences TMT Gender Heterogeneity

David Bendig, Professor, University of Münster, Münster, Germany

Academia and practice agree that top management team (TMT) gender heterogeneity is beneficial for firm performance and firms implemented various initiatives to promote gender heterogeneity. Still, the glass ceiling seems to be hard to crack and many TMTs remain homogenous. The CEO decides who enters the TMT. We take an upper echelons view and scrutinize how CEO characteristics drive TMT gender heterogeneity. We draw on a sample of S&P 500 firms from 2006 to 2017 to test our hypothesis. We find that CEOs' narcissism, gender, and functional variety are significant predictors of TMT gender heterogeneity. Our findings contribute to TMT composition and diversity research.

■ VWB35

Virtual Room 35

Modelling on Energy and Climate Change

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Hua Liao, Beijing Institute of Technology, Beijing Institute of Technology, China

1 - Dynamic Subsidy Policies With A Renewable Energy Target

Lei Zhu, Beihang University, Beijing, China, leizhu@buaa.edu.cn, Junqi Liu, Wei Zhang

This paper offers insights into quantifying FITs levels for the policy-makers to match the expected installed capacity target with minimum policy costs under uncertainty. We incorporate real options and stochastic dynamic programming to model the strategic behaviour between Policy-maker and investor while considering the learning effects of costs and the intermittent nature of renewable energy generation. An approach that combines binary tree scenarios generation and a least squares Monte Carlo method is adopted for the numerical solution to obtain the optimal FITs plan in practice. China's offshore wind power investment is used as a case study to investigate the relationships among the optimal dynamic FITs level, total policy costs, the expected capacity target, and learning effects.

2 - Effectiveness Of Electric Vehicle Subsidies In China: A Panle Study

Tong Zhang, Australian National University, Australia

EVs are likely to emerge as the main means of zero-carbon road transport, and China is ahead of many other countries in terms of adoption. This study estimates the effect of EV purchase subsidies on the adoption of electric vehicles for 324 prefecture-level cities in China over January 2016-December 2019. The findings suggest that a 1,000 CNY increase in the per-vehicle purchase subsidy for domestic EVs on average leads to a 2-7% increase in uptake. However these subsidies discourage uptake of imported EVs. Higher awareness of subsidies among consumers is associated with a larger proportion. Simulations indicate that an increase in the per-vehicle purchase subsidy on EVs in China is able to reduce CO2 emissions at a subsidy cost of about 589CNY (US$94) per tonne.

3 - What Would The Simulated Climate And Optimal Policy Be If A Two-sector DICE Model Used

Liao Hua, Beijing Institute of Technology, 5 ZHONGGUANCUN SOUTH STREET, Beijing, 100081, China, liaohua55@163.com, Huiying Ye

Highly aggregated Integrated Assessment Models (IAM) capture limited information of economic structure. We modify DICE by diving the output into consumer and capital goods, and consider their quite different characteristics of embodied carbon intensity and climate vulnerability. Under optimal policy path, comparing with the modified model, the aggregate DICE-like model overestimates GDP growth, investment rate and CO2 emissions. As for policy variables, it overestimates the emission control rate as well as carbon tax.

■ VWB36

Virtual Room 36

Environment, Energy, and Natural Resources II

Contributed Session

Chair: Diwas Paudel, University of South Florida, Tampa, FL, 33613, United States

1 - Optimized Lease Planning For Real Estate Portfolios

Claudio Gambella, Research Staff Member, IBM Research Europe, Dublin, Ireland, Michael Barry, John D. Sheehan, Joern Ploennigs

Real Estate has long been the second or third highest annual operating expense for companies after labor cost. 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.

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 Real Estate Portfolio Management.

2 - Demand Response For Natural Gas Subject To Pipeline Network Constraint

fuyu hu, Postdoc, Los Alamos National Laboratory, los alamos, NM, United States, hufuyu2010@gmail.com, Kaarthik Sundar, Shriram Srinivasan, Russell Bent

Increasing Natural Gas (NG) needs of residential customers during the winter months presents an opportunity for developing NG-only Demand Response (DR) programs. This talk will introduce a simple NG-only DR program using Mixed-Integer Linear Programs for residential customers, show the benefits of such a program in simulation and discuss challenges, both research and technological, that need to be addressed to bring these programs into practice. The results highlight that DR brings significant benefits to residential users in terms of consumption savings and performance gains.

3 - Analysis Of Sales Of Electric Vehicles And Charging Infrastructure In Mexico

Adrian Ramirez Nafarrate, Professor, Universidad Panamericana, Zapopan, Jalisco, Mexico, adrian.ramirez@asu.edu, Hugo Briseño, Ozgur M. Araz

In Mexico, the sales of electric and hybrid vehicles have also increased significantly between 2016 and 2020. However, compared with the sales of conventional vehicles, the EVs represent a very small proportion. In this presentation, we explore the factors associated with the adoption of EVs in Mexico using a linear regression approach and also present a simulation model to evaluate the charging infrastructure for interurban travel. The results show a high correlation between EV sales and sustainable practices in the states of Mexico and the need for more charging stations to allow low-range EVs travelling between main cities.

4 - Fleet Size And Charging Infrastructure Capacity For Ridehailing Services Using Autonomous Evs

Diwas Paudel, University of South Florida, Tampa, FL, United States, Tapas K Das

We develop a robust stochastic mixed integer model which, for any given part (percentage) of the current demands in the city that the SAEV fleet might intend to serve, yields optimal SAEV actions and corresponding capacity plan (fleet size and charging infrastructure) that maximizes gross profit. The model solution yields optimal capacity plan, which varies depending on the decision makers choice of the level of conservatism towards robustness. Expansion of the existing capacity to meet an increased demand and sensitivities of battery capacity and power network configurations are also explored.

5 - EFFICIENT EV CHARGING VIA THROUGHPUT MAXIMIZATION

Yize Chen, University of Washington, Seattle, WA, United States, yizechen@uw.edu

The proliferation of electric vehicles calls for reliable and efficient operations of EV charing stations, which are often limited by the charging capacity and electrical network constraints. In this talk, by taking the state-of-charge information into account, we formulate the EV charing problem as a throughput maximization problem. The resulting adaptive charing algorithm can not only serve the most charging sessions, it can only schedule the charing rate by respecting the charing rate and demand congestion constraints.

■ VWB37

Virtual Room 37

Macro Energy Systems: Political Economy of Net-Zero Energy Systems Planning

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Michael R Davidson, University of California, San Diego, University of California, San Diego, La Jolla, CA, 92093, United States

1 - Renewable Energy Expansion In The Western U.S. Under Political Constraints

Fikri Kucuksayacigil, University of California San Diego, 8202 Regents Road Unit 304, San Diego, CA, 92122, United States, kucuksayacigil@gmail.com, Michael R. Davidson

The Western U.S. will need to install 500-600 GW of wind and solar power by 2050 in order to stay on track for global targets to mitigate climate change. Building and integrating these variable renewable energy sources will require increases in flexibility and coordination across eleven states in the West. However, states differ in their policies on key renewable energy-enabling policies and steps such as renewable portfolio standards / clean energy standards, net-metering, regionalizing system operation, and transmission build-out. We analyze region-wide market operation with such political realities. Using an optimization model, we consider capacity and operational decisions in 2030 and 2045 given scenarios of state alignment by policy area. We consider in detail the current status and projected pipeline of transmission projects in addition to upgrade potential.

2 - Racial Equity in Energy and Sustainability: A Case Study in Mexico

Rodrigo Mercado Fernandez, Appalachian State University, 1137 West Grace Street Apt 206, Richmond, VA, 23220, United States, rodmerfdez@gmail.com, Erin Baker

Using Mexico as a case study, we employ a bottom-up model of the electrical system to identify critical geographic areas of investment for installed capacity and transmission that are robust across a set of climate mitigation pathways derived from multiple Integrated Assessment Models. We find that more diverse energy portfolios are associated with relatively less transmission investment; and that despite a lack of robustness in the location of installed capacity investments, investment in transmission expansion is fairly robust across pathways.

3 - Exploring The Role Of Electric Vehicles In Africa's Energy Transition

Michael Dioha, Carnegie Institution for Science, Stanford, CA, United States, mdioha@carnegiescience.edu, Lei Duan, Tyler Ruggles, Sara Bellocchi, Ken Caldeira

We employ a bottom-up modelling framework to examine the interplay of electric vehicles (EVs) and variable renewables (VRE) in Africa using Nigeria as a case study. Our results indicate that despite having a natural gas-dominated electricity system, the deployment of EVs can support the decarbonization of the Nigerian transport sector but at a relatively high cost. The cost of EVs would need to drop by ~40% to become cost-competitive. However, if VRE delivers the EVs power requirement with a bidirectional smart charging strategy, then the cost of EVs would need to decline by only ~30% to be a cost-effective option. Not all EVs need to participate in a bidirectional charging strategy in order to realize its full benefits; there is substantial benefit from flexibility in charging loads. Robust policies are needed to support EVs.

4 - Energy Pathways For Southern Africa Under Socio-environmental Constraints And Climate Risks

Ranjit Deshmukh, Assistant Professor, University of California Santa Barbara, Santa Barbara, CA, United States, AFM Kamal Chowdhury

The Southern African Power Pool, a twelve-country regional grid, is a unique power system because of its significant potential for all major generation fuels or technologies -- coal, natural gas, large hydropower, nuclear, wind, and solar -- to meet future electricity demand. We employ a modeling framework that combines geospatial (MapRE), hydrologic (VIC-Res), and electricity grid-investment (GridPath) models to study cost and emissions impacts of different energy pathways for southern Africa under technical, economic, and socio-environmental constraints and climate change risks that especially affect renewable energy siting and hydropower sustainability. Our results inform the strategic planning of generation capacity and transmission interconnections to affordably and reliably meet southern Africa's rapidly growing energy demand.

■ VWB38

Virtual Room 38

Quantitative Approaches for Conservation, Natural Resource Management, and Energy

Sponsored: ENRE/Environment and Sustainability

Sponsored Session

Chair: Ted Pavlic,

1 - The Value Of Remotely-Sensed Data In Terrestrial Habitat Corridor Design For Large Migratory Species

Kailin Kroetz, Assistant Professor, Arizona State University, Tempe, AZ, United States, Kailin.Kroetz@asu.edu, Bryan Leonard, Arthur Middleton

Cost-effective conservation program design to support seasonal migratory species is urgently needed but is challenging and costly to implement in practice. Specifically, migratory species traverse large spatial scales and require path connectivity to complete migrations. However, the seasonality of migrations presents opportunities for cost savings relative to traditional species conservation approaches that involve year-round purchases or easements. These saving may be enhanced by advances in satellite data enabling tracking of animal movement and habitat quality. We use an integer programming approach to develop landscape-scale conservation plans for migratory species in the Greater Yellowstone Ecosystem and compare outcomes with and without high resolution satellite data.

2 - Evaluation Of United States Biomethane Policies For Promoting Sustainable Use Of Resources

Nathan Parker, Arizona State University, Tempe, AZ, United States, ncparker@asu.edu

Biomethane from wastes promises to fulfill multiple sustainability goals but faces challenges in costs and local impacts. A range of federal, state and local policies are in place to encourage the development of this resource. This study evaluates the potential supply of biomethane in the United States using mixed integer programming to optimize the siting of infrastructure to bring the supplies to market. The expected industry with the existing policy mosaic is compared with optimal industry designs to maximize climate mitigation, minimize exposure to pollutants and maximize resource efficiency.

3 - Interactions Between Lithium Mining, Aquifer, and Local Communities in Salar de Atacama, Chile: An Agent-based Model

Wenjuan Liu, Arizona State Unversity, Tempe, AZ, United States, Datu Buyung Agusdinata

The local impacts of lithium (Li) mining are not well understood. The study develops an agent-based model applied to the lithium mining industry in Salar de Atacama Chile, to understand how Li-brine pumping behaviors of the mining industry affect the groundwater movements and stress dynamics of local livelihoods under different future mining scenarios. We investigate how uncertainties in the groundwater system affect the stress dynamics of social actors and found these uncertainties delay feedbacks to the social system, leading to mismatched evolution of dynamics in both systems. We suggest possible ways to build livelihood resilience and incorporate such ways into model improvement.

■ VWB39

Virtual Room 39

Market Design for Smart Local Energy Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Thomas Morstyn, University of Edinburgh, University of Edinburgh, United Kingdom

Co-Chair: Paul Cuffe, University College Dublin, University College Dublin, Ireland

1 - Inefficient Tariffs and the Escalating Welfare Losses Associated with Distributed Energy Resource Deployment

Niall Farrell, Queen's University Belfast & Economic and Social Research Institute, Dublin, Ireland

Distortionary electricity tariffs create a platform for growing welfare losses with expected technological change. If tariffs are inefficient, utilities may adjust their tariffs on foot of changes in demand, to recover costs. Deployment of distributed energy resources (e.g. solar) benefits adopters at the expense of non-adopters as tariffs are recalibrated to recover fixed costs. Reform on Coasian principles avoids these welfare losses and redistributional effects. The structure of electricity tariffs will therefore determine whether technological change is beneficial to consumers.

2 - A Network-Aware Peer-to-Peer Market Mechanism for District Heating Systems

Linde Frölke, Technical University of Denmark, Kgs. Lyngby, Denmark, linfr@dtu.dk, Tiago Sousa, Pierre Pinson

District Heating systems become more distributed with the rise of heat prosumers. This calls for suitable heat market mechanisms that optimally integrate these actors. We propose a network-aware heat market with peer-to-peer trades as a Quadratic Program, which determines the optimal dispatch and nodal marginal prices. While heat network dynamics are generally represented by non-convex constraints, we convexify this formulation by fixing temperature variables and neglecting pumping power. Through a dual analysis we reveal loss components of nodal prices, as well as relations between nodal prices and between seller and buyer prices. A case study illustrates the dynamics of the network-aware market by comparison to our proposed loss-agnostic benchmark. We show that the mechanism effectively promotes local heat consumption and thereby reduces losses and total cost.

3 - Fairness In Distribution Network Management

Archie Chapman, Senior Lecturer, The University of Queensland, Brisbane, Australia, archie.chapman@uq.edu.au

The rapid rise of rooftop PV installations has triggered detrimental impacts on distribution networks, which risk being replicated with other distributed energy resources (DER), such as residential batteries and electric vehicles. In response, distribution network operators have begun to mandate connection codes, such as inverter Volt/Var control (VVC) and/or PV active power curtailment (APC), to mitigate network problems. However, these can cause an unfair amount of network support to be sourced from DER in certain locations. In this context, we discuss techno-economic considerations of fairness in distribution networks by introducing a distributed optimal power flow method for fair DER coordination with VVC and APC inverter control modes.

4 - Application of the Level Method for Computing Locational Convex Hull Prices

Nicolas Stevens, UCLouvain, Louvain la Neuve, Belgium, Anthony Papavasiliou, Ilyes Mezghani

Convex hull pricing is a well-documented method for coping with the non-existence of uniform clearing prices in electricity markets with non-convex costs and constraints. We revisit primal and dual methods for computing convex hull prices, and discuss the positioning of existing approximation methods in this taxonomy. We propose a dual decomposition algorithm known as the Level Method and we adapt the basic algorithm to the specificities of convex hull pricing. We benchmark its performances against a column generation algorithm that has recently been proposed in the literature. We provide empirical evidence about the favorable performance of our algorithm on large test instances based on PJM and Central Europe.

5 - A Distributed Market Architecture for Local Energy Communities

Bertrand Cornélusse, University of Liège, Liège, Belgium

We study the possibility to distribute the computation of an equilibrium of a centralized local market design that enables members of an energy community to exchange energy and services among themselves, next to the usual interactions they can have with the public grid. The market aims at maximizing the social welfare of the community, through a more efficient allocation of resources, the reduction of the peak power, and the increased amount of reserve, achieved at an aggregate level. Each member is incentivized to participate in the community on a voluntary basis. The overall framework is formulated in the form of a bilevel model, where the lower level problem clears the market, while the upper level problem plays the role of the community microgrid operator.

6 - Insights from the Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models (GO-P2P) by IEA

Alexandra Schneiders, Energy Institute (University College London, UCL), London, United Kingdom

This presentation will be given as part of the panel session "Market Design for Smart Local Energy Systems". It will be on the latest findings from the Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models (GO-P2P), a project of the User-Centred Energy Systems Technology Collaboration Programme by the International Energy Agency (IEA). Its aim is to study and analyse peer-to-peer energy trading, transactive energy and community self-consumption pilots being rolled out across the world, including the US. I will speak about the pilots we are analysing and also delve into legal and policy issues pertinent to peer-to-peer energy trading.

■ VWB40

Virtual Room 40

Risk-Aware Electricity Grids and Markets Operations

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Ali Daraeepour, Princeton University, Princeton University, Princeton, NJ, 08540-5222, United States

1 - Presenter

Ali Daraeepour, Princeton University, Acee Bldg 086 Olden St # 016, Princeton, NJ, 08540-5222, United States

2 - Evaluating Different Approaches To Hedge Against The Uncertainty Of Variable Renewable Resources: A PJM Case

Xiaodong Zhang, PhD Student, Duke University, Durham, NC, 27708, United States, xiaodong.zhang828@duke.edu, Ali Daraeepour, Mauricio Hernandez, Dalia Patino-Echeverri

Risk-aware reserve requirements (RRR) are found with a stochastic unit commitment model that minimizes the risk-adjusted expected cost of satisfying electricity demand. This study investigates the effect of RRR on costs and other outcomes, in systems with high penetration of variable renewable electricity (VRE). We simulate the operations of PJM system and examine the commitment and dispatch of energy and reserves, emissions, costs, and generator's cycling. We compare the performance of RRR relative to risk-neutral deterministic and stochastic unit commitments.

3 - Implications Of Risk-aversion, Strategic Behavior And Elastic Electricity Demand For Capacity Market Designs

Steffen Kaminski, KU Leuven, Leuven, Belgium, steffen.kaminski@kuleuven.be, Mihaly Dolanyi, Kenneth Bruninx, Hanspeter Höschle, Erik Delarue

Assuming perfectly competitive market participants and an optimal demand curve, a capacity market will deliver the optimal capacity mix. However, real-life investors may exhibit risk-averse and/or strategic behavior, as well as changes in the consumers' resources, which may lead to higher demand elasticity. This talk sheds light on the impact of potential risk-averse, strategic behavior, and a price-elastic electricity demand on the evolution of the power system and its implications for capacity market design revealing a need for capacity markets if energy demand becomes price-elastic and providing methods for regulators to disentangle risk-averse and strategic behavior.

4 - Enabling Inter Area Reserve Exchange Through Market Mechanisms

Orcun Karaca, ETH Zurich, Zurich, Switzerland, okaraca@control.ee.ethz.ch, Stefanos Delikaraoglou, Maryam Kamgarpour

Considering the sequential clearing of energy and reserves in Europe, enabling inter-area reserve exchange requires optimally allocating inter-area transmission capacities between these two markets. To achieve this, this talk provides a market-based allocation framework and derive payments with desirable properties. The proposed min-max least core selecting payments achieve individual rationality, budget balance, and approximate incentive compatibility and coalitional stability. The results extend the works on private discrete items to a network of continuous public choices.

5 - Risk-hedging In Renewable-dominant Electricity Markets

Robert Mieth, New York University, Brooklyn, NY, United States, Yury Dvorkin

This talk presents a risk-complete electricity market and proposes a set of mechanisms allowing for identifying and hedging against physical and financial risks in renewable-rich power systems. We take the perspective of the system operator and derive a risk-aware market design, which deals with the stochasticity of renewable resources and credible contingencies. Additionally, we introduce suitable financial products, e.g., variance swaps, that facilitate hedging against financial risks and incentivize system-beneficial behavior.

■ VWB41

Virtual Room 41

Interpretable Data Analytics and Machine Learning: Exact and Approximation Algorithms

Sponsored: Computing Society

Sponsored Session

Chair: Yongchun Li, Virginia Tech, Virginia Tech, Blacksburg, VA, 24060-6536, United States

1 - Learning Optimal Prescriptive Trees From Observational Data

Nathanael Jo, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos, Sina Aghaei, Andres Gomez

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.

2 - Large-scale Inference Of Sparsely-varying Markov Random Fields

Salar Fattahi, Assistant Professor, University of Michigan, 1433 Dwight Way Apt C, Ann Arbor, MI, 94702-2147, United States, fattahi@umich.edu, Andres Gomez

We study the problem of inferring time-varying Markov random fields (MRF), where the underlying graphical model is both sparse and changes sparsely over time. Most of the existing methods for the inference of time-varying MRFs rely on the regularized maximum likelihood estimation, that typically suffer from weak statistical guarantees and high computational time. Instead, we introduce a new class of constrained optimization problems for the inference of sparsely-changing MRFs. The proposed optimization problem is formulated based on the exact L0 regularization, and can be solved in near-linear time and memory. Moreover, we show that the proposed estimator enjoys a provably small estimation error. Our proposed method is extremely efficient in practice: it can accurately estimate time-varying graphical models with more than 500 million variables within one hour.

3 - Learning Hierarchical Interactions At Scale: A Convex Optimization Approach

Wenyu Chen, Massachusetts Institute of Technology, 70 Pacific St Apt 640c, Cambridge, MA, 02139-4204, United States, Hussein Hazimeh, Rahul Mazumder

We consider models that have the main features as well as pairwise interactions, with variable selection under the strong hierarchy: an interaction is non-zero only if its associated main features are non-zero. Existing methods cannot scale for problems with $p\sim10^3$ main features (thus a total of p^2 features). We study a convex relaxation that enforces strong hierarchy and develop a highly scalable algorithm based on active set method and proximal gradient descent. We propose novel proximal screening rules and gradient screening strategy to further speed up the computation. We establish linear convergence guarantee for our framework. In practice, our framework outperforms the state of the art in terms of prediction and variable selection and can achieve over a 4900x speed-up. It can also handle much larger problems with $p = 50,000$ ($\sim 10^9$ interactions).

4 - Scalable Sparse PCA: A Tractable MIP Under Statistical Assumptions

Kayhan Behdin, Massachusetts Institute of Technology, Cambridge, MA, United States, behdink@mit.edu, Rahul Mazumder

We consider Sparse Principal Component Analysis (SPCA) under the spiked covariance model. The SPCA problem can be reformulated as a Mixed Integer Problem (MIP) with optimal statistical properties. However, current MIP algorithms for SPCA do not scale beyond datasets with 1000s of variables. In this work, we propose new MIP formulations for SPCA via statistical modeling and reduction. By utilizing properties of the spiked model, we provide Mixed Integer Quadratic Program (MIQP) and Mixed Integer Second Order Cone Program (MISOCP) formulations for SPCA. We provide statistical guarantees for our MIQP formulation in terms of estimation error. In addition, we provide tailored cutting plane algorithms based on outer approximation. Numerical experiments on synthetic and real datasets show that our algorithms scale to large datasets with up to 104 variables in tens of minutes.

5 - Fast Semidefinite Optimization With Latent Basis Learning

Rajiv Sambharya, Princeton University, Princeton University, Princeton, NJ, United States, rajivs@princeton.edu

We introduce a data-driven method to quickly solve semidefinite programs (SDPs) coming from the same family. These SDPs often arise in machine learning and real-time decision making, where a sequence of similar problems needs to be quickly solved. Our method leverages common structure across the family to learn a latent basis representation, which is then used as input to a second-order cone program, whose solution approximates the original SDP solution. To do this, we marry the strength of neural networks in uncovering structure from data with differentiable optimization which allows end-to-end training of the bases and approximate problems to minimize suboptimality and infeasibility.

■ VWB42

Virtual Room 42

Computing

Contributed Session

Chair: Cheng Lu, Apple, Daly City, CA, 94014, United States

1 - Learning-based Resource Management for Mobile Edge Computing Systems

Hana Khamfroush, University of Kentucky, Lexington, KY, United States, khamfroush@uky.edu, Sam Heshmati

With the growing needs of real-time data analytics, mobile edge computing (MEC) is becoming a popular technology to process large scale data at the edge of the system and close to the users. MEC however comes with its own limitations such as limited computing, communication, and storage resources. Therefore, smart resource management strategies are needed to provide efficient use of these resources. This talk will address the use of deep learning models for resource management in the mobile edge computing systems. Challenges and opportunities are presented, while discussing some preliminary results.

2 - Adversarial Attack and Defense for Tabular Data Regression

Yoon Sang Cho, Korea University, Seoul, Korea, Republic of, yscho187@korea.ac.kr, Seoung Bum Kim

Adversarial attack refers to generating adversarial examples that decrease the performance of the predictive model. In contrast, adversarial defense regularizes the model with adversarial training using adversarial examples. However, relevant studies mainly address the image classification problem. In this study, we propose the normalized gradient sign method (NGSM) that can perform variable-wise attacks as an adversarial attack method for tabular data regression. Experimental results show that our method outperformed existing methods in real-world industrial data where obtaining regularization performance is essential.

3 - Numerical Solutions to a Fredholm Form of Integral Equations for Finite Measures

Shukai Li, Northwestern University, Evanston, IL, United States, Sanjay Mehrotra

We study a form of integral equations for finite measures, which arise in many applications including stationary distribution problems and Markov chain Monte Carlo. We exploit the properties of our equations and apply a discretization approach for approximate solutions. Specifically, we construct a Banach space of distribution functions to reformulate the problem into a Fredholm-form operator equation and outline necessary and sufficient conditions for applying collective compactness theory. We provide convergence results for the discretization approach and analyze how to compute the approximate solutions as well as their error bounds via a linear program under appropriate assumptions.

4 - A Unified Efficient Approach for Minimizing a Convex Separable Sum of Fidelity and Regularization: The 1D Generalized Total Variation Problem

Cheng Lu, University of California-Berkeley, Berkeley, CA, United States, chenglu@berkeley.edu, Dorit S. Hochbaum

We study a 1-dimensional discrete signal denoising problem that generalizes the total variation regularization problem. We devise a unified approach to solve the problem for general convex fidelity and regularization functions that is based on the Karush-Kuhn-Tucker optimality conditions. This results in the fastest algorithm known for the problem. If the fidelity functions are differentiable and the regularization functions are strictly convex we derive an even faster algorithm. Our C++ implementation of the method is considerably more efficient in practice than popular nonlinear optimization solvers for the problem.

■ VWB43

Virtual Room 43

Procurement Design

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Marion Ott, ZEW – Leibniz Centre for European Economic Research, ZEW – Leibniz Centre for European Economic Researc, Mannheim, 68161, Germany

Co-Chair: Nicolas Fugger, University of Cologne, University of Cologne, Mannheim, 68161, Germany

1 - Optimal Reserve Prices In Auctions With Expectations-based Loss-averse Bidders

Antonio Rosato, University of Technology-Sydney, 2 York Street, Sydney, 2000, Australia, Benjamin Balzer

We characterise the optimal reserve price in first-price and second-price auctions with independent private values when bidders are expectations-based loss averse. The optimal reserve price differs across the two auction formats. Moreover, there is less exclusion compared to the risk-neutral and risk-averse benchmarks. Finally, we show that random reserve prices can be optimal for the seller.

2 - Does Expectation-based Loss Aversion Explain Non-truthful Preference Reporting In Strategy-proof Matching Mechanisms?

Thomas Kittsteiner, RWTH Aachen University, Lehrstuhl für VWL, inbes. Mikroökonomie Templergra, Aachen, 52062, Germany

Expectation-based loss aversion (EBLA) has been suggested as an explanation of true preference misreporting in strategy-proof matching mechanisms. EBLA implies disappointment aversion. Reporting the true ranking might create an expectation that proves too optimistic ex post, leading to a disappointment. To avoid such disappointment, it might be optimal to over-rank a less desirable, but a more probable, option over a more desirable, but less probable, option. We test this hypothesis in a simple experiment with only two options. Varying probabilities of availability of different options in a between-subject design, we find a small and statistically insignificant effect in the direction predicted by EBLA. However, responses to debriefing questions suggest that the small effect is more likely to be due to a preference vs. probability tradeoff thinking rather than EBLA.

3 - Coordination And Predation In Multi-unit Auctions: Why Pricing Rules Matter

Daniel Marszalec, Assistant Professor, ICU (International Christian University), Tokyo, Japan, daniel.marszalec@gmail.com, Alexander Teytelboym, Sanna Laksá

Auctions with below-bid pricing (e.g., uniform-price, and ascending auctions) have remarkable theoretical properties, but practitioners are skeptical about their implementation. We present a dynamic model of collusion in multiunit auctions that explains this gap between theory and practice. To sustain collusion at the reserve price, bidders submit crank-handle bids. The cost of sustaining crank-handle collusion depends on the degree of below-bid pricing in the auction. Our model predicts that crank-handle collusion is easier to sustain in auctions with more below-bid pricing and when bidders are more symmetric. Evidence from auctions of fishing quota in the Faroe Islands supports our predictions.

4 - Exploiting Uncertainty About the Number of Competitors in Procurement Auctions

Nicolas Fugger, University of Cologne, L 7 1, Mannheim, 68161, Germany

Most of the literature on auctions assumes that participants observe the number of competitors. However, this is typically not the case in procurement practice. We investigate how the buyer should react to suppliers' uncertainty and whether she should commit to a specific auction format before observing the number of qualified suppliers or benefits from making the auction design depend on the actual number.

Suppliers' risk aversion makes commitment to first-price auctions attractive for the buyer. However, suppliers' inability to interpret the buyer's auction format choice correctly makes it attractive to make the format choice depend on the number of suppliers. We test these theoretical predictions in a lab experiment. We find evidence for both behavioral patterns and observe that the buyer yields significantly better prices if she commits to a first-price auction.

5 - Heterogeneity In Multi-unit Common Value Procurement Auctions

Marion Ott, ZEW – Leibniz Centre for European Economic Research, L 7 1, Mannheim, 68161, Germany, marion.ott@zew.de, Karl-Martin Ehrhart, Jan Kreiss

Bidders' profits and their frequency of losses in an experiment on multi-unit procurement auctions when bidders have common costs develop differently than theory predicts when the number of goods increases, and bidders are not better off in the pay-as-bid than in the uniform-price auction. We show how bid heterogeneity works in favor of the bidders under uniform pricing but not under pay-as-bid pricing as the number of goods increases, so that for the largest number of goods bidders are better off and less susceptible to the winner's curse than in equilibrium.

1 - Vertical Integration In Auction Markets

Sander Onderstal, University of Amsterdam, Postbus 15953, Amsterdam, 1001 NL, Netherlands, Ruben Van Oosten

We analyze the effects of vertical integration in auction markets. We do so using a symmetric independent private-values model in which the auctioneer sets a reserve price and invests in the end product's (match) quality. We find that in the integration scenario the auctioneer invests more than in the separation scenario on average, and that she gives a bidding advantage to the integrated bidder relative to the other bidders. The merging parties always benefit from vertical integration. Vertical integration has ambiguous effects on consumer surplus, non-merging bidder surplus, and total welfare. Our results are relevant for vertical integration in ad auctions, platform markets, and procurement.

■ VWB44

Virtual Room 44

Deep Learning/Maching Learning VI

Contributed Session

Chair: Zheng Zhang, University of Tennessee, Knoxville, Knoxville, TN, 37996-4515, United States

1 - Deep Learning-based Disease Diagnostic Biomarker Detection With Metabolomics Data

Seonyoung Kim, Chungnam National University, Daejeon, Korea, Republic of, 1020peace@gmail.com, Taewon Go, Dongil Kim

Biomarkers play important roles in the early diagnosis of disease to improve the survival rate of patients. To determine the type and stage of diseases and the corresponding treatment options, the target biomarkers should be identified. Metabolomics provides information on cellular metabolic processes that drive tumorigenesis and tumor progression. In this study, we propose deep learning methods to detect disease diagnostic biomarkers with metabolomics. Through experiments, we compare the performance of the proposed method and other machine learning methods.

2 - Impact Of Market Factors On Demand And Prices Of Remanufactured Products: A Machine Learning Approach

Yeun Soo Park, University of Birmingham, Birmingham, United Kingdom, YXP089@student.bham.ac.uk, Gu Pang, Joseph Sanderson

The majority of the existing research into market factors, sold prices and demand of remanufactured products is largely based on conventional statistical models. Such models are not capable of capturing the non-linear behaviour. In this study, we deploy machine learning approaches to shed light on the non-linear effect of e-commerce market factors as predictors of sold prices and demand of remanufactured electronics. Our results suggest our proposed approach can achieve better prediction. The managerial insights are reported through comparisons of the impact of these market factors on the sold prices and demand of remanufactured products.

3 - Classification Of Human Habits From Voice Data Using Machine Learning

Takaya Yokoo, Tokyo University of Science, Chiba, Japan, 7420529@ed.tus.ac.jp, Ryo Hatano, Hiroyuki Nishiyama

The human voice is influenced not only by physical factors such as gender and age, but also by habitual factors such as drinking and smoking. If habitual factors can be predicted from voice, it will be helpful for e.g., preventing lifestyle-related diseases. In this study, we propose a machine learning method to predict a human habitual information, such as drinking, smoking, and sleep, from human voice data. We extract acoustic features from voice data of subjects, train machine learning models to classify their habits, and evaluate the performance of each learning models. As for the acoustic features, we also employ i-vector which are commonly used in the research field of speaker identification.

4 - Interpretable Trees

Zheng Zhang, University of Tennessee, Knoxville, Knoxville, TN, United States, zzhan100@vols.utk.edu

Tree- and rule-based models have been known to have good interpretability, as the trained predictive models form a set of decision rules that are easy to understand in practice. Existing methods select the best model by minimizing the prediction errors on both child nodes (i.e., too much or too little) and predict values as the average of all observations in each terminal node. In this paper, we propose a split criterion based on rank concordance and a rule by fitting each terminal node with a linear function. The proposed method rather than the traditional performed better in accuracy and interpretability (e.g., capture the variations and associations between target variable and predictors).

■ VWB45

Virtual Room 45

Analytics II

Contributed Session

Chair: Wei Zou, Wuhan, 430070, China

1 - Impact And Risk Models On COPD-related Hospitalizations And Emergency Room Visits By Combining Multi-year Claims Data With Environmental Data Sets

Divya Mehrish, CapsicoHealth Intern; Stanford University Student, CapsicoHealth, Palo Alto, CA, United States, divyasmehrish@gmail.com, J. Sairamesh, Laurent Hasson, Monica Sharma, Rudy Banerjee, Jakob Bjorner

Chronic obstructive pulmonary disease (COPD) is the fourth-leading cause of death in the U.S. Our study examines clinical and environmental impacts on 90-day hospitalizations, ER visits and readmissions. We integrate 2017-18 CMS claims data with daily weather and pollution data in FL, NY and PA (high annual hospitalization rates). Our logistic regression models show 88% accuracy for 90-day hospitalizations and 74% for ER visits; 94% and 79% with boosted tree-based models. Our models all show 64% accuracy for 30-day readmissions. Our results, which show the clear relationship between the environment and COPD hospital and ER cases, can help care managers target high-risk populations.

2 - Estimation Of Obesity Based On Personal Behaviors And Physical Condition

Wei Zou, Clark Univerisity, WORCESTER, MA, United States, zouwei_lab@sina.com

Obesity is a complex health issue caused by many factors such as personal behaviors, medication use, and genetics. The number of obese people has increased rapidly. To decrease the possibility of obesity and help people keep healthy, we study the features that cause obesity directly by employing several machine learning models such as Logistic Regression, Tree-based method, support vector machine, and K Nearest Neighbors. We will conduct K-fold cross-validation to choose the best model and obtain a prediction accuracy. Our results show that the three most important obesity factors are weight, height, and gender. We also will discuss and compare our results to others in the existing literature.

■ VWB46

Virtual Room 46

Recent Development of Recommender Systems in Business Applications

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Pan Li, United States

3 - Customer Engagement Prediction on Social Media: A Graph Neural Network Method with Attention Mechanism

Tengteng Ma, University of Illinois at Chicago, Chicago, IL, United States, Yuheng Hu, Yingda Lu, Siddhartha Bhattacharyya

With the rapid prevalence and the massive user growth on social media platforms, how to target potential customers on social media efficiently has become increasingly important for companies. In this work, we design a Graph Neural Network model called GACE to predict customer engagement (like/comment/share) of brand posts. We exploit large-scale content consumption information from the perspective of heterogeneous network and learn customer latent representation by employing Graph Neural Network technique. GACE is examined using a large-scale Facebook dataset and the result shows significant performance improvement compared with state-of-the-art baselines. Besides, the effectiveness of attention mechanism together with our theory-driven meta-paths reveal the potential interpretability of the proposed model.

4 - Personalized Food Recommendation System For Mhealth

Xiaotong Sun, Indiana University, Bloomington, IN, United States, xs14@iu.edu, Nathan Yang, Daiva Nielsen, Jingjing Zhang

We present a novel framework for food recommendation system design for mHealth. One complication often faced when building food recommendation system is the large number of constraints the system needs to account for (e.g., food preferences, goal-based reference points, nutritional needs). To accommodate for these constraints, our system leverages recent developments in reinforcement learning to train the system using a large-scale dataset from a popular mobile fitness app.

5 - Uncertainty Counts: Bayesian deep learning-based tensor factorization and application in Recommender Systems

shikai Fang, The university of utah, United States

We apply Bayesian deep learning models as novel tools to handle tensors, the most common data form in Recommender Systems . As deep neural networks offer a strong fitting ability, the robustness and uncertainty from the Bayesian framework enable potentials on the domain-specifical interpretability and decision-making during the recommend pipeline.

■ VWB47

Virtual Room 47

New Methods in Asset Pricing and Allocation

Sponsored: Finance

Sponsored Session

Chair: Victor DeMiguel,

1 - A Robust Approach To Optimal Portfolio Choice With Parameter Uncertainty

Nathan Lassance, Assistant Professor of Finance, UCLouvain, 1/105 rue Marcel Thiry, Louvain-la-Neuve, 1348, Belgium, nathan.lassance@uclouvain.be, Alberto Martin-Utrera, Majeed Simaan

Kan and Zhou (2007) introduce a framework to portfolio selection under estimation risk that consists in optimizing the investor's expected out-of-sample utility of a combination of the sample tangency portfolio and the sample minimum-variance portfolio. In this paper, we extend the analysis of Kan and Zhou and propose a methodology that accounts for both the expectation and the variance of the investor's out-of-sample utility. Our framework delivers robust portfolios that outperform those that ignore either estimation risk or the investor's utility variance in the presence of parameter uncertainty.

2 - Can Machine Learning Help To Select Portfolios Of Mutual Funds?

Andre A.P. Santos, University of Edinburgh, Edinburgh, United Kingdom, andreportela@gmail.com
Andre A.P. Santos, Universidade Federal de Santa Catarina, Florianopolis, Brazil, andreportela@gmail.com, Victor DeMiguel, Javier Gil-Bazo, Francisco J Nogales

Identifying outperforming mutual funds ex-ante is a notoriously difficult task. We use machine learning methods to exploit the predictive ability of a large set of mutual fund characteristics that are readily available to investors. Using data on US equity funds in the 1980-2018 period, the methods allow us to construct portfolios of funds that earn positive and significant out-of-sample risk-adjusted after-fee returns as high as 4.2% per year. We also show that such outstanding performance is the joint outcome of both exploiting the information contained in multiple fund characteristics and allowing for flexibility in the relationship between predictors and fund performance.However, we also find that the performance of all our portfolios has declined over time, consistent with increased competition in the asset market and diseconomies of scale at the industry level.

3 - Which Factors With Price-impact Costs?

Sicong (Allen) Li, London Business School, London, United Kingdom, ali@london.edu, Victor DeMiguel, Alberto Martin-Utrera

We show that the squared Sharpe ratio criterion considered by Barillas and Shanken (2017) is no longer appropriate to compare factor models in the presence of price-impact costs. Instead, we propose comparing factor models in terms of their mean-variance utility net of price-impact costs and develop a formal statistical test to compare nested and non-nested factor models. Empirically, we find that price-impact costs change the relative performance of factor models. For instance, while in the absence of costs a seven-factor model considered in DeMiguel, Martin-Utrera, Nogales, and Uppal (2020) is the best low-dimensional model we consider, in the presence of price-impact costs the six-factor model of Fama and French (2018) is better.

4 - Reinforcement Learning: Theory and Applications in Finance

Justin Sirignano, University of Illinois at Urbana-Champaign, Irvine, CA, 92617, United States

We prove that a single-layer neural network trained with the Q-learning algorithm converges in distribution to a random ordinary differential equationas the size of the model and the number of training steps become large. Analysis of the limit differential equation shows that it has a unique stationary solutionwhich is the solution of the Bellman equation, thus giving the optimal control for the problem. In addition, we study convergence of the limit differential equation to thestationary solution. In conclusion, applications of reinforcement learning to optimal execution of orders in quantitative finance are presented.

■ VWB48

Virtual Room 48

Neural Networks

Contributed Session

Chair: Roman Simon Hahn, Milan, 20136, Italy

1 - Analysis For The Continuous Version Of The Alternative Fuel Refueling Station Location Problem

Sara F. Abu Aridah, Ph.D. Student, Pennsylvania State University, University park, PA, United States, Omar Abbaas, Jose Antonio Ventura

We address the deviation-flow refueling station location problem. We start with a continuous network where any point is considered as a candidate station location. Then the network is discretized by rounding distances and the driving range to the closest integer multiple of a common divisor value. This reduces the required computational effort to solve the problem. In this network, we prove that given any feasible solution with refueling stations located at non-integer distances from network vertices, it is always possible to find an equivalent integer solution. These results are used to discretize the network and propose an efficient polynomial time algorithm to locate a set of refueling stations.

2 - Predicting Utility Power Line Risk From Tree Failure Via An Interpretable Convolutional Neural Network

Nasko Apostolov, Graduate Research Associate, University of Massachusetts Amherst, Amherst, MA, United States, aapostolov@umass.edu, Ryan Suttle, Jimi Oke, Sanjay Arwade, Brian Kane

Automating tree risk assessments, which are critical to the integrity of utility power lines, could potentially yield significant cost savings while boosting community resilience. We train a novel convolutional neural network to predict tree failure likelihood categories using augmented inputs from expert-assessed tree images. Via cross-validation and hyperparameter optimization, we obtain a binary classifier with an accuracy of 0.94 (SD = 0.1). We assess the visual interpretability of the classifier using techniques such as gradient-weighted class activation maps. Our framework demonstrates the potential of artificial intelligence for sustainable infrastructure management.

3 - Classifying Soil Moisture Levels Of Grazeland Using Uav Imagery Data Based On A Convolutional Neural Network Method

Angela Avila, University of Texas at Arlington, Arlington, TX, United States, angela.avila2@mavs.uta.edu, Jianzhong Su, Heidi Taboada, Huihui Zhang

In field management, soil moisture is a key predictor in yield success. With acres of fields and mindfulness of water conservation, our goal is to maximize crop production at minimal cost. Unmanned Aerial Vehicles can be used to take images and provide information on ground moisture. We can then derive vegetation indices and use Convolutional Neural Network to distinguish well maintained areas from areas that are in water deficit. With imaging data collected in Fort Collins ARS, we will train the CNN system to successfully reach about 89% accuracy in predicting an image class correctly. With UAV data and CNN method we can precisely predict soil moisture levels and tend to areas with more irrigation needs.

4 - Do Neural Networks Have A Mean Dimension?

Roman Hahn, Bocconi University, Milan, Italy, roman.hahn@unibocconi.it, Emanuele Borgonovo, Christoph Feinauer

Neural networks are considered black-box models. Among other things, the interaction size of inputs for forming a decision is unknown to its user. The mean dimension of neural networks can provide such an average interaction size. We show that we can estimate the mean dimension accurately for neural networks in a known setting. This notion then can shed light into the network by providing information on the effect of the architecture on the interaction size and how the average interaction size evolves during trainging. We demonstrate these findings using image classification experiments on the cifar10 database and the LeNet, ResNet and DenseNet architectures.

■ VWB49

Virtual Room 49

Multiple Perspectives of GDN

Sponsored: Group Decision and Negotiation

Sponsored Session

Chair: Danielle C. Costa Morais, Universidade Federal de Pernambuco - UFPE, Recife - PE, 52020-212, Brazil

1 - The Mitigating Impact Of Family Firm Narcissism On Companies' Carbon Emissions

Florian Bartels, University of Muenster, Muenster, Germany, florian.bartels@uni-muenster.de, David Bendig

Family firms (FF) play a central role in mitigating climate change through the reduction of carbon emissions (CE; cf. Dyer & Whetten, 2006). Drawing on narcissistic organizational identification (NOI) theory (Galvin et al., 2015), we introduce the Family Firm Narcissism (FFN) scale, measuring how central the family sees itself for the organization's identity. We find a negative relationship between FFN and direct CE ($p < .01$) for our S&P 500 sample, being amplified by industry dynamism ($p < .01$) and strategic rival flexibility ($p < .05$). We advance NOI theory to the group-level, introduce the novel FFN measure addressing FF heterogeneity, and are the first to empirically analyze CE in the FF context.

2 - The Effect Of Religious Board Members On Corporate Digital Innovation

Fabian Ernst, Research Associate, Westfälische Wilhelms-Universität, Münster, Germany, David Bendig

Religious beliefs of executives influence corporate outcomes such as earnings management (Cai et al., 2019). We argue that religiosity fosters increased risk-aversion (Hilary & Hui, 2009) and that religious executives promote values such as traditionalism and security (Saroglou et al., 2004), reducing their appetite for digital innovation (DI).

We propose a novel measure for the religiosity of board members based on their education and leisure activities. We utilize patent data to measure DI orientation for our S&P 500 sample.

Our results show that firms with religious boards put less emphasis on DI, attenuated by the religiosity of the firm's employees and industry-specific IT intensity.

3 - Incentive-based Decentralized Routing For Human-driven Vehicles

Chaojie Wang, Georgia Institute of Technology, Atlanta, GA, United States, cwang717@gatech.edu, Srinivas Peeta

Existing routing strategies entail strong assumptions on traveler behavior and availability of network-level traffic information, and high computational burden, which weaken their deployment ability and effectiveness. To address these gaps, this study proposes an incentive-based routing strategy, which leverages the heterogeneity in individual preferences to enhance system performance. Using edge computing in mobile applications, we propose a decentralized algorithm to mitigate the computational burden and protect user privacy, thereby enabling the proposed routing strategy to be deployable in real-time.

■ VWB50

Virtual Room 50

Learning and Optimizing with Structure

Sponsored: Simulation Society

Sponsored Session

Chair: Giulia Pedrielli, Arizona State University, Arizona State University, Scottsdale, AZ, 85251-1470, United States

1 - Scalable High-dimensional Bayesian Optimization With Black-box Constraints

Matthias Poloczek, Amazon, San Francisco, CA, United States, David Eriksson

The global optimization of a high-dimensional black-box function under black-box constraints is a pervasive task in machine learning, control, and engineering. These problems are difficult for current approaches due to the curses of dimensionality, the heterogeneity of the underlying functions, and the often small and non-convex sets of feasible points that impact the performance of Bayesian optimization methods that otherwise have become the de-facto standard for sample-efficient optimization in unconstrained settings.In this talk I will present the scalable constrained Bayesian optimization (SCBO) algorithm and show experimental results that demonstrate a SOTA performance.

2 - Multi-information Source Optimization Through Gaussian Process Sparsification

Antonio Candelieri, Assistant Professor, PhD, University of Milano-Bicocca, Milan, Italy, antonio.candelieri@unimib.it

This paper presents a Multi-Information Source Optimization (MISO) approach which significantly differs from methods based on fusing Gaussian Processes (GPs). Analogously to these methods, each source is modelled as a GP, but instead of fusing GPs accounting for correlation between sources, GP sparsification is adopted to select only "reliable" observations from cheap sources, depending on a simple model discrepancy measure and the GP's prediction uncertainty. Reliable observations are used to "augment" the set of those collected from the objective function, then a single model, named Augmented GP, is trained on this augmented set. An acquisition function is designed to choose the next source-location pair to query. Results on test problems and a hyperparameter optimization task are presented, comparing the proposed MISO-AGP against its fused-GP counterpart.

3 - Pure Exploration In Multi-armed Bandits With Graph Side Information

Gautam Dasarathy, Arizona State University, Tempe, AZ, United States, gautamd@asu.edu, Parth Thaker, Nikhil Rao

We consider the problem of identifying the best arm(s) in a multi-armed bandit. In particular, we consider the setting where the algorithm additionally has access to similarity information amongst the arms in the form of a graph. In order to demonstrate the advantage this extra information bequeaths us, we introduce a novel combinatorial complexity measure. Using this measure, we devise novel algorithms that provably identify the best arm(s) while requiring far fewer samples than the traditional pure exploration techniques for multi-armed bandits. We finally provide experimental demonstrations that support our theoretical findings.

4 - A Comparative Study Of BO Algorithms

Szu Hui Ng, National University of Singapore, Singapore, Singapore, isensh@nus.edu.sg, Haowei Wang

Bayesian optimization (BO) has been widely applied to solve black-box global optimization problems. Its sequential approach adaptively learns to effectively search in often complex spaces. In this article, we consider several recent versions of BO and conduct a comprehensive empirical comparison of these algorithms under various scenarios. The algorithms' accuracy and computation times are reported, and some practical guidelines are provided.

5 - Constrained Two-step Look-Ahead Bayesian Optimization

Yunxiang Zhang, Cornell University, 113 Valentine Pl, Apt 968, Ithaca, NY, 14850, United States, Peter Frazier, Xiangyu Zhang

Non-myopic Bayesian optimization (BO) offers improved query efficiency over traditional myopic methods, but computationally efficient BO methods for contrained problems have not yet been developed. We argue that being non-myopic is even more important in constrained problems because fear of violating constraints pushes myopic methods away from sampling the boundary between feasible and infeasible regions, slowing the discovery of optimal solutions with tight constraints. In this talk, we introduce a computationally efficient two-step lookahead constrained BO acquisition function with a novel likelihood-ratio-based acquisition function optimization technique, which achieves state-of-the-art performance in experiments.

6 - Beyond The Pareto Efficient Frontier: Constraint Active Search For Multiobjective Experimental Design

Gustavo Malkomes, Intel, San Francisco, CA, United States, gustavo.malkomes@intel.com

Many problems in engineering design and simulation require balancing competing objectives under the presence of uncertainty. Sample-efficient multiobjective optimization methods like Bayesian optimization focus on the objective values in metric space and ignore the sampling behavior of the design configurations in parameter space. Consequently, they provide little actionable insight on how to choose designs in the presence of metric uncertainty. We propose a new formulation that accounts for the importance of the parameter space through defining a region of satisfaction. We introduce an active search algorithm to efficiently discover the region and diversely sample satisfactory designs.

■ VWB51

Virtual Room 51

Social Presence in Service Industries

Sponsored: Service Science

Sponsored Session

Chair: Mayukh Majumdar, Texas A&M University, College Station, TX, 77840, United States

1 - Multi-path Analysis For Promoting Public Participation In Digital Governance Platform—A Configuration Analysis Based On Qca Approach

WenJie Bao, phd.candidate, Guanghua School of Management, Peking University, Beijing, China, chris_jie@stu.pku.edu.cn, Xifei Liu

Digital transformation has become a hot topic in various fields. With the advent of digitization, various platforms have been applied to the field of rural governance. To increase citizen engagement, some digital governance platforms establish online communities. Community residents can socialize on the platforms so that governance platforms have the attributes of social media. How to improve citizens' enthusiasm in digital governance has become a concern of the Chinese government. Based on Qualitative Comparative Analysis (QCA) method, this study explored several configurations that can lead to high citizen activity in digital governance platform.

2 - The Impact of Chatbot Disclosure and Anthropomorphism on Users' Switching Intentions

Jonilda Bahja, PhD Student, Virginia Tech, Blacksburg, VA, United States, Paul B. Lowry

The dilemmaof how chatbot features effect users' behavioral intentions remains an ongoingdebate. Previous literature on chatbot disclosure and its human-like featuresconverges to the notion that results are contextual and vary greatly based onthe type of user's behaviors. Furthermore, it is recognized that users perceivethese chatbot aspects to be more important in the context of chatbot servicefailure. Yet, little attention is given to the interaction joint effect amongthese characteristics, and if through trust and social presence they lead toswitching intentions. Hence, the purpose of this study is to examine the jointindirect effect of chatbot identity disclosure and anthropomorphism on user'sswitching intentions, by focusing on the context of the chatbot service failurein hospitality and tourism. Specifically, the targeted population is hotelchatbot users in the United States. A factorial survey method design will beemployed with three factors: anthropomorphism, chatbot identity disclosure, andchatbot service outcome. Final data will be collected via Amazon MechanicalTurk online platform during January-February 2021. The findings of this study willadvance the literature by providing empirical evidence on the influence ofchatbot disclosure and anthropomorphism in users' switching intentions.Furthermore, the interaction of these variables will shed light on theimportance of both constructs in influencing directly social presence andtrust. This study will pioneer the way for more research in understanding theeffects of chatbot cues in the context of chatbot service failure forhospitality and tourism. Lastly, businesses invested in chatbots will benefitby gaining insights on the interaction of chatbot features and their ultimateeffect on the users' switching intentions.

3 - Improving Social Media Presence Of Firms Under Budget Constraints: A Multi-method Approach

Mayukh Majumdar, PhD Candidate, Mays Business School, College Station, TX, United States, mmajumdar@mays.tamu.edu, Subodha Kumar, Chelliah Sriskandarajah

The use of social media platforms by firms to promote their products among the public has received major attention among researchers and practitioners, especially the image-based content given the widespread availability of multimedia-based platforms. In this study, we examine the role of post features in driving user engagement and the operational value in the analysis of social media content. We use a combination of deep learning method, econometric approach, and optimization framework to offer relevant managerial insights under budget constraints.

■ VWB52

Virtual Room 52

Artificial Intelligence for Social Media

Sponsored: Social Media Analytics

Sponsored Session

Chair: Enhao Liu, Ohio State University, Ohio State University, Columbus, OH, 43210-1273, United States

1 - A Sentiment Analysis Of Covid-19 Vaccine Ins Social Media

Mehdi Mashayekhi, 629 Harley Dr Apt 4, Columbus, OH, 43202-1805, United States

Vaccine hesitancy one of the major issues fighting COVID19. There is misinformation about the symptoms of the vaccines, their efficacies, their approval process, etc. The misinformation could contribute to people avoiding getting vaccinated. In this research, we perform a sentiment analysis about COVID-19 vaccine in social media.

2 - Is The Data Suitable? The Comparison Of Keyword Versus Location Filters In Crisis Informatics Using Twitter Data

Ben Alexander Rachunok, Ph.D., Stanford University, Stanford, CA, 94305, United States, rachunok@stanford.edu
Ben Alexander Rachunok, Ph.D., Purdue University, West Lafayette, IN, United States, rachunok@stanford.edu

Twitter's Terms of Service, restrict the quantity and types of data which can be collected from the platform. Accordingly, there are multiple ways to retrieve data from Twitter with no consensus among researchers as to standard data collection procedures. In this work, we compare two Tweet datasets gathered around Hurricane Harvey---the second-most expensive US hurricane on record---via different methods and show the significant role of the tweet retrieval source on study insights and results. One dataset was collected using keywords to filter relevant data, the other using geographical location. We find that while keyword-based data is more suited to tracking public engagement and identifying information brokers, location-based data is needed to characterize local situational information and communication behaviors.

■ VWB53

Virtual Room 53

Advances in Econometrics and Business Analytics

Sponsored: Social Media Analytics

Sponsored Session

Chair: Alexander Semenov, University of Florida and St. Petersburg State University, University of Florida and St. Petersburg State Uni, Shalimar, 32579-1163, United States

1 - Artionyms And Machine Learning: Auto Naming Of The Paintings

Anna Altynova, Saint-Petersburg State University, Saint-Petersburg, Russian Federation, st068237@student.spbu.ru, Alexander Semenov, Dmitry Grigoriev, Valeria Kolycheva

Image captioning is a question of great interest in a wide range of applications. Although previous research has established that captioning of photos can be done with rather high efficacy, there is little published data about generation of captions for artistic paintings. In this research, we propose a deep neural network architecture that is capable to generate a name for a given painting. We describe the model and compare its abilities with several state-of-the-art models. We evaluate the model using image captioning metrics and discuss its capacity to generate art-related names.

■ VWB54

Virtual Room 54

Analytical and Empirical Models for Nonprofits

Sponsored: Public Sector OR

Sponsored Session

Chair: Telesilla Olympia Kotsi, The Ohio State University, The Ohio State University, Columbus, OH, 43206-3579, United States

1 - Client-Volunteer Relationships And Satisfaction In A Non-Profit Organization: The Case Of Meals On Wheels Atlanta

Shikha Safaya, Georgia Institute of Technology, Atlanta, GA, United States, ssafaya3@gatech.edu, Basak Kalkanci, Ravi Subramanian

We partner with Meals on Wheels Atlanta, a non-profit organization providing meals and personal interactions to seniors who have limited mobility and are food insecure. We examine how key factors related to service design, including service frequency and duration, contribute to satisfaction of seniors and volunteers and ensure high service quality and sustained volunteer engagement.

2 - How to Build Resilience in Food Bank Operations

Pelin Pekgun, University of South Carolina, Columbia, SC, United States, Luv Sharma, Olga Perdikaki, Fan Zou

The COVID-19 pandemic has severely impacted food bank operations with increased unemployment resulting in a significant spike in demand while disrupting in-kind donations and food distribution networks. In this study, we investigate the role of a critical factor in influencing the ramp-up in distributional capacity for food banks during the pandemic: their partner agencies. In doing so we hope to shed light on how food banks can build resilience towards major disruptions like the current COVID-19 pandemic.

3 - Improving Drinking Water Access In Sub-Saharan Africa

Chengcheng Zhai, Kelley school of Business, 1750 north range road, apt b301, bloomington, IN, 47408, United States, zhaic@iu.edu, Kurt M. Bretthauer, Jorge Mejia Alfonso J. Pedraza-Martinez

Access to water remains a significant problem for poor communities in many developing countries. In 2017, over 135 million people in sub-Saharan Africa (SSA) walked more than 30 minutes to get water each day (UNICEF and WHO 2019). New water projects, such as building water wells, have been the primary operational response to mitigate the drinking water crisis. These projects can reduce households' distance to safe drinkable water, improving the water accessibility level. Thus, where to build additional water projects to achieve such a goal is the consistent question among non-governmental organizations (NGOs) dedicated to improving access to water and it is of vital importance due to limited financial resources available in the rural areas. It is also the research question we investigate in this project.

4 - Risk-averse Placement Optimization In Refugee Resettlement

Narges Ahani, Worcester Polytechnic Institute, 100 Institute Road, MA, Worcester, MA, 01609, United States, nahani@wpi.edu, Osman Ozaltin, Andrew C Trapp

Refugees are resettled into communities in many ways, and more recently with the carefully designed use of analytical approaches. The refugee placement optimization software Annie™ MOORE estimates refugee-locality match quality scores using predictive modeling of past refugee placement and outcomes data to generate the likelihood of employment for incoming refugees. While estimated scores are used for offline optimal matching of arriving refugees in subsequent placement periods, inherent uncertainty exists with respect to the quality score estimation. This uncertainty can lead to different optimized outcomes that risks adverse effects on refugee welfare. We explicitly incorporate risk into the optimization of refugee outcomes and propose new methods to hedge against this risk, while retaining a majority of the total expected employment.

5 - Presenter

Manoj Vanajakumari, NC, United States

■ VWB55

Virtual Room 55

Disaster and Disruption Management I

Contributed Session

Chair: Azadeh Sadeghi, University of Michigan- Flint, Flint, MI, 48502, United States

1 - Post-Hurricane Damaged Timber Management Problem Using Bilevel Model Formulation

Amin Aghalari, Mississippi State University, STARKVILLE, MS, United States, aa2683@msstate.edu, Mohammad Marufuzzaman, Badr Aladwan, Shaun Tanger, Bruno Silva

This study proposes a bi-level mixed-integer linear programming model to optimize different critical decisions (e.g., purchasing, storage, and transportation decisions) of a post-hurricane damaged timber management problem. Further, this study develops two exact solution methods, namely, the enhanced Benders decomposition and the Benders-based branch-and-cut algorithms to efficiently solve the model in a reasonable timeframe. We use 15 coastal counties in southeast Mississippi to visualize and validate the algorithms' performance.

2 - Optimal Selection Of Pre-event Short And Long-term Mitigation Strategies For Flooding Hazards

Himadri Sen Gupta, University of Oklahoma, Norman, OK, United States, hgupta@ou.edu, Omar Magdy Nofal, Andres David Gonzalez, Charles D. Nicholson, John W. van de Lindt

We propose a mathematical model to study the effects and tradeoffs associated with pre-event short-term and long-term mitigation strategies to minimize the economic loss associated with flooding hazards. We illustrate the capabilities of the model with a case study on Lumberton, NC. Lumberton has been affected by severe flooding events with significant recurring economic loss. The model uses the cost from a portfolio of mitigation strategies, each representative of a different mitigation strategy, and the resulting flood-induced monetary losses corresponding to each strategy. Finally, the optimal flood mitigation plan for buildings is provided based on a mitigation budget constrained.

3 - Use Of Ships For Fuel Emergency Distribution On Islands

Vahid Eghbal Akhlaghi, University of Iowa, Iowa City, IA, United States, vahid-eghbalakhlaghi@uiowa.edu, Ann Melissa Campbell

We present a mixed-integer programming model to examine the strategies for using ships to supplement the fuel supply on islands after a major disaster. The problem is motivated by practices proposed by FEMA after recent hurricanes in the Caribbean. The model presented includes decisions about routing ships to ports and assignment of fuel dispensing sites to ports to minimize the latest time a fuel distribution site receives its required fuel supply. An extension of the model to consider the use of standby ships is introduced. After proving the NP-hardness of the problem, we derive structural properties, lower bounds, and valid inequalities. A case study based on real data for Puerto Rico is presented.

4 - Modeling Of Covid-19 Trade Measures On Essential Products: A Multiproduct, Multicountry Spatial Price Equilibrium Framework

Mojtaba Salarpour, University of Massachusetts-Amherst, Amherst, MA, United States, msalarpour@umass.edu, Anna B. Nagurney, June Dong

We develop a unified variational inequality framework in the context of spatial price network equilibrium problems that handles multiple products with multiple demand and supply markets in multiple countries as well as multiple transportation routes. The model incorporates a plethora of distinct trade measures, which is particularly important in the pandemic, as PPEs and other essential products are in high demand, but short in supply globally. In the model, product flows as well as prices at the supply markets and the demand markets in different countries are variables that allows us to seamlessly introduce various trade measures, including tariffs, quotas, as well as price floors and ceilings.

5 - A Scenario-based Stochastic Model For VRP In PD-HL
Azadeh Sadeghi, University of Michigan-Flint, Flint, MI, United States, as262914@ohio.edu, Felipe Aros-Vera

We develop a two-stage stochastic programming model for the distribution of water in Post-Disaster Humanitarian Logistics (PD-HL). The model solves the Social Cost Vehicle Routing Problem incorporating uncertainty in travel times. The objective of the model minimizes social cost which includes logistics and deprivation costs. Deprivation costs incorporate the survivors' suffering due to the lack of access to critical supplies. The case study of water distribution in the aftermath of Hurricane Maria in 2017 evaluates the efficacy of the distribution and compares it with the deterministic version of the model.

■ VWB56

Virtual Room 56

Retail Management I

Contributed Session

Chair: Jingran Zhang, Marshall University, Huntington, WV, 25755, United States

1 - Strategic Choice Of Sales Channel In The Presence Of Consumer Showrooming And Webrooming
Prasenjit Mandal, Indian Institute of Management Calcutta, Kolkata, India, prasenjitm@iimcal.ac.in, Preetam Basu, Samir Biswas

Consumers often involve in hybrid shopping behaviors, such as showrooming and webrooming, in which they use one channel to gather product information but complete product purchases in a different channel. This paper studies the impact of such free-riding consumer behaviors on the multichannel sales operations of a supply chain consisting of a manufacturer and a downstream brick-and-mortar (BM) retailer. We find that both the manufacturer and the retailer may benefit from the former's dual-channel sales strategy. Contrary to the common wisdom, our findings reveal that both consumer showrooming and webrooming may benefit the BM retailer and the manufacturer, thereby leading to a win-win outcome.

2 - Selling To Nanostores Directly Or Through A Platform?
Jiwen Ge, Assistant Professor, Dongbei University of Finance and Economics, Dalian, China, jiwenge@dufe.edu.cn, Han ZHU

Lingshoutong is a new platform which bridges CPG manufacturers and over a million nanostores in China. Competing manufacturers can either serve nanostores directly or through the platform with the option to market products to consumers directly. We study the platform's role in the manufacturer competition.

3 - Routing Of Ecommerce Orders In An Omnichannel Retailer With Fulfillment Centers
Sanchoy Das, Professor, New Jersey Institute of Technology, Newark, NJ, United States, das@njit.edu, Jingran Zhang, Sevilay Onal

To grow their online business and meet the need for fast fulfillment, retailers have built ecommerce fulfillment centers to complement the store-ending distribution channel. Online orders can be fulfilled from either the center or the store. Store inventory is more expensive to locate and maintain but serves both walk-in and online customers. Center inventory is more economical but serves only online customers. Store demand is localized and at risk of discounting. We propose a dynamic order routing models based on real-time sales and inventory data across the retailer network.

■ VWB57

Virtual Room 57

Sreekumar Bhaskaran

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

Chair: Sreekumar R Bhaskaran, Southern Methodist University, Southern Methodist University, Dallas, TX, 75275-0333, United States

1 - Never Too Late? The Role Of Visiting Delay In Crowdsourcing Contests
Anant Mishra, Carlson School of Management, University of Minnesota, 321 19th Ave S, Minneapolis, MN, 55455, United States, mish0049@umn.edu, Brian Lee

We capture the heterogeneity in contest awareness on a platform among solvers in terms of visiting delay (i.e., the time that elapses between the start of a contest and a solver's first visit to the contest) and examine how it impacts submission behavior as well as contest outcomes.

2 - Entrepreneurial Mindset And Behavior For Product Introduction Decisions
Sinan Erzurumlu, Babson College, 231 Forest St, Tomasso 123, Babson Park, MA, 02457, United States, serzurumlu@babson.edu, Sreekumar R. Bhaskaran, Karthik Ramachandran

Firms often face a choice between developing a risky, advanced, product and launching an on-hand product. While launching the on-hand product might bring much needed revenues, it could affect the profitability of the advanced product under development depending on the consumer experience with the launched on-hand product. We present evidence from behavioral studies that study how product managers in established and startup firms make these decisions. We particularly examine the impact of cash constraint, available options and trade-off; our findings reveal insights on how to position project continuation with respect to cash on hand, value of the project and the leanness of development process.

3 - The Emergence Of Novel Product Uses: An Investigation Of Ikea Hacks
Shi-Ying Lim, National University of Singapore, 15 Computing Drive, Singapore, 117418, Singapore, Tian Chan

Exaptation refers to the emergence of novel functionalities in existing products. We examine how different search triggers for creative problem solving affect the occurrence of exaptations by comparing "problem-first" searches with "product-first" searches in a user-innovation context. In a problem-first search, a user-innovator defines the problem before arriving at a viable solution; in a product-first search, a user-innovator identifies the product to be used before seeking out a viable need. Using a novel data set comprising user hacks of IKEA products, we present evidence that hacks originating from a product-first search are less likely to generate exaptations than are hacks originating from a problem-first search. However, we also show that this difference is mitigated when the user-innovator has hacking experience or when the product is more modular.

4 - Where To Pop-up? Channel Operation Strategies Under Price Harmonization
Arunima Chhikara, University of Kansas, Lawrence, KS, United States, arunima.chhikara@warrington.ufl.edu, Avinash Geda, Nazli Turken, Janice E. Carrillo

Price harmonization across different channels is a widely practiced marketing strategy. Contrary to the intuition that dual-channel firms utilize both channels under channel-specific pricing strategy, we find conditions when a single (online/offline) channel dominates the dual-channel policy under the price harmonization strategy. We find that for the price harmonization strategy, the optimal channel selection, and the optimal prices depend on market sizes, on-hand inventory, and salvage value. Our results are important to channel managers' coordinated decisions when offering a product in their respective channels to optimize the overall profits at the retailer level.

5 - Adapting To Unknown Unknowns: Shepherding Radical Innovations To Market
Gulru F. Ozkan-Seely, University of Washington Bothell, 18115 Campus Way NE, University of Washington Both, Bothell, WA, 98011, United States, gulru@uw.edu, Surya D. Pathak, Mohan V Tatikonda

In this paper, we investigate the adaptive mechanisms employed by managers of projects that aim to yield novel innovations and involve high levels of uncertainty and ambiguity. We consider that project planning may enable or constrain the downstream ability to enact different adaptive mechanisms during the execution phase. We employ data collected from sixteen new product development projects from one organization and compound it with an optimal control model to understand managers' adaptation strategies and their outcomes. Our data analysis shows that to managers employ seven different adaptive behaviors ranging from taking no action to modifying the goals of the project.

■ VWB58

Virtual Room 58

Operations/ Marketing Interface II

Contributed Session

Chair: Honggang Hu, University of Florida, Gainesville, FL, 32611-1942, United States

1 - Competitive Equilibria In Product-plus-service Solutions With Customer Self-selection And Taste Heterogeneity
Arvind Sainathan, Neoma Business School, Reims, France, sainathanarvind@gmail.com

Many firms do not just sell products or services but solutions, integrated combinations of products and services. We analyze the competition between two solution providers (SPs) who sell to taste-heterogeneous customers. Type 1 customers are solution-based and consider the entire solution. Type 2 (Type 3) customers are product-first (service-first) and are primarily concerned about product component(s) (service component(s)). We first model customer self-selection in a novel way through an optimization problem. We then characterize different types of competitive equilibria between the SPs. We find that customer composition plays an integral role in determining the nature of equilibrium.

2 - Design Of Returnless Refunds In Online Retailing
Alireza Yazdani, Assistant Professor, Cal Poly Pomona, Pomona, CA, United States, ayazdani@cpp.edu, Eren Basar Cil, Monire Jalili, Michael Pangburn

Firms participating in online marketplaces often allow customers to return a product for a full refund. Given the costs associated with reverse product flows, in some cases retailers may benefit from allowing customers to keep returned products while yet obtaining a refund. We analyze the optimal structure of such a refund policy to maximize the firm's expected profits while considering strategic consumer behavior. We find that the firm's commitment to such a policy optimally influences the proportion of the return requests that are granted a returnless refund.

3 - Selling Fewer Better Things: Serving Variety With Slow Fashion
Monire Jalili, Bentley University, Waltham, MA, United States, mjalili@bentley.edu, Michael Pangburn, Seyed Alireza Yazdani Tabaei

The promise of slow fashion is to induce the consumption of longer-lasting items, thus reducing waste. Rather than purchase every latest fashion, consumers benefit from reusing products from their closet, if they have low sensitivity to trends or when a popular trend returns to fashion, hence potentially saving money over time. In a market where popular trends change periodically, we consider a seller facing customers with heterogeneous sensitivity to those trends. The seller has the flexibility to choose between serving the market with disposable (low quality) or reusable (high quality) products, or a mix of the two, and we analyze the seller's optimal segmentation and pricing strategy.

4 - Agency Or Wholesale? The Role Of Retail Pass-through
Honggang Hu, PhD student, University of Florida, Gainesville, FL, United States, hongganghu@ufl.edu, Quan Zheng, Xiajun Amy Pan

Previous studies suggest that e-tailers prefer agency selling to traditional wholesale selling due to channel efficiency. However, in a common e-tailer channel, we discover that the e-tailer's choice of selling format is critically moderated by the relative intensity of supplier competition, driven by the cross-brand retail pass-through behavior and competition mode (Bertrand or Cournot) among suppliers. Moreover, we caution against the seemingly-innocuous cost normalization under agency selling, and surprisingly find that the suppliers may benefit from higher marginal costs.

■ VWB60

Virtual Room 60

Analytics and Cyber Physical Systems(CPS)

Contributed Session

Chair: Hadi Ghayoomi, United States

1 - Game Theory For Security - A Tutorial
Quanyan Zhu, New Your University, New York, NY, United States, Stefan Rass

With the growing sophistication of the attacks and the complexity of the system, the protection using traditional methods could be cost-prohibitive. A new perspective and a new theoretical foundation are needed to understand security from a strategic and decision-making perspective. Game theory provides a natural framework to capture the adversarial and defensive interactions between an attacker and a defender. It provides a quantitative assessment of security, prediction of security outcomes, and mechanism design tools that can enable security-by-design, reverse the attacker's advantage, and deter its actions. This tutorial provides an introduction to game-theoretic security research.

2 - Assessing Resilience Of Hospitals To Cyberattack
Hadi Ghayoomi, George mason University, Fairfax, VA, United States, hghayoom@gmu.edu, Kathryn Laskey, Elise Miller-Hooks, Charles Hooks

This presentation investigates the impact on emergency hospital services from initiation through recovery of a distributed denial of service (DDoS) attack affecting the emergency department, intensive care unit and supporting laboratory services. Recovery strategies of paying ransom to the attackers with follow-on restoration and in-house full system restoration from backup are compared. A multi-unit, patient-based and resource-constrained discrete-event simulation model of a typical U.S. urban tertiary hospital is adapted for this purpose.

■ VWB64

Virtual Room 64

Federated learning and multi-task learning-I

Sponsored: Opt/Machine Learning

Sponsored Session

Chair: Kaizheng Wang, PhD, Columbia University, NY, United States

1 - An Efficient Framework For Clustered Federated Learning
Dong Yin, DeepMind, Mountain View, CA, United States, yindong10@gmail.com

We address the problem of federated learning (FL) where users are distributed and partitioned into clusters. This setup captures settings where different groups of users have their own objectives but by aggregating their data with others in the same cluster, they can leverage the strength in numbers in order to perform more efficient federated learning. For this new framework, we propose the Iterative Federated Clustering Algorithm (IFCA), which alternately estimates the cluster identities of the users and optimizes model parameters for the user clusters. We analyze the convergence rate of this algorithm first in a linear model with squared loss and then for generic strongly convex and smooth loss functions. We also present experimental results showing that our algorithm is efficient in non-convex problems such as neural networks.

2 - Straggler-resilient Federated Learning: Leveraging the Interplay Between Statistical Accuracy and System Heterogeneity
Ramtin Pedarsani, UC Santa Barbara, ECE Department, UCSB, Santa Barbara, CA, 93106, United States

Federated Learning involves learning from data samples distributed across a network of clients while the data remains local. Federated learning is prone to multiple system challenges including system heterogeneity where clients have different computation and communication capabilities. We propose a novel straggler-resilient federated learning method that incorporates statistical characteristics of the clients' data to adaptively select the clients. The key idea of our algorithm is to start the training procedure with faster nodes and gradually involve the slower nodes in model training once the statistical accuracy of the data corresponding to the current participating nodes is reached.

3 - Learning With User-Level Differential Privacy
Ananda Theertha Suresh, Google Research, New York, NY, United States

Much of the literature on differential privacy focuses on item-level privacy, where loosely speaking, the goal is to provide privacy per item or training example. However, recently many practical applications such as federated learning require preserving privacy for all items of a single user, which is much harder to achieve. Therefore understanding the theoretical limit of user-level privacy becomes crucial. We study the fundamental problems of discrete distribution estimation, high-dimensional mean estimation, and empirical risk minimization under user-level differential privacy. For all these problems, we provide polynomial time algorithms and information theoretic lower bounds.

■ VWB65

Virtual Room 65

Recent Advances in Integer Programming

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Moira MacNeil, University of Toronto, Toronto, ON, M4Y 1E5, Canada

1 - Achieving Consistency With Cutting Planes
John Hooker, Carnegie Mellon University, 5000 Forbes Ave, Pittsburgh, PA, 15213, United States, jh38@andrew.cmu.edu, Danial Davarnia, atefeh rajabalizadeh

Cutting planes can accelerate branch-and-bound search by cutting off fractional solutions of the linear programming relaxation. Yet they can also reduce backtracking by excluding inconsistent partial assignments -- that is, partial assignments that cannot be extended to a full feasible assignment. The constraint programming community has studied consistency extensively and uses it to reduce backtracking. We extend this approach to integer programming. We present a theoretical framework and elucidate the connection with the convex hull and cutting planes. We propose a cutting plane algorithm for achieving partial consistency and show that it can substantially reduce the search tree. More broadly, we suggest that consistency concepts offer a new perspective on IP that can lead to a better understanding of what makes branching methods work.

■ VWB63

Virtual Room 63

Distributed Algorithms for Power System Operations II

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Kibaek Kim, Argonne National Laboratory, Argonne National Laboratory, Lemont, IL, 60439-4801, United States

1 - A Distributionally Robust Control Of Distribution Grids With High Penetration Of Distributed Energy Resources

Geunyeong Byeon, Arizona State University, 750 S. Ash Avenue, Apt 9031, Tempe, AZ, 85281, United States, Kibaek Kim, Mihai Anitescu

We study a control mechanism for distribution grids with high penetration of distributed energy resources (DERs) that coordinates various control measures on different timescales and localizes the impact of uncertainty. A two-stage distributionally robust optimization (DRO) problem is proposed to determine a here-and-now decision on slow-timescale control measures as well as a coordination plan of local control systems based on possible recourse controls on fast-timescale against the worst-case probability distribution of DER outputs. We present a cutting plane method for solving the DRO problem that leverages a discretization scheme for the boundary of the support set and parallel computation. We conduct numerical experiments on various test systems and demonstrate the benefit of the proposed control scheme and the performance of the solution method.

2 - Parameter Learning In Alternating Direction Method Of Multipliers

Alyssa Kody, Argonne National Laboratory, Lemont, IL, United States, akody@anl.gov, Youngdae Kim, Kibaek Kim, Daniel K Molzahn, Daniel K Molzahn

For many large-scale physical networked systems, optimization tasks are traditionally performed using centralized methods, which can pose scalability issues. Many researchers have proposed the use of distributed methods, which enable parallelization. However, distributed methods like ADMM (Alternating Direction Method of Multipliers) can take many iterations to converge to a sufficiently high accuracy. The convergence rate is strongly correlated with the choice of penalty or step-size parameters, which are often defined heuristically. We develop a policy that learns the parameter values iteration-to-iteration that accelerate the convergence rate. We use reinforcement learning techniques to select parameters and train our policy using advanced neural network models. We demonstrate this method for ADMM via the distributed AC Optimal Power Flow problem.

3 - A Globally Convergent Distributed Jacobi Scheme For Block-structured Nonconvex Constrained Optimization Problems

Anirudh Subramanyam, Argonne National Laboratory, 9700 S. Cass Ave, Lemont, IL, 60439-4801, United States, asubramanyam@anl.gov, Youngdae Kim, Michel Schanen, Francois Pacaud, Mihai Anitescu

We develop a distributed parallel algorithm for block-structured nonconvex constrained optimization problems. Our algorithm performs Jacobi-type proximal updates of the augmented Lagrangian, requiring only local solutions of individual block nonlinear programming (NLP) problems. We provide a cheaply computable Lyapunov function that allows us to establish local and global convergence, and a simple and practical rule for updating the parameters. This in contrast to existing algorithms for nonconvex optimization based on ADMM, which rely on at least one of the following: Gauss-Siedel or sequential updates, global NLP solutions, non-computable Lyapunov functions, and careful tuning of algorithm parameters. Numerical experiments showcase its advantages for large-scale problems, including a 9000-bus AC optimal power flow instance over 100 time periods.

4 - Solving Large-scale Optimal Power Flow Problems With GPU Accelerators

François Pacaud, Argonne National Laboratory, Chicago, IL, United States

This talk presents an efficient method for solving large-scale optimal power flow problems with GPU accelerators. We revisit the reduced-space method of Dommel and Tinney to work directly in the non-Euclidean manifold corresponding to the nonlinear power flow equations. Our algorithm extracts at each iteration a reduced gradient and a reduced Hessian, and use an interior point algorithm to solve the OPF to optimality. All the algorithm is running directly on GPU, in a parallel fashion. In this talk, we will focus on the challenges we have encountered to implement the automatic differentiation backend and the optimization algorithm on GPU architecture, and present a comparison with Ipopt.

2 - Rank-one Updates For The Roundoff-error-free LU And Cholesky Factorizations

Adolfo R. Escobedo, Assistant Professor, Arizona State University, Po Box 878809, Tempe, AZ, 85287-8809, United States, adres@asu.edu, Venkata S. Gudivada

LU and Cholesky matrix factorization algorithms are core subroutines used to solve large numbers of linear systems encountered while solving an optimization problem. Standard factorization algorithms are highly efficient but remain susceptible to the accumulation roundoff errors, which can lead solvers to return feasibility and optimality certificates that are actually invalid. This talk introduces rank-one updates for the roundoff-error-free (REF) factorization framework, a toolset built on integer-preserving arithmetic for solving systems of linear equations exactly and efficiently. The developed rank-one updates enable the implementation of the REF framework, originally developed for linear programming, to various other problem classes (e.g., quadratic optimization). Computational results demonstrate the efficiency of the REF rank-one updates.

3 - On Stability Number Of Some Markovian Random Graphs

Yiran Zhu, The University of Edinburgh, Edinburgh, United Kingdom, Y.Zhu-95@sms.ed.ac.uk, Akshay Gupte

Computing the maximum size of an independent set in a graph G = (V;E), called the stability number (G), is a famous combinatorial optimization problem. Although this numberis in general hard to approximate within factor |V|, for random graphs there have been numerous studies on bounding (G) asymptotically. Almost all of these results are for the Erdös-Rényi random graph G(n,p) that has n vertices and edges being i.i.d. Bernoulli random variables (r.v.) with success probability p between 0 and 1.We are interested in a random graph model in which edges are generated dynamically with respect to a Markov process. Asymptotic results on both vertex degree and stability number are studied.

4 - A Dual Bounding Framework For Binary Quadratic Combinatorial Optimization

Mahdis Bayani, Polytechnique of Montreal, Montreal, QC, Canada, mahdis.bayani@polymtl.ca

Binary quadratic programming is a combinatorial optimization problem with binary variables and quadratic objective function. In this study, we propose a framework to reformulate a BQP problem with linear constraints to a new BQP defined on a graph. This framework relies on the concept of stars in graphs and partitioning the quadratic costs into in-star and out-of-star interactions. We exploit the star-based structure of the reformulation to develop column generation algorithms. We evaluate the performance of our methodology on different applications with different quadratic structure. The results suggest that the framework outperforms state-of-the-art solver in almost all the instances with zero out-of-star interactions in terms of both dual bound and computational time, while they delineate a potential direction to improve some instances of general BQP problems.

■ VWB67

Virtual Room 67

Recent Advances in High-Order Methods

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: César A. Uribe,

Co-Chair: Soomin Lee, Yahoo! Research, Yahoo! Research, Sunnyvale, CA, 94087, United States

1 - Hyperfast Second-Order Local Solvers for Efficient Statistically Preconditioned Distributed Optimization

Cesar A. Uribe, Rice University, 1307 Richmond Ave APT 234 Houston, TX, Houston, TX, 77006, United States, cauribe@rice.edu, Pavel Dvurechensky, Dmitry Kamzolov, Aleksandr Lukashevich, Soomin Lee, Erik Ordentlich, Alexander Gasnikov

Statistical preconditioning leads to fast methods for distributed large-scale problems allowing fewer communications. Multiple workers compute gradients in parallel, which are used by a central node to update the parameter by solving an auxiliary smaller scale problem. Previous works require an exact solution of the auxiliary problem at every iteration, which may be impractical. This paper proposes a method that allows the inexact solution of the auxiliary problem, reducing the total computation time. Moreover, for loss functions with high-order smoothness, we exploit the structure of the auxiliary problem and propose a method with complexity O(^1/5), where is the local condition number. We show complexity estimates which are provably better than variance reduction methods and with the same convergence rate as statistical preconditioning with exact solutions.

2 - Newton Method Over Networks Is Fast Up To The Statistical Precision

Amir Daneshmand, Purdue University, 221 S. 9th Street, Apt 8, Lafayette, IN, 47901, United States, Gesualdo Scutari, Pavel Dvurechensky, Alexander Gasnikov

We propose a distributed cubic regularization of the Newton method for solving empirical risk minimization problems over a network of agents, modeled as undirected graph. The algorithm employs an inexact, preconditioned Newton step at each agent's side: the gradient of the centralized loss is iteratively estimated via a gradient-tracking consensus mechanism and the Hessian is subsampled over the local data sets. No Hessian matrices are exchanged over the network. Our convergence analysis reveals that statistically accurate solutions are achievable in roughly the same number of iterations of the centralized cubic Newton, at the cost of limited communications per iterations. This represents a significant improvement with respect to existing, statistically oblivious, distributed Newton-based methods over networks.

3 - A Stochastic Newton Algorithm For Distributed Convex Optimization

Brian Bullins, Toyota Technological Institute-Chicago, Chicago, IL, United States, Kumar K Patel, Ohad Shamir, Nathan Srebro, Blake Woodworth

We propose and analyze a stochastic Newton algorithm for distributed convex optimization. At the heart of our approach is recent work showing that quadratic objectives can be optimized to high accuracy using a parallel algorithm with only a single round of communication. Our algorithm expresses the Newton update as the solution to a quadratic problem which we optimize using stochastic gradients and stochastic Hessian-vector products for the objective, both of which can typically be computed efficiently. We analyze our method for quasi-self-concordant objectives (e.g., logistic regression), and demonstrate that it can in some instances achieve faster convergence rates than comparable first-order methods while requiring less communication and a similar amount of computation.

4 - A Hybrid Algorithm For Distributed Consensus Optimization

Ermin Wei, Northwestern University, Northwestern Univ 2145 Tech Dr # L310, Evanston, IL, 60208-0884, United States, ermin.wei@northwestern.edu, Xiaochun Niu

We consider a consensus optimization problem in a multi-agent network, where all agents are connected to a central server. Current distributed algorithms fail to capture the heterogeneity in agents' local computation capacities. We propose a new primal-dual algorithm framework that allows different agents to perform various types of updates. Specifically, each agent can choose to perform first-order or second-order Newton-type updates. Theoretically, we prove that our algorithm achieves a linear convergence rate regardless of the distribution of first and second order updates used. Numerical studies are provided to demonstrate the efficacy of our method in practice. To the best of our knowledge, this is the first hybrid algorithmic framework allowing heterogeneous local updates for distributed consensus optimization with a provable convergence guarantee.

■ VWB68

Virtual Room 68

Stochastic Optimization Methods in Machine Learning

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Aritra Dutta, Thuwal, 23955-6900, Saudi Arabia

Co-Chair: El houcine Bergou, INRA-KAUST, INRA-KAUST, Jeddah, Saudi Arabia

1 - Local SGD Meets Asynchrony

Vyacheslav Kungurtsev, Czech Technical University, 9 Jiriho z Podebrad, Kv 22, Prague, 13000, Czech Republic

Distributed variants of stochastic gradient descent (SGD) are central to training deep neural networks on massive datasets. Several scalable versions of data-parallel SGD have been developed, leveraging asynchrony, communication-compression, and local gradient steps. Current research seeks a balance between distributed scalability--seeking to minimize the amount of synchronization needed--and generalization performance--seeking to achieve the same or better accuracy relative to the sequential baseline. However, a key issue in this regime is largely unaddressed: if ``local" data-parallelism is aggressively applied to better utilize the computing resources available with workers, generalization performance of the trained model degrades. In this talk, we present a method to improve the "local scalability" of decentralized SGD. In particular, we propose two key techniques: (a) shared-memory based asynchronous gradient updates at decentralized workers keeping the local minibatch size small, and (b) an asynchronous non-blocking in-place averaging overlapping the local updates, thus essentially utilizing all compute resources at all times without the need for large minibatches. Empirically, the additional noise introduced in the procedure proves to be a boon for better generalization. On the theoretical side, we show that this method guarantees ergodic convergence for non-convex objectives, and achieves the classic sublinear rate under standard assumptions.On the practical side, we show that it improves upon the performance of local SGD and related schemes, without compromising accuracy.

2 - Peeling Back the Layers of Deep Neural Networks

Aritra Dutta, KAUST, Division of Computer, Electrical and Mathemat, Al, Thuwal, 23955-6900, Saudi Arabia

When there are a lot of training data, or the deep neural network is too large, distributed parallel training becomes essential, which refers to either data or model parallelism. In both cases, parallelism introduces various overheads. Network communication is one such significant overhead in large-scale distributed deep learning. Many compressed communication schemes, in the form of sparsification or quantization of stochastic gradients, have been proposed to minimize the problem. However, there exists a significant discrepancy between theory and practice. Theoretical analysis of most existing compression methods assumes compression is applied to the gradients of the entire model. However, practical implementations in popular deep-learning toolkits such as TensorFlow or PyTorch operate individually on the gradients of each layer of the model. In this talk, we show that theoretically, layer-wise compression is better because the convergence rate is upper bounded by that of entire-model compression for a wide range of biased and unbiased compression methods. However, despite the theoretical bound, our experimental study of six well-known compression methods demonstrates that convergence, in practice, may or may not be better, depending on the actual trained model and compression ratio. Our findings suggest that it would be advantageous for deep learning frameworks to include support for both layer-wise and entire-model compression.

3 - Adaptive Acceleration for First-order Methods

Jingwei Liang, Queen Mary University of London, GREYC, CNRS UMR 6072, 6 Bd du Marechal Juin, London, 14050, United Kingdom

: First-order operator splitting methods are ubiquitous among many fields through science and engineering, such as inverse problems, image processing, statistics, data science and machine learning, to name a few. In this talk, through the fixed-point sequence, I will first discuss a geometry property of first-order methods when applying to solve non-smooth optimization problems. Then I will discuss the limitation of current widely used "inertial acceleration" technique, and propose a trajectory following adaptive acceleration algorithm. Global convergence is established for the proposed acceleration scheme based on the perturbation of fixed-point iteration. Locally, connections between the acceleration scheme and the well-studied "vector extrapolation technique" in the field of numerical analysis will be discussed, followed by acceleration guarantees of the proposed acceleration scheme. Numeric experiments on various first-order methods are provided to demonstrate the advantage of the proposed adaptive acceleration scheme.

4 - ALMA: Alternating Minimization Algorithm for Clustering Mixture Multilayer Network

Teng Zhang, University of Central Florida, 176 Reserve Cir, Oviedo, FL, 32765, United States

The paper considers a Mixture Multilayer Stochastic Block Model (MMLSBM), where layers can be partitioned into groups of similar networks, and networks in each group are equipped with a distinct Stochastic Block Model. The goal is to partition the multilayer network into clusters of similar layers, and to identify communities in those layers. Jing et al. (2020) introduced the MMLSBM and developed a clustering methodology, TWIST, based on regularized tensor decomposition.The present paper proposes a different technique, an alternating minimization algorithm (ALMA), that aims at simultaneous recovery of the layer partition, together with estimation of the matrices of connection probabilities of the distinct layers. Compared to TWIST, ALMA achieves higher accuracy both theoretically and numerically.

■ VWB69

Virtual Room 69

Reinforcement Learning

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Zaiwei Chen, Georgia Institute of Technology, Atlanta, GA, 30318, United States

Co-Chair: Siva Theja Maguluri, ISyE Georgia Tech, ISyE Georgia Tech, Atlanta, GA, 30339, United States

1 - Finite Sample Analysis Of Off-policy Natural Actor-critic Algorithm

Sajad Khodadadian, Georgia Institute of Technology, Atlanta, GA, United States, skhodadadian3@gatech.edu

In this paper, we provide finite-sample convergence guarantees for an off-policy variant of the natural actor-critic (NAC) algorithm based on Importance Sampling. In particular, we show that the algorithm converges to a global optimal policy with a sample complexity of O(-3log2(1/)) under an appropriate choice of stepsizes. In order to overcome the issue of large variance due to Importance Sampling, we propose the Q-trace algorithm for the critic, which is inspired by the V-trace algorithm. This enables us to explicitly control the bias and variance, and characterize the trade-off between them. As an advantage of off-policy sampling, a major feature of our result is that we do not need any additional assumptions, beyond the ergodicity of the Markov chain induced by the behavior policy.

2 - Causal Reinforcement Learning

Devavrat Shah, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States

We shall discuss adaptation of methods from causal inference with observational data to enable model estimation and policy learning in the context of reinforcement learning using observational or offline data. We will report on what can be solved and where challenges remain.

3 - Langevin DQN

Vikranth Reddy Dwaracherla, Stanford University, Stanford, CA, United States,

Algorithms that tackle deep exploration -- an important challenge in reinforcement learning -- have relied on epistemic uncertainty representation through ensembles or other hypermodels, exploration bonuses, or visitation count distributions. An open question is whether deep exploration can be achieved by an incremental reinforcement learning algorithm that tracks a single point estimate, without additional complexity required to account for epistemic uncertainty. We answer this question in the affirmative. In particular, we develop Langevin DQN, a variation of DQN that differs only in perturbing parameter updates with Gaussian noise and demonstrate through a computational study that the presented algorithm achieves deep exploration. We also offer some intuition to how Langevin DQN achieves deep exploration.

4 - Global Optimality Guarantees For Policy Gradient Methods

Jalaj Bhandari, Cold Spring Harbor Lab, 500, Riverside Drive, Room 832, New York, NY, 10027, United States, Jalaj Bhandari, Columbia University, New York, NY, United States, jb3618@columbia.edu, Daniel Russo

Policy gradients methods apply to complex, poorly understood, control problems by performing stochastic gradient descent over a parameterized class of polices. Unfortunately, even for simple control problems solvable by standard dynamic programming techniques, policy gradient algorithms face non-convex optimization problems and are widely understood to converge only to a stationary point. This work identifies structural properties - shared by several classic control problems - that ensure the policy gradient objective function has no suboptimal stationary points despite being non-convex. When these conditions are strengthened, this objective satisfies a Polyak-lojasiewicz (gradient dominance) condition that yields convergence rates. We also provide bounds on the optimality gap of any stationary point when some of these conditions are relaxed.

5 - Finite-Sample Analysis Of Reinforcement Learning Algorithms: A Lyapunov Approach

Zaiwei Chen, Georgia Institute of Technology, Atlanta, GA, 30318, United States

This paper develops an unified framework to study finite-sample convergence guarantees of a large class of value-based asynchronous Reinforcement Learning (RL) algorithms. We do this by first reformulating the RL algorithms as Markovian Stochastic Approximation (SA) algorithms to solve fixed-point equations. We then develop a Lyapunov analysis and derive mean-square error bounds on the convergence of the Markovian SA. Based on this result, we establish finite-sample convergence bounds for asynchronous RL algorithms such as Q-learning, n-step TD, TD(\lambda), and off-policy V-trace. As a by-product, by analyzing the performance bounds of the TD(\lambda) (and n-step TD) algorithm for general \lambda (and n), we demonstrate a bias-variance trade-off, i.e., efficiency of bootstrapping in RL. This was first posed as an open problem in (Sutton, 1999).

■ VWB70

Virtual Room 70

Frontier of Optimization and Machine Learning

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Ilan Lobel, New York University, New York, NY, 10012-1807, United States

Co-Chair: Omar Besbes, Columbia University, New York, NY, 10027-6945, United States

Co-Chair: Yuri Fonseca, New York, NY, 10027, United States

1 - Offline And Online Learning From Optimal Actions

Yuri Fonseca, Columbia University, 3022 Broadway, 4th floor west, New York, NY, 10027, United States, Omar Besbes, Ilan Lobel

We study the offline and online problem of contextual optimization where instead of observing the loss, we observe the optimal action an oracle with full knowledge would have taken. At each period, the decision-maker has access to a new set of feasible actions to select from and to a new contextual function that affects that period's loss function. In the offline setting, the decision-maker has already collected information from multiple periods. We aim to minimize regret, which is defined as the difference between our losses and the ones incurred by an all-knowing oracle. Through our offline analysis, we tightly connect the type of performance that can be achieved as a function of the underlying geometry of the information induced by offline data. For the online setting, we leverage this tight link to optimize regret.

2 - Finite Sample Analysis Of Minimax Offline Reinforcement Learning: Completeness, Fast Rates And First-order Efficiency

Masatoshi Uehara

We offer a theoretical characterization of off-policy evaluation (OPE) in reinforcement learning using function approximation for marginal importance weights and q-functions when these are estimated using recent minimax methods. Under various combinations of realizability and completeness assumptions, we show that the minimax approach enables us to achieve a fast rate of convergence for weights and quality functions, characterized by the critical inequality \citep{bartlett2005}. Based on this result, we analyze convergence rates for OPE. In particular, we introduce novel alternative completeness conditions under which OPE is feasible and we present the first finite-sample result with first-order efficiency in non-tabular environments, i.e., having the minimal coefficient in the leading term.

3 - Data-driven Exploration In Sequential Decision-making

Mohsen Bayati, Stanford University, Stanford, CA, 94305-7216, United States, Nima Hamidi

In sequential decision-making problems, exploration refers to active experimentation to learn decision-reward functions that benefits long-term decision-making, at the expense of a short-term opportunity cost. While it is established that some amount of exploration is necessary in most situations, empirical evidence suggest that well-known algorithms such as OFUL or Thompson Sampling (TS) suffer from over-exploration. In this talk we show techniques that control the rate of exploration in OFUL and TS based on the observed data. The resulting methods enjoy the same theoretical guarantees as OFUL and TS while substantially reduce their opportunity cost in empirical simulations.

4 - Risky Investments Under Static And Dynamic Information Acquisition

Jussi Keppo, National University of Singapore. Singapore, 119245, Singapore, keppo@nus.edu.sg, Hong Ming Tan, Chao Zhou

We study the management of risky investments under static and dynamic information acquisition policies and under different environments such as falling cost of information. We show that borrowing-constrained or highly risk-averse investors have low demand for information. Thus, these investors learn the least. We also show that under the dynamic policy, the investor's unconditional expected optimal quantity of information and investment amount are higher than under the static policy. However, when the initial belief of the investment payoff is either high or low, both policies give about the same expected results. Thus, to incentivize firms and investors to acquire information and invest when the initial belief of their risky investment payoff is mediocre, governments should allow them to obtain information dynamically.

5 - An Inverse Optimization Approach To Measuring Clinical Pathway Concordance For Colon And Breast Cancer

Nasrin Yousefi, University of Toronto, 30 Charles St W unit 1114, Toronto, ON, M4Y1R5, Canada, Timothy Chan, Yusuf Shalaby

Clinical pathways outline standardized processes in the delivery of care for a specific disease. Clinical pathway concordance (CPC) refers to the degree of alignment between the actual care patients receive and the ideal care described in a clinical pathway. It is important to measure CPC so that variations in health system performance and bottlenecks in the delivery of care can be detected, monitored and acted upon. We develop a general methodology for measuring CPC based on inverse optimization, apply our novel concordance metric to real datasets of colon and breast cancer patients, and show that it has a statistically significant association with survival.

6 - Learning To Schedule Heuristics In Branch And Bound

Antonia Chmiela, Zuse Institute Berlin, Berlin, Germany, chmiela@zib.de, Elias B. Khalil, Ambros Gleixner, Andrea Lodi, Sebastian Pokutta

Primal heuristics play a crucial role in exact solvers for Mixed Integer Programming (MIP). While much of MIP research focuses on designing effective heuristics, the question of how to manage them has not received equal attention. Generally, solvers follow hard-coded rules that might not yield the best performance when considering specific problem classes. In this work, we propose the first data-driven framework for scheduling heuristics in a MIP solver. By learning from data describing the performance of primal heuristics, we obtain a problem-specific heuristic schedule that finds many solutions at minimal cost. We provide a formal problem description and propose an efficient algorithm for computing such a schedule. Compared to a state-of-the-art academic MIP solver, we are able to reduce the average primal integral by up to 49% on two classes of challenging instances.

■ VWB72

Virtual Room 72

Location Problems and Geometric Optimization

Sponsored: Location Analysis

Sponsored Session

Chair: Mehdi Behroozi, PhD, Northeastern University, Northeastern University, MA, United States

1 - Approximation Algorithms For Continuous K-medians Problem

Reyhaneh Mohammadi, Northeastern University, 45 Stuart Street, Apt 808, Boston, MA, 02116, United States

Given a set of points, k median problem seeks to find k points/locations in a way to minimize the total Euclidean distance between each point and its nearest median point. In this project we investigate the continuous version of this problem when the set of points form a continuum. In this version, given a convex polygon and an integer k, we aim at finding k medians inside the polygon to minimize the objective function. We present two fast approximation algorithms with factors less than 2 for this problem.

2 - Geometric Optimization Approaches For Downsizing Logistics Problems

Peiqi Wang, Northeastern University, Boston, MA, United States, wang.peiq@northeastern.edu

This paper focuses on a special case of location problems where the goal is to downsize the existing facilities. Recent trends towards e-commerce and the impact of the COVID-19 pandemic is forcing many companies to make downsizing decisions to endure under these largely unforeseen market conditions. Hence the survival of many companies depends on making downsizing decisions efficiently and correctly. Computational geometry and optimization approaches have been successfully used in many logistics problems including location problems. We introduce several optimization models for different variants of the downsizing problem, develop geometric optimization algorithms to solve them and conduct a theoretical analysis to measure the impact of downsizing.

Wednesday, 9:00AM - 9:30AM

■ VW85-1

Virtual Room 85

Technology Showcase: Production Scheduling Optimization in MATLAB: From Problem Formulation to Application Deployment

Technology Showcase

1 - Production Scheduling Optimization in MATLAB: From Problem Formulation to Application Deployment

Chris Lee, MathWorks, Waltham, MA, United States, Steve Grikschat

MATLAB Optimizationmakes it easy to solve decision and operations optimization problems, such asproduction scheduling. In this talk, we will focus on a demonstration ofthe problem-based optimization modeling workflow in MATLAB for a gasolineblending production schedule problem. We will see how the problem-basedworkflow makes it easy to define, verify, and solve a complex problem with anintuitive formulation. We will also cover the workflow for packaging theoptimization problem into an easy-to-use application for wider deployment.

Wednesday, 9:45AM - 10:45AM

■ WP01

CC - Ballroom A /Virtual Theater 1

Plenary: Improving Supply Chain Resilience: Looking Back and Looking Forward

Plenary Session

1 - Plenary: Improving Supply Chain Resilience: Looking Back and Looking Forward

Christopher S. Tang, University of California-Los Angeles, UCLA Anderson School of Management, Operations and, Los Angeles, CA, 90095-1481, United States

Prolonged shortages of PPE, vaccines, and semiconductor chips during the Covid-19 Pandemic exposed the vulnerabilities of global supply chains. In this plenary talk, I share my observations and discuss potential steps that government representatives, industry leaders, and INFORMS members can take to improve supply chain resilience.

Wednesday, 11:00AM - 12:30PM

■ VWA62

Virtual Room 62

Emerging Technologies and Methods for Airline and Airport Operations

Sponsored: Aviation Applications

Sponsored Session

Chair: Lishuai Li, City University of Hong Kong, City University of Hong Kong, Kowloon, ?, Hong Kong

1 - Investment Optimization For Electric And Hydrogen Aircraft Fueling Operations

Simon J van Oosterom, Delft University of Technology, Delft, Netherlands, simon.vano@xs4all.nl

In this presentation, we discuss optimization models to determine the most cost-effective airport infrastructures that support electric and hydrogen-propelled flights. Specifically, we determine optimal electric battery-charging and hydrogen-canister charging infrastructures that satisfy the energy demand of electric/hydrogen aircraft. Our approach is illustrated in a case study for a large European airport.

2 - Incorporating Network Properties In Modelling And Solving The Airport Slot Allocation Problem

Konstantinos G. Zografos, Lancaster University, Lancaster, United Kingdom, k.zografos@lancaster.ac.uk, Merve Keskin

The demand at congested airports is managed through allocation of slots to airlines' requests. Since these allocations are initially performed individually for each airport, the single airport schedules need to be coordinated to ensure seamless schedule coordination at network level. We introduce a novel mathematical model and an efficient solution algorithm for optimizing the allocation of airport slots at network level. The proposed model incorporates properties of the underlying network to: i) adjust the slot allocations of individual airports, ii) ensure airline schedule feasibility throughout the network, and iii) minimize the deviation from the initial schedules.

3 - Understanding Collusion In Multilevel Markets

Nicole Adler, The Hebrew University of Jerusalem, Jerusalem, Israel, Amir Brudner, Riccardo Gallotti, Jose J. Ramasco, Filippo Privitera

We propose a game-theoretic formulation that integrates consumer behavior data, drawn from information and communication technologies, with economic data. Utilizing discrete choice models and developing a catchment area game which analyzes the Greater London multi-airport region, we search for horizontal collusion between airports and vertical collusion with airlines. We find horizontal collusion is defined as very likely in the symmetric case but unlikely once we analyze the real world because of market-specific imbalances. This approach overcomes the information asymmetry issue long defined but not yet solved when regulating two-sided platforms such as airports, malls, Amazon and Ebay.

4 - Comparative Ranking Of The Effect On Re-routed Aircraft Due To Historical Space Vehicle Launches

Sanjiv Shresta, DOT, Washington, DC, United States

The growth of commercial space operations has resulted in increased frequency of space vehicle launches. To ensure safe operations, airspace around launch trajectories are closed to aircraft during a launch. Aircraft that plan to fly through a launch airspace must reroute to avoid the launch airspace. Measuring the effect of launches on flights is difficult because rerouting is a common occurrence, irrespective of a launch. We present a methodology for identifying the set of flights that are affected by a space vehicle launch, by comparing flight plans across multiple non-launch days with the launch day flight plan. In this way, a consistent methodology can be applied across many launches.

■ VWC01

Virtual Room 01

Advanced Data Analytics in Healthcare

Sponsored: Data Mining

Sponsored Session

Chair: Cheng-Bang Chen, University of Miami, University of Miami, Miami, FL, 33143, United States

Co-Chair: Bing Yao, Oklahoma State University, Oklahoma State University, Stillwater, OK, 74075, United States

1 - A Hybrid Computer Simulation Approach to Manage No-Shows in Primary Care Operations

Ammar Abdul Motaleb, University of Texas at Arlington, Arlington, TX, United States, Amith Viswanatha, Yuan Zhou, Yan Xiao, Kay Yut Chen, Ayse Gurses, PROMIS Lab Investigators

Patient no-show and late cancellation disrupt the exasperated primary care operations. This practice has adverse ramifications such as decreased clinic resources utilization, increased healthcare costs, among others. To examine the impacts of such disruption on clinic operations and patient satisfactions, this study develops a hybrid computer simulation model that integrates discrete-event simulation (DES) and agent-based simulation (ABS) to represent the flow of patients and micro-level behaviors of clinic personnel. Further, this study designs a set of computer experiments to evaluate the effectiveness of various no-show handling strategies and sheds some lights on its implications in primary care operations management.

2 - A Novel Heterogeneous Recurrence Analysis For Medical Imaging Characterization

Yujie Wang, University of Miami, Miami, FL, United States, Cheng-Bang Chen

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 people's health status. Since over 50% of medical data are in medical imaging formats, there is an urgent need to develop an effective and efficient analytical framework to characterize the complex spatial patterns from the medical images. This research presents a novel heterogeneous recurrence analysis of spatial data, developing an innovative recurrence hyperplane representation to capture, extract and quantify the heterogeneous spatial recurrences in the medical images. Both simulations and real-world studies illustrate that the proposed methodology can effectively characterize the complex spatial patterns from the medical images and provide subtle information to improve the diagnosis.

3 - Trustworthy AI Based Hospital Census Forecasting Application

Mihir Mehta, Penn State University, University Park, PA, 16801-4585, United States, Biplab Sudhin Bhattacharya, Eric Reich, Soundar Kumara

COVID-19 hospital census forecasting provides crucial insights to clinical leadership for developing effective resource allocation and scheduling policies. We develop a sequence-to-sequence deep learning-based trustworthy and deployment-friendly application to forecast COVID-19 hospital census for a multi-hospital health care system. The application demonstrates actionable results and proposes a trust index to quantify the trustworthiness of the model performance. Based on the same, we develop a visualization-based trust evaluation and monitoring procedure.

4 - Monte Carlo Tree Search For Optimal Cancer Intervention Strategies Among BRCA Mutation Carriers

Wuyang Qian, Oklahoma State University, Stillwater, OK, United States, wuyang.qian@okstate.edu, Bing Yao

Breast and ovarian cancer is the second and fifth leading cause of cancer death of women in the US. Prophylactic surgeries involving removing organs from the patient's body would significantly reduce the risk of cancer for mutation carriers. The problem is when should mutation carrier women receive prophylactic surgeries to not only decrease cancer incidence rate but also maintain a high level of quality-adjusted life years (QALYs). The proposed research aims to develop a sequential decision-making framework for optimal cancer intervention strategies through Monte Carlo Tree Search (MCTS), which increases the computation efficiency. The proposed framework will be validated through a simulation and further evaluated using real-world breast cancer and ovarian cancer data.

■ VWC02

Virtual Room 02

Robustness of Neural Networks

Sponsored: Data Mining

Sponsored Session

Chair: Somayeh Sojoudi, University of California-Berkeley, Berkeley, CA, 94530, United States

Co-Chair: Brendon Anderson, University of California-Berkeley, Berkeley, CA, 94709-1543, United States

1 - Improved Certification For The Robustness Of ReLU Neural Networks

Ziye Ma, University of California, Berkeley, Somayeh Sojoudi

In this presentation, we consider the problem of certifying the robustness of pre-trained ReLU neural networks against adversarial input perturbations. To be more specific, we only consider the semidefinite programming (SDP) approach of certification. However, although proven to be tighter than many existing methods, even SDP approaches suffer from large relaxation gaps when used on large networks with many hidden layers. Towards this end, we introduce 2 theoretically sound and empirically proven techniques to further bridge this gap when the current SDP approach is unsatisfactory. Both techniques can achieve exact certification in the asymptotic regime with exponential complexity. Moreover we show that even with polynomial complexity both techniques can greatly reduce the relaxation gap when compared to the original method.

2 - Convex Formulation Of Robust Two-layer Neural Network Training

Yatong Bai, University of California, Berkeley, Berkeley, CA, United States, Tanmay Gautam, Yu Gai, Somayeh Sojoudi

Recent work has shown that the training of a two-layer, scalar-output fully-connected neural network with ReLU activations can be reformulated as a finite-dimensional convex program. Leveraging this result, we derive convex optimization approaches to solve the "adversarial training" problem, which aims to train neural networks that are robust to adversarial input perturbations. These convex problems are derived for the cases when hinge loss and squared loss between the network output and the target are used to calculate the training cost. Our work provides an alternative adversarial training method over the current approximation methods, such as Fast Gradient Sign Method (FGSM) and Projected Gradient Descent (PGD). We demonstrate in different experiments that the proposed method achieves higher adversarial robustness than existing training methods.

3 - Data-Driven Certification Of Neural Networks With Random Input Noise

Brendon Anderson, University of California, Berkeley, Berkeley, CA, 94709-1543, United States, Sojoudi Somayeh

A novel robustness certification method is introduced that lower-bounds the probability that neural network outputs are safe when the input is subject to random noise from an arbitrary probability distribution. The bound is cast as a chance-constrained optimization problem, which is then reformulated using input-output samples to make the optimization constraints tractable. We develop sufficient conditions on the number of samples needed to make the robustness bound hold with overwhelming probability, and we show for a special case that the proposed optimization reduces to an intuitive closed-form solution. Synthetic, MNIST, and CIFAR-10 case studies experimentally demonstrate that this method is able to certify robustness against various input noise regimes over larger uncertainty regions than prior state-of-the-art techniques.

4 - A Closer Look At Accuracy Vs. Robustness

Yao-Yuan Yang, University of California, San Diego

Current methods for training robust networks lead to a drop in test accuracy, which has led prior works to posit that a robustness-accuracy tradeoff may be inevitable in deep learning. We take a closer look at this phenomenon and first show that real image datasets are actually separated. With this property in mind, we then prove that robustness and accuracy should both be achievable for benchmark datasets through locally Lipschitz functions, and hence, there should be no inherent tradeoff between robustness and accuracy. Through extensive experiments with robustness methods, we argue that the gap between theory and practice arises from two limitations of current methods: either they fail to impose local Lipschitzness or they are insufficiently generalized.

■ VWC03

Virtual Room 03

Robust Learning Methods for Econometrics and Business Analytics

Sponsored: Data Mining

Sponsored Session

Chair: Artem Prokhorov, St.Petersburg State University, St.Petersburg State University, Woodcroft, 2767, Australia

1 - Feature selection via a modern optimisation lens: helping insurers ask the right questions.

Jessica Wai Yin Leung, The University of Sydney, Sydney, Australia, Dmytro Matsypura

2 - Adversarial Classification via Distributional Robustness with Wasserstein Ambiguity.

Stephen J Wright, Professor, University of Wisconsin-Madison, Computer Sciences Department, University Of Wiscon, Madison, WI, 53706-1613, United States, Nam Ho-Nguyen

We study a model for adversarial classification based on distributionally robust chance constraints. We show that under Wasserstein ambiguity, the model aims to minimize the conditionalvalue-at-risk of the distance to misclassification, and we explore links to adversarial classification models proposed earlier and to maximum-margin classifiers. We also provide a reformulation of the distributionally robust model for linear classification, and show it is equivalent to minimizing a regularized ramp loss objective. Numerical experiments show that, despite the nonconvexity of this formulation, standard descent methodsappear to converge to the global minimizer for this problem. Inspired by this observation, we show that, for a certain separable distribution, the only stationary point of the regularized ramp loss minimization problem is the global minimizer.

3 - Mixed Integer Optimization for Time Series Change Points Detection

Alexander Semenov, University of Florida and St. Petersburg State University, Shalimar, FL, 32579-1163, United States, Artem Prokhorov, Anton Skrobotov

Identifying structural breaks in time series data is a major area of interest within econometrics. Traditionally, researchers relied on statistical approaches e.g. Bai and Perron (1998). Recently, a growing literature is showing attractive properties of Mixed Integer Optimization (MIO) methods, as means of obtaining efficient solutions in a wide range of statistical problems. In this paper we develop a MIO method for the identification of structural breaks in time series data.

To demonstrate the effectiveness of our approach, we conduct extensive numerical experiments on synthetic and real-world data. The proposed MIO representation is solved using a well-known optimization solver. We examine optimal and sub-optimal solutions, and the effect of tuning the parameters. We show how to choose the tuning parameters and compare our results with established methods.

4 - Irrational Exuberance: Correcting Bias In Probability Estimates

Bradley Rava, University of Southern California, Los Angeles, CA, United States, Peter Radchenko

We consider the common setting where one observes probability estimates for a large number of events. Selecting events corresponding to the most extreme probabilities can result in systematically underestimating the true level of uncertainty. We develop an empirical Bayes approach “Excess Certainty Adjusted Probabilities” (ECAP), using a variant of Tweedie’s formula, which updates probability estimates to correct for selection bias. ECAP directly estimates the score function associated with the probability estimates, so it does not need to make any restrictive assumptions about the prior on the true probabilities. ECAP also works well in settings where the probability estimates are biased. We demonstrate through theoretical results and empirical analysis that ECAP can provide significant improvements over the original probability estimates.

5 - Robust Inference On Income Inequality: T-statistic Based Approaches

Rustam Ibragimov, Professor of Finance and Econometrics, Imperial College Business School, London, United Kingdom, Paul Kattuman, Anton Skrobotov

The paper focuses on applications of the recently developed t-statistic based robust inference approaches in the analysis of inequality measures and their comparisons. Two samples dealt with are partitioned into fixed numbers q1, q2≥ 2 (e.g., q1 =q2 = 2, 4, 8) of groups, inequality measures are estimated for each group, and inference is based on a standard two-sample t–test with the resulting q1+q2 group estimators. This results in valid inference under the conditions that group sample inequality measures are asymptotically independent, unbiased and Gaussian of possibly different variances or scale mixtures of normal random variables. These conditions are typically satisfied in empirical applications. The inference approaches compare favorably with other methods. Their use is illustrated by comparisons of inequality measures across different regions in Russia.

■ VWC04

Virtual Room 04

Modern Topics on Mining Massive Spatial-temporal Data

Sponsored: Data Mining

Sponsored Session

Chair: Qiong Zhang, Clemson University, Clemson, SC, 29634, United States

Co-Chair: Whitney Huang, Clemson University

1 - Climate Models, Large Spatial Datasets, And Harnessing Deep Learning For A Statistical Computation

Douglas Nychka, Ph.D., Colorado School of Mines, Golden, CO, United States, Florian Gerber

Climate simulations of the Earth's atmosphere and ocean yield large and complex data sets that require statistics for their interpretation. Throughout these problems is the need for estimating covariance functions over space and time and accounting for the fact that the covariance may not be stationary. This talk focuses on a new computational technique for fitting covariance functions using maximum likelihood. We report how a neural network (aka deep learning) model can be trained to give accurate maximum likelihood estimates based on the spatial field or its empirical variogram. Why train a neural network to reproduce a statistical estimate? The advantage is that the neural network model evaluates very efficiently and gives speedups on the order of a factor of a hundred or more and facilitates a more flexible and iterative approach to building spatial statistical models.

2 - Statistical And Computational Problems In Space Weather Data Challenges

Yang Chen, PhD, University of Michigan, Ann Arbor, MI, United States

I will introduce several data challenges in the field of space weather, which studies the conditions between the Sun and the Earth. For example, a big solar flare might cause outages in the earth’s electrical power grids and disturbances of satellites in orbit. Therefore, early warnings of potential strong solar flare events are of great importance. Results and ongoing work on solar flare predictions will be presented in the first half of the talk. In the second half of the talk, I will present video imputation methods that we developed for the reconstruction of the total electron content (TEC) maps. For ground to satellite communication and satellite navigation, TEC is a good parameter to monitor for possible space weather impacts.

3 - Statistical Quality Control Using Image Intelligence: A Sparsity Learning Approach

Yicheng Kang, Bentley University, Waltham, MA, United States,

In image-based quality control, image data often take the form of image streams in the sense that images from the process are being collected over time. In such applications, a fundamental task is to properly analyze image data streams. In this paper, we propose to transform images using a two-dimensional wavelet basis and monitor the wavelet coefficients by sparsity learning-based multivariate control charts. By adapting the sparsity learning algorithm to our quality control problem, the proposed method is able to detect shifts in the wavelet coefficients in a timely fashion and simultaneously identify those shifted coefficients. Combining this feature with the localization property of the wavelet basis, our method also enables accurate diagnosis of faulty image regions. In addition, the proposed charting statistics have explicit formulas, so they are easy to compute.

4 - A Combined Physical-statistical Approach For Estimating Storm Surge Risk

Whitney Huang, Assistant Professor, Clemson University, Clemson, SC, United States, Emily Tidwell

Storm surge poses severe threat to property and life in a coastal region. Thus, it is crucial to assess the storm surge risk, typically summarized by r-year surge return level. However, it is challenging to reliably estimate this quantity due to the limited observations in space and time. This talk presents an approach to integrate physical and statistical models to estimate extreme storm surge. Specifically, A physically-based hydrodynamics model is used to provide the needed interpolation in space and extrapolation in both time and atmospheric conditions. Statistical modeling is used to 1) estimate the input distribution for running the computer model, 2) develop a statistical emulator in place of the computer simulator, and 3) estimate uncertainty due to input distribution, statistical emulator, and missing/unresolved physics.

■ VWC05

Virtual Room 05

Time to Introduce Digital Hygiene: How to Avoid Data Privacy Pitfalls in Pandemic-era

Sponsored: Data Mining

Sponsored Session

Chair: Hongyi Huang, University of Maryland-College Park, College Park, MD, 20740, United States

1 - Safeguarding Data Privacy In The Era Of Artificial Intelligence

Kwan-Yuet Ho, United States

Because knowing individuals' preferences is a lucrative business, personalization has become a common task among data science teams in various commercial and government sectors. The inevitable use of personal data puts people's privacy at risk. Some hackers might simply steal the data illegally. Some employees who are working on the data and machine learning models might make inappropriate use of the data for their own purpose. Sometimes even if the data are turned "anonymous," the use of artificial intelligence can sometimes reveal the identity of the individuals represented by the data. In this talk, I will talk about how to protect the privacy of everyone in three aspects: 1) the system architecture design; 2) the rule-based removal of the sensitive information; and 3) the use of machine learning models to further eliminate information about the individuals.

2 - Digital Hygiene Emergency Under The Pandemic

Hongyi Huang, University of Maryland-College Park, College Park, MD, 20740, United States

As Covid hit the globe, our privacy is exposed to unexpected vulnerabilities. From camera breach to invasive proctoring software, from digital trails intrusion to PPI data marketplaces, the data hygiene issues have sticked out as the foremost concerns and threats. Unfortunately, currently no national level privacy legislation serves credible deterrence. Except the pioneer state California has passed Customer Data Protection Act (CDPA), only few other states have proposed data privacy bills. Companies are limited to the practices such as hiring third party audit or self-regulatory tentative within finite domain. It is time to detect, measure, and manage the data privacy risks avoiding the big lost for every stakeholder. Online privacy, or eventually virtual reality life privacy will only mean more after the pandemic is alleviated. This pandemic is just a catalyst.

3 - Opportunities And Challenges Of Personalization In Digital Health

Kerry Weinberg, League, Boston, MA, United States

This talk will cover several opportunities and challenges to personalizing digital health experiences using machine learning and other data driven methods. These opportunities and challenges shared are inferred from general industry and regulatory trends as well as specific insights from Kerry's work as VP Data at League and prior experience leading Data Science & Engineering for Amgen Digital Health. In particular, the role of health data interoperability, consumer trust of digital health, and evolving nature of data privacy will be explored in the context of personalization of digital health applications, platforms, and experiences.

4 - The Value Of Privacy On Online Social Networking Services: A Choice Based Conjoint Study

Jimmy Quan, Student Researcher, Temple University, Philadelphia, PA, United States, Pallavi Chitturi, David Schuff

Privacy concerns around social media are part of the larger issue of data privacy involving the storage, re-purposing, provision to third parties, and displaying of information on the Internet (Meehan 2019). What trades offs are individuals willing to make to ensure the privacy of their data on social media? Are consumers willing to pay a monthly fee for enhanced privacy controls or make tradeoffs between privacy and other features of a social network service? We use a choice based conjoint approach to understand how consumers develop preferences for choice options, if they are willing to pay for privacy or accept some privacy violations, and if di erent user groups have di erent privacy valuations.

5 - Customers Privacy Protection Behaviors In E-commerce Transactions: The Role Of Privacy Concerns, Privacy Risks, And Privacy Policies.

Katia Guerra, University of North Texas, Denton, TX, United States, Vess Johnson

This research investigates the impact of information privacy concerns on the awareness of privacy risks and on the awareness of organizational privacy policies toward the adoption of customers' privacy protection behaviors in the context of e-commerce transactions. We develop a research model and we test it by employing a Qualtrics online survey questionnaire. We use crowdsourcing through Mechanical Turk to collect data. The contribution of this study is to shed the light on the mechanisms that lead consumers to take privacy protection behaviors rather than to interrupt e-commerce transactions in the light of privacy risks, on one side, and organizational privacy policies, on the other side.

■ VWC06

Virtual Room 06

AI-enabled Precision Medicine

Sponsored: Data Mining

Sponsored Session

Chair: Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong

1 - Dynamically Subtyping of Patients with Decompensated Cirrhosis for Predictive Analytics

Haolin Wang, Chongqing Medical University, Chongqing, China

Cirrhosis is the final common pathway for most liver diseases, leading to significant morbidity and healthcare costs. To track the progression of the disease and address the heterogeneity in the patients, this study investigates data-driven approaches for patient subtyping and develops predictive models enhanced by dynamic classifier selection to facilitate the development of effective interventions tailored to patient-specific health conditions.

2 - Network-based Prediction of the Disclosure of Suicidal Ideation in Online Counseling Sessions

Zhongzhi Xu, City University of Hong Kong, Hong Kong, 410000, China

In psychological services, the transition to the disclosure of suicidal ideation is a critical point warranting intervention. Towards this goal, we developed and tested a network-based model to predict such transitions in online synchronous text-based counseling services. This model can potentially help improve the preparedness and efficiency of text-based counseling services.

3 - Bayesian Network Learning for Heart Failure Risk Stratification

Jiandong Zhou, City University of Hong Kong, Hong Kong, Sharen Lee, Gary Tse, Qingpeng Zhang

Risk stratification has been a quite important module in computational cardiovascular sciences. Bayesian network learning becomes an emerging solution to interpretable cardiovascular risk prediction. We construct the model and present a retrospective cohort study about how Bayesian network learning approach can provide casual inference evidences for rational risk predictions.

4 - A Weakly-supervised Approach For Thoracic Diseases Detection

Sadaf Kabir, West Virginia University, Morgantown, WV, 26505, United States, Ali Dabouei, Leily Farrokhvar

Recent advances in medical imaging have significantly helped healthcare providers with clinical diagnosis and treatment decisions. Deep learning algorithms can provide physicians with consistent second opinions using enhanced clinical image processing. In this study, we propose a weakly-supervised approach with the aim of efficient downsampling of high-resolution chest X-ray images. Using this approach, the spatial information of input images is preserved for a precise thoracic disease prediction. Based on initial results, the proposed framework successfully improves the performance of the diagnosis of thoracic diseases.

■ VWC07

Virtual Room 07

Disinformation: An Evaluation of Its Presence, Impacts, and Defenses

Sponsored: Data Mining

Sponsored Session

Chair: Thushara Gunda, Sandia National Laboratories, United States

Co-Chair: Nicole Murchison, Sandia National Laboratories, Albuquerque, NM, United States

1 - Disinformation Targeting

Kathleen M. Carley, Carnegie Mellon University, Sewickley, PA, 15143-8871, United States

Most disinformation has a short half-life with no target. In other cases, communities or individuals are targeted, their social environment manipulated, and the stories they read altered thus increasing the target's disinformation vulnerability. Bots, trolls sub-conscious cues and memes are used to socially and cognitively manipulate users to achieve strategic disinformation spread. Information maneuvers used to strategically disperse disinformation and manipulate underlying community structures to achieve strategic goals are described and their use during various events discussed.

2 - Human-constrained Machine Learning For Deception Detection In Text

Travis Bauer, Sandia National Laboratories, Albuquerque, NM, United States

We discuss the application of psychology-informed machine learning models to the problem of disinformation detection, termed Human-Constrained Machine Learning. Being grounded in psychology research, the modeling approach explicitly represents and makes predictions based upon knowledge of human behavior. Past research suggests that linguistic cues can be indicative of intentionally deceptive writing. We applied a compression-based algorithm, Prediction by Partial Matching, over sequences of parts of speech (e.g., adjective, adverbs) to differentiate deceptive from credible writing. Four studies demonstrate an ability to differentiate fraudulent from non-fraudulent data. Those studies are complimented by a validation study with experienced human raters. This work suggests a domain agnostic generally usable capability for deception detection in text.

3 - Misinformation as a Political Weapon

Julie Ricard, Mozilla Foundation, Mexico

Bolsonaro's Brazil Since the 2018 presidential elections, the Brazilian public sphere has been prone to widespread misinformation. We will focus on misinformation campaigns that involve and/or have been endorsed by the highest levels of government, including the current president himself. Ranging from fires in the Amazon rainforest, to Covid-19 and hydroxychloroquine, we will discuss how misinformation spreads and what its political goals are.

4 - Characterizing And Comparing Covid-19 Misinformation Across Languages, Countries And Platforms

Jacqueline Otala, Clarkson University, Potsdam, NY, United States, Golshan Madraki, Isabella Grasso, Yu Liu, Jeanna Matthews

We investigate COVID-19 misinformation in multiple languages/countries: Chinese/China, English/USA, and Farsi/Iran; on multiple platforms: Twitter, Facebook, Instagram, WhatsApp, Weibo, WeChat and TikTok. Utilizing opportunistic sampling, we compiled 200 items of viral and debunked misinformation across these languages, countries and platforms from January 1-August 31 2020. While it was observed that COVID-19 misinformation on social media varied across different languages, politics was observed as the root of most collected misinformation across all three languages. We further observe the impact of government platform restrictions on content in China, Iran, and USA.

■ VWC08

Virtual Room 08

Innovation/ Entrepreneurship II

Contributed Session

Chair: Nilam Kaushik, Indian Institute of Management Bangalore (IIMB), Bangalore, 560076, India

1 - An Empirical Assessment Of The Role Of Multinational Vs Entrepreneurial Firms In The Development Of Markets: Evidence From African Mobile Telecommunications Industry

Mohammad Jahanbakht, Assistant Professor, University of Texas at Arlington, Fort Worth, TX, United States, Romel Mostafa, Soheil Hooshangi

Although the impact of pre-entry knowledge on firms' innovative decisions and performance is known in the industry evolution literature, the nature of relationship between firm-level innovations and market-level competitive outcomes is not well-established. Using GMM method with instrument on a panel data from African mobile telecom industry, we find that a small number of firms are capable of implementing trailblazing strategies which result in a disproportionally large impact on evolution of market-level outcomes, such as adoption, price, and industry capital expenditure. We discuss that a differentiating attribute of these firms is their superior pre-entry knowledge of local markets.

2 - Fundamental Limits Of Learning: A Mathematical Framework

Yian Yin, Northwestern University, Evanston, IL, United States, Dashun Wang

A key aspect in human activities concerns how one learns from past experience. The learning curve literature has documented a robust relationship between experience n and unit cost c: cn ~ n- , with [0,1]. Yet rich empirical results across industries have consistently reported a typical ≈ 0.32 and lack of high > 0.5, raising a fundamental paradox: Is the limit = 1 achievable? Here we develop a general learning model and prove a fundamental limit of learning ≤ ≤ 0.5. We further show that both the technology landscape and strategic explorations of new technology are critical for achieving , which have direct implications for the diagnosis, improvement, and planning of many innovative activities.

3 - Do Elite Innovation Companies Need CSR? An Investigation Of The Interactions Between Innovation And Ethical Pay, CSR, And Firm Profits

Patti Miles, Associate Professor of Management, University of Maine, Bangor, ME, United States, John N. Angelis

Companies that invest in CSR or Ethical Pay usually benefit from improved reputation and legitimization in the eyes of the public, investors, and their employees. However, a company that is highly rated by investors for its innovation may be less likely to need such investments. Using an elite sample of innovation companies created by Clay Christensen (Forbes Top 100 Innovative Companies list), we find that innovative companies are significantly more likely to pay median employees more and be more profitable. However, innovative companies do not necessarily spend more on CSR, and CSR does not successfully mediate the relationship between innovation companies and profits.

4 - A Field Experiment On Diversity And Collaboration In Multi-disciplinary Technological Innovation

Nilam Kaushik, Indian Institute of Management Bangalore (IIMB), Bangalore, India,

We report on a field experiment in which 860 university-educated individuals were randomly assigned into teams to participate in ideating and innovating Internet-of-Things applications. We study how surface-level team diversity and knowledge diversity affect team performance.

■ VWC09

Virtual Room 09

Equity and Social Justice in Health Care Operations

Sponsored: Health Applications Society

Sponsored Session

Chair: Michele Samorani, Santa Clara University, Santa Clara, CA, 95053, United States

1 - Fair Allocation Decisions In Multi-stakeholder Healthcare Scenarios

David Rea, Lehigh University, Bethlehem, PA, 45221-0211, United States, Leonardo Lozano, Craig Froehle

Healthcare is rife with difficult multi-stakeholder tradeoffs. Decisions have direct implications for the well-being of patients, providers, and healthcare systems. In such scenarios, inter-stakeholder fairness is a natural concern. Importantly, stakeholder groups are not monoliths. Individual patients and providers differ in their needs, preferences, and expectations. Simultaneously management of these intra-stakeholder and inter-stakeholder tradeoffs is further complicated by the discrete nature of healthcare allocation decisions. This research proposes a framework for incorporating fairness into algorithmic objectives. The generalizability of the framework is shown through examples from teleradiology and inter-hospital transport.

2 - The Role Of Race And Socio-economic Factors In Appointment No-shows

Shannon Harris, Assistant Professor, Virginia Commonwealth University, Richmond, VA, 23223-7631, United States, Michele Samorani, Paolo Roma

Existing research in predicting no-show probabilities for outpatient appointments has found no-shows to be correlated with race and socio-economic factors, with more vulnerable populations having a higher probability of no-show. However, existing research has not disentangled the role of race from that of socio-economic factors. In this study we empirically study a large appointment data set and attempt to answer the question: are no-shows a racial or a socio-economic issue?

3 - Implicit Racial Bias In Healthcare Scheduling Delays
Michele Samorani, Santa Clara University, Leavey School Of Business, Santa Clara University, Santa Clara, CA, 95053, United States, Nan Liu, Shannon Harris, haibing lu

We show that the traditional objective of minimizing patients' waiting time and provider overtime leads to scheduling the patients at higher risk of no-show farther into the future than other patients. The reason is that by doing so, the clinic increases the show probability of the patients that are more likely to show up while decreasing the show probability of the patients that are less likely to show up. This strategy will consequently reduce the variability in number of shows, and ultimately decrease the schedule cost. However, because no-show probabilities are often correlated with race, this scheduling strategy results in unintended racial disparities in terms of access to care.

4 - A Decision-making Model To Optimize The Impact Of Community-based Health Programs
Eduardo Pérez, Associate Professor, Texas State University, San Marcos, TX, United States, eduardopr@txstate.edu, Yan Li, José A. Pagán

Hospitals and clinics are increasingly interested in building partnerships with community-based organizations to address the social determinants of health. Choosing among community-based health programs can be complex given that programs may have different effectiveness levels and implementation costs. This study develops a decision-making model that can be used to evaluate multiple key factors that would be relevant in resource allocation decisions related to a set of community-based health programs. The decision-making model compares community-based health programs by considering funding limitations, program duration, and participant retention until program completion. Specifically, the model allows decision makers to select the optimal mix of community-based health programs based on the profiles of the population given the above constraints.

5 - Disparity in Medical Appointment Scheduling: An Analytical Study of Waiting Time
Karen T. Hicklin, University of Florida, Gainesville, FL, 32611, United States

Recent studies have shown that access to timely and effective health care is associated with racial/ethnic identities, which creates and perpetuates disparities in health outcomes. This disparity also exists in appointment scheduling. In previous work, it was shown that traditional scheduling systems cause the wait time for Black patients to be approximately 30% longer compared to non-Black patients. We extend the previous work to develop an analytical model to characterize disparity in wait times for patients with historically lower no-show probability rates. Through this characterization, we identify conditions in which disparity occurs.

■ VWC10

Virtual Room 10

Optimization and Model-based Approaches to Genetic Screening and Genetic Decision making

Sponsored: Health Applications Society

Sponsored Session

Chair: Daniel Adelman, University of Chicago, Booth School of Business, Chicago, IL, 60637-1610, United States

Co-Chair: Kanix Wang, University of Chicago Booth School of Business, Chicago, IL, 60637-6877, United States

1 - Optimal Genetic Screening For Cystic Fibrosis
Hussein El Hajj, Virginia Tech, Durham Hall Blacksburg, VA, 24061-1019, United States, hme35@vt.edu, Ebru Korular Bish, Douglas R. Bish

Cystic fibrosis is among the most prevalent life-threatening genetic disorders. Early diagnosis improves quality of life and reduces healthcare expenditures. Most cystic fibrosis newborn screening processes start with a bio-marker test; followed by a genetic test, ending with diagnostic testing, which corrects false positives. On the other hand, a false negative represents a missed cystic fibrosis diagnosis. An important decision is which variants to include in the screening panel to reduce the false negative probability under a testing budget. We develop novel stochastic optimization models, and identify key structural properties of optimal panels, and use these properties to develop efficient algorithms.

2 - Enhancing Field Trials Of Genetically Modified Organisms With Optimization
Valeri Vasquez, Berkeley, Berkeley, CA, United States

Optimization is crucial to defining effective deployment strategies for genetically engineered mosquitoes (GEMs). These transgenic organisms are designed for use as public health interventions; release details can be calibrated to save on implementation costs, to avoid the ecological consequences of excessive deployments, or to mitigate the potential epidemiological shortcomings of inadequate scheduling. I develop a nonlinear mathematical program to optimize field trial deployments of GEMs in a variety of environmental contexts. The model incorporates realistic resource constraints and ecological data and is parameterized by laboratory-informed genetic inheritance patterns.

3 - Universal Newborn Genetic Screening For Pediatric Cancer Predisposition Syndromes: Model-based Insights
Jennifer M. Yeh, PhD, Harvard Medical School/Boston Children's Hospital, Boston, MA, 02115, United States,

Genetic testing for pediatric cancer predisposition syndromes (CPS) could augment newborn screening programs, but with uncertain benefits and costs. Using data available from ClinVar, gnomAD, SEER cancer registries and published studies, we developed the Precision Medicine Policy and Treatment (PreEMPT) model to estimate the clinical benefits and cost-effectiveness of population-based newborn screening for 11 CPS genes. Our findings suggest that population-based genetic screening of newborns may reduce mortality associated with childhood cancers and could be cost-effective as sequencing costs decline. This study demonstrates how advances in genetics can be applied to populations, what the implications might be for public health, and how decision modeling can be used to evaluate the impact of genetic screening on population health.

4 - Exact Site Frequency Spectra Of Neutrally Evolving Tumors, Transition Between Power Laws And Signatures Of Cell Viability
Einar Bjarki Gunnarsson, University of Minnesota, Twin Cities, Minneapolis, MN, United States, Kevin Leder, Jasmine Foo

The site frequency spectrum (SFS) is a popular summary statistic of genomic data. In this work, we derive exact expressions for the expected SFS of a cell population that evolves according to a stochastic branching process, first for cells with an infinite line of descent and then for the total population. We find that while the rate of mutation scales the SFS of the total population linearly, the rates of cell birth and cell death change the shape of the spectrum at the small-frequency end, inducing a transition between a 1/j2 power-law spectrum and a 1/j spectrum as cell viability decreases. We show that this insight can in principle be used to estimate the ratio between the rate of cell death and cell birth, as well as the mutation rate, using the site frequency spectrum alone.

■ VWC11

Virtual Room 11

Advances in Health Care Policy

Sponsored: Health Applications Society

Sponsored Session

Chair: Joel Goh, NUS Business School, Singapore, 119245, Singapore

1 - Lung Transplantation Policy Design: Tradeoff Curves Through Optimization
Theodore P. Papalexopoulos, Massachusetts Institute of Technology, Cambridge, MA, 02114-4338, United States, Dimitris Bertsimas, Nikolaos Trichakis

The Organ Procurement & Transplant Network (OPTN) has recently embarked on a program to migrate all US organ allocation policy to a continuous distribution model, starting with lungs. The OPTN's policy design process seeks to strike a balance between multiple efficiency and fairness objectives, while reconciling disparate value judgments from a diverse set of stakeholders. In this work, we introduce a novel decision-support tool for policymakers that is designed to facilitate efficient and wide-ranging exploration of policy outcomes and their inherent tradeoffs. We describe the underlying optimization methodology at a high-level and tradeoff analysis that helped guide the OPTN Lung Transplantation Committee's decision making process.

2 - Outcome-based Pharmaceutical Contracting With Heterogeneous Patient Groups
Andrew ElHabr, Georgia Tech, Atlanta, GA, 30318-8272, United States, Can Zhang, Turgay Ayer

We study under what market conditions and drug characteristics payers and pharmaceutical manufacturers are better off engaging in an outcomes-based contract, an agreement that links payments for drugs to drug effectiveness, over a nominal-pricing contract when there are heterogenous patient groups. One finding is that drugs that are more effective for the larger patient group can be good candidates for outcomes-based contracts. We also find that drugs that are not highly valuable to patients can be good candidates for outcome-based contracts in this setup.

3 - Using Agent-based Simulation To Optimize Vaccination Schedules And Non-pharmaceutical Interventions To Control Covid-19 Outbreaks

Serin Lee, University of Washington, Seattle, WA, United States, Zelda B. Zabinsky, Shan Liu

Concerns are growing that annual vaccinations will be needed to guard against COVID-19 outbreaks from new variants and immunity loss. Using an agent-based simulation that is calibrated to the greater Seattle area, we simulate different vaccination schedules and non-pharmaceutical interventions to control outbreaks of COVID-19. Vaccination schedules include timing, age prioritization, and requirement policies. Non-pharmaceutical interventions that we simulate include face mask use, testing, and contact tracing. Several factors, including vaccination willingness and vaccine effectiveness against variants are considered.

■ VWC12

Virtual Room 12

Mitigating Strategies and Operations in Confronting Covid-19

Sponsored: Health Applications Society

Sponsored Session

Chair: Jin Qi, Hong Kong University of Science and Technology, Hong Kong, Hong Kong

1 - Presenter

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong

2 - Capacitated SIR Model With An Application To Covid-19

Chaoyu Zhang, University of Toronto, Toronto, ON, Canada, Ming Hu, Ningyuan Chen

The classical SIR model and its variants have seen great success in understanding and predicting infectious diseases' spread. We extend the SIR model to incorporate the limited testing capacity, which is one of the most notable challenges in the COVID-19 outbreak. Specifically, based on the SIR model, we impose a testing capacity that is shared among the infected and uninfected people. We show first- and second-order structural properties of one measure, the number of infected people, concerning the testing capacity, degree of testing people without symptoms (or level of hospital panic run), incubation/testing turnaround time, and infection rate. In particular, we show that in the early stage of a pandemic, the total number of infections is concavely decreasing in the testing capacity. We use the COVID-19 data to calibrate our model and point out its policy implications.

3 - Resource Planning And Operations Rescheduling Under An Epidemic

Xiangtong Qi, Hong Kong Univ of Science & Technology (HKUST), Dept of IELM, HKUST, Kowloon, Hong Kong

The outbreak of an infectious disease will occupy a huge amount of medical resource, causing serious disruption to the regular service of the public health system. In this talk, we introduce a framework of handling such disruptions in the context of operating theaters. The frame includes a centralized resource planning for multiple hospitals in a region, multiple-days operations planning for one hospital, and detailed daily schedule for arranging operating rooms. We develop models and solutions for the above decision-making problems.

4 - The Effect Of Correlations On Group Testing Against COVID-19

Aiqi Zhang, Chinese University of Hong Kong, Hong Kong,

Group testing has been widely adopted during COVID-19 due to the shortage of testing resources. It essentially helps to screen for the presence of a virus within a large population. We study the optimal group testing policies where the infection of subjects may be correlated and the information of prevalence rates and correlations may be unknown. We examine the joint effect of the parameters on the efficiency of testing procedures, and characterize important structural properties of the optimal testing policies.

■ VWC13

Virtual Room 13

Health Care, Modeling and Optimization VII

Contributed Session

Chair: Haolin Feng, Sun Yat-sen University, Guangzhou, 510275, China

1 - VRP With Release Dates And Deadlines: A Blood Sample Collection Application

Fernando A. C.C. Fontes, Faculdade de Engenharia, Universidade do Porto, NI, Porto, 4200-465 PORTO, Portugal, Dalila B. M. M. Fontes, Helena V Ferreira

Blood sample collection is critical due to the blood short lifespan. Once extracted, the blood samples are stored until collected, transported, and delivered to the lab. Biological degradation imposes a limit on the time between extraction and delivery. If this limit is not respected, the blood must be disposed of and a new extraction arrange for, which in addition to the extraction, collection, and delivery costs, also implies environmental costs associated with the disposal of biological residues. This problem can be cast as a VRP with release dates (the extraction timing) and deadlines (the lifespan). We propose a MILP model to solve this problem.

2 - Advanced Evolutionary Algorithm For Routing And Scheduling Problem In Home Health Care

Yoram Clapper, Vrije Universiteit, Amsterdam, Netherlands Joost Berkhout, Rene Bekker, Dennis Moeke

Home health care service providers seek to deploy their staff as effectively as possible, which often translates to the well-known Home Health Care Routing and Scheduling Problem (HHRSCP). The larger part of the available algorithms that are applied to the HHCRSP focus on the operational level, and less on the tactical level. In this study we develop an advanced evolutionary algorithm by extending the permutation Gene-pool Optimal Mixing Algorithm (pGOMEA) that optimizes the HHRSCP on an operational level, while paying attention to the tactical level as well.

3 - Optimizing The Patient Logistics In A Hospital Regarding Fairness Aspects And Break Assignments

Jens Brunner, University of Augsburg, Augsburg, Germany,

In hospitals, patients often have to wait a very long time before they are transported from one ward to another. One of the main reasons for this is incorrect staff and route planning for patient transportation. The resulting waiting times of patients lead to a reduction in patient care. We formulate this problem as a vehicle routing problem with route balancing and time windows. We present a MIP model that minimizes patient waiting times, balances the workload of the staff, and also takes into account the planning of a break. Since up to 900 patients have to be transported every day in practice, we decompose our compact model by a Dantzig-Wolfe reformulation to speed up the solution process.

4 - Balancing Accessibility And Efficiency In The Distribution Of The Covid-19 Vaccine In Oregon: A Mixed-integer Programming Approach

Defeng Tao, Student, Oregon State University, Corvallis, OR, United States, Joseph Kapena Agor, Hector Vergara, Jessina McGregor, Jessina McGregor, Alex Brown

In the Covid-19 vaccine distribution problem, balancing accessibility and operational costs can be challenging. Accessibility is a quality with which services can be easily obtained or used traditionally measured via distance. Total operation cost includes fixed cost, labor cost, transportation cost, and holding cost of inventories when running facilities. We propose a mixed-integer programming model to determine sites for COVID-19 vaccination in the state of Oregon to maximize accessibility while minimize operational costs. The trade-off between those objectives will be discussed.

5 - The Impact Of Advanced Digital Technologies On Patient Referral And Healthcare Operations

Xiaofang Wang, Professor, Renmin University of China, Beijing, China, Yuhan Yan

Patient referral between different hospitals can be facilitated by high-level digitalization. But more frequent referrals and information sharing may harm some hospitals' revenue. We analyze the tradeoffs and discuss relevant incentive schemes to provide insights from the perspective of social welfare optimization.

6 - Appointment Scheduling For A Multi-physician Outpatient Clinic: The Convexity Results

Haolin Feng, Sun Yat-sen University, Guangzhou, China, Zitian Li

We study the appointment scheduling problem of outpatient clinics with multiple physicians. Stochastic service time is considered, and the decisions are appointment time for the given set of patients. The objective of the scheduling problem is to optimize the (weighted) expected value of the sum of patient waiting, the server's idling and overtime. We derive the expression of the performance measures and provide the theoretical results regarding the convexity of the optimization problem.

■ VWC14

Virtual Room 14

Telemedicine Platforms and Healthcare Policies

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Guangwen (Crystal) Kong, Temple University, Temple University, Minneapolis, MN, 55455-0150, United States

1 - The More The Better? Operations And Incentives Of An On-demand Medical Crowdsourcing Platform

Jingxuan Geng, Temple University, Philadelphia, PA, United States, Guangwen (Crystal) Kong, Marco Shaojun Qin

The boom of online medical crowdsourcing platforms provides more equal access to medical resources for patients. A distinct feature of the on-demand medical crowdsourcing platform we considered is that they provide an affordable way to enable patients to seek multiple opinions from experienced doctors participate. We consider an on-demand medical crowdsourcing platform that designs the optimal price and reward scheme with operational leverage such as a control limit on the number of doctors. We extend the analysis to two more realistic scenarios when consumers are delay sensitive and service level are heterogeneous. We collect data from one on-demand doctor platform and empirically validate the main results of the analytical model. Our research contributes to the literature on on-demand platforms and online healthcare services.

2 - Evaluating Success Rate of Threshold Public Good Project: Theory and Experiment

Shihong Xiao, The Hong Kong University of Science and Technology, Hong Kong, Hong Kong, Ying-Ju Chen, Yu_Ping Chen

In this study, we examine how the success rate of a discrete threshold public good project depends on the threshold through both theory and experiment. We consider a setting where a population of individuals make binary private contribution decisions to a public good project. The project is successful only if the number of contributions exceeds a certain threshold. Individuals are heterogeneous in their cost of contribution. We find that the project success rate may be non-monotonic on the threshold in theory and use experiments to evaluate our theoretical findings.

3 - Delivering Multi-specialty Care Via On-demand T elemedicine Platforms

Lingjiong Zhu, Florida State University, Tallahassee, FL, 32306, United States, Sergei Savin, Yuqian Xu

The on-demand telemedicine platforms represent a rapidly growing segment of the healthcare industry. In this paper, we examine a key feature of such multi-specialty telemedicine platforms, namely, the presence of interaction between the demand for general and specialized care by developing and analyzing a model that combines the decisions by patients, physicians, and the platform, and contrast it with the no-interaction benchmark setting. We find that for moderately compensated specialists, the demand interaction between the general and specialized care lowers the barrier for specialists to join the platform, but also that the benefits of demand interaction subside as specialist wage levels increase.

■ VWC15

Virtual Room 15

Ride Sharing Operations

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Hongyao Ma, Columbia University, New York, NY, 02138-2933, United States

Co-Chair: Chiwei Yan, University of Washington Seattle, San Francisco, CA, 94158-1507, United States

Co-Chair: Hamid Nazer, Uber, San Francisco, CA, 94103, Un ited States

1 - Labor Cost Free-Riding in the Gig Economy

Zhen Lian, Cornell University, Cornell Tech, NY, 10044, United States, Sebastien Martin, Garrett J. van Ryzin

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. These diseconomies of scale are strong too; firms smaller than a critical size pay the minimal rate possible (the workers' reservation wage), while all firms larger than the critical size earn the same total profit regardless of size. This scale disadvantage in labor costs contradicts the conventional wisdom that gig companies enjoy strong network effects and suggests that small firms have significant incentives to join an existing gig economy, implying gig markets are highly contestable. Yet we also show that the formation of a gig economy requires the existence of a large firm, in the sense that an equilibrium without any firms participating only exists when no single firm has enough demand to form a gig economy on its own. The findings are consistent with stylized facts about the evolution of gig markets such as ridesharing.

2 - Randomized FIFO Mechanisms

Hongyao Ma, Columbia University, Cambridge, MA, 02138-2933, United States, Francisco Castro, Hamid Nazerzadeh, Chiwei Yan

We study the matching of jobs to workers in a queue, for example a ridesharing platform dispatching drivers to pick up riders at an airport. Under FIFO dispatching, the heterogeneity in earnings from different trips incentivizes drivers to cherrypick, increasing riders' waiting times for a match, and resulting in a loss of efficiency and reliability. We introduce a family of randomized FIFO mechanisms. By sending declined trips gradually down the queue in a randomized manner, a randomized FIFO mechanism achieves the optimal outcome in equilibrium. Extensive counterfactual simulations using data from the City of Chicago demonstrate substantial improvements of revenue and throughput compared to the status quo FIFO dispatching.

3 - Autonomous Vehicles in Ride-hailing and the Threat of Spatial Inequalities

Jian Gao, UCLA Anderson School of Management, Los Angeles, CA, United States, Francisco Castro, Sebastien Martin

In the future, ride-hailing platforms 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 on service reliability. We introduce a game-theoretic queueing model where HVs strategically choose to join the platform. The platform maximizes its profit by solving a driver allocation problem. We show that the introduction of AVs will deteriorate the service level. As the platform incorporates AVs, it will prioritize them which will affect the earning of HVs and drive them out of the market. This effect is not homogeneous across areas: while high-demand areas will see reasonable service levels, remote areas will suffer from a drop in service level. We illustrate these effects using New York City TLC data. Our work highlights potential threats when introducing AVs in the market.

4 - Matching Drivers to Riders: A Two-stage Robust Approach

Oussama Hanguir, Columbia University, New York, NY, 10025, United States, Omar El Housni, Vineet Goyal, Clifford Stein

Matching riders to drivers efficiently is a fundamental problem for ridesharing platforms who need to match the riders as soon as the request arrives with partial knowledge about future requests. A myopic approach that computes an optimal matching for current requests ignoring future uncertainty can be highly sub-optimal. In this paper, we consider a two-stage robust optimization framework for this matching problem where future demand uncertainty is modeled using a set of demand scenarios (specified explicitly or implicitly). The goal is to match the current request to drivers (in the first stage) so that the cost of first stage matching and the worst case cost over all scenarios for the second stage matching is minimized. We show that the two-stage robust matching is NP-hard under various cost functions and present constant approximation algorithms for different settings.

■ VWC16

Virtual Room 16

Data-driven Learning in Revenue Management

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: N. Bora Keskin, Duke University, Durham, NC, 27708, United States

Co-Chair: Yuexing Li, Duke University, Durham, NC, 27703-6548, United States

1 - Provably Optimal Reinforcement Learning for Online Inventory Models With Cyclic Demands

Xiao-Yue Gong, Massachusetts Institute of Technology, Cambridge, MA, 02139-4301, United States, David Simchi-Levi

Motivated by a long-standing gap between inventory theory and operations practice, we study online inventory models with unknown cyclic stochastic demands. We design efficient reinforcement learning algorithms with provable theoretical guarantees that cater to the specific structures of inventory management problems. We apply a standard performance measure in online learning literature, regret, defined as the difference between the expected total cost of a policy and that of the optimal policy with full knowledge of the demand distributions.This paper first introduces an easier family of models--episodic models--where inventory is discarded at the end of every cycle. Our policies achieve ~O(\sqrt{T}) regret for both the episodic lost-sales model with zero lead time, and the episodic multi-product backlogging model with lead times, fixed joint-ordering costs and order limits. The regret bounds of our policies match the regret lower bounds that we prove for these models. Next, we build upon these policies for episodic models to devise meta algorithms for the more difficult non-discarding models with cyclic demands. Our policies achieve ~O(\sqrt{T}) regret for both the lost-sales model with zero lead time and the backlogging model with zero lead time, again matching the regret lower bounds for these models. We achieve ~O(T^{5/6}) regret for the multi-product non-discarding backlogging model with lead times, fixed joint-ordering costs and order limits. Our policies allow the input of expert advice to further improve their performance in real applications. Importantly, some of our algorithms apply more generally to a variety of operations research problems beyond inventory management.

2 - Quality Learning In A Dynamic Mutual Data Exchange Model

Ebru Kasikaralar, University of Chicago, Chicago, IL, United States, John R. Birge

Advances in storing and processing big data have transformed how digital platforms learn about product quality, user preferences and make pricing decisions accordingly. Due to the increase in data privacy concerns, policies restricting access to consumers' data are expected to become more prevalent. However, personal data is essential in generating successful matching algorithms and enhancing the customers' purchase experience. Hence, we introduce a model where the buyers and a firm directly interact with each other in two different markets: product and data market. There is a costly dynamic data exchange between the firm and the consumers, where the firm offers incentives to buyers to sell data. The firm uses acquired data from consumers to learn the underlying product quality, and consumers use the acquired data from the firm to make strategic purchase decisions.

3 - Data-driven Newsvendor: Algorithms And Optimal Performance

Omar Mouchtaki, Columbia University, New York, NY, United States, Omar Besbes

We study the classical newsvendor problem in which the decision-maker must make decisions to trade-off underage and overage costs. In contrast to the typical setting, we assume that the decision-maker does not know the underlying distribution driving uncertainty but has only access to past data drawn from the underlying distribution (e.g., past demand). In turn, the key question is how to map existing data to an optimal decision. We evaluate the performance of any algorithm through its worst-case relative expected regret, compared to an oracle with knowledge of the distribution. We provide the first finite sample exact analysis of the classical Sample Average Approximation (SAA) algorithm for this class of problems across all data sizes. We further derive an optimal algorithm and its associated performance. It yields significant improvements over SAA for small data sizes.

4 - Deep Learning For Visual Advertising On Digital Platforms

Yuexing Li, Duke University, Durham, NC, 27703-6548, United States, N. Bora Keskin, Shaoxuan Liu, Jing-Sheng, Jeannette Song

We consider a digital platform that aims to crop and display N images to its customers to help with their purchasing decisions. For each image, the platform chooses a cropping window and observes the resulting conversions, i.e., the customer purchasing decisions. The platform does not know how cropped images influence conversions. We design a neural network policy that dynamically learns this relationship and adjusts images to maximize conversion. We derive a theoretical performance guarantee proving the asymptotic optimality of our policy. Using real-life data from a large online travel platform, we show that our policy achieves considerable improvement over the incumbent policy of the platform. The results also reveal that our policy exhibits good performance even if the functional relationship between images and conversion is misspecified.

■ VWC17

Virtual Room 17

Joint Inventory and Pricing Models

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Burcu B Keskin, University of Alabama, Tuscaloosa, AL, 35406-4062, United States

Co-Chair: Emily Barbee, University of Alabama, Tuscaloosa, AL, United States

1 - Inventory And Pricing Optimization For Resale Firms

Emily C. Barbee, University of Alabama, University of Alabama, Tuscaloosa, AL, United States, Burcu B. Keskin

Recent growth in e-commerce and sustainability has fueled demand for resale. Resale firms source used goods from consumers online. Supply is uncertain and item quality varies. We model this unique context as a joint inventory and pricing problem. We investigate responsive and committed pricing under price- and quality-dependent demand.

2 - Understanding Demand Using Choice Modeling In An Omni-channel Environment

Jia Guo, California State University-East Bay, Hayward, CA, 94568, United States, Burcu B. Keskin

We study which type of physical store an online-first retailer should open while considering the tradeoff between the increased profits from newly acquired demand and the increased fulfillment costs from cannibalized demand. We build a stylized model to describe the interaction between retailer's offline extensions and customer's purchasing behavior.

3 - Advanced Mathematical Methods Of Optimal Inventory Systems With Piecewise Linear Concave Ordering Costs.

Md Abu Helal, Southern Arkansas University, Magnolia, AR, United States, Alain Bensoussan, Viswanath Ramakrishna, Suresh P. Sethi

We study infinite-horizon stochastic inventory problems with general demand distributions and piecewise-linear concave ordering costs. Such costs arise in the important cases of quantity discounts or multiple suppliers. We consider the case of concave cost involving two linear segments. We show that certain three and four parameter generalizations of the classical (s,S) policy are optimal. Our contributions consist of generalizing the demand, solving a functional Bellman equation for the value function that arises in the infinite-horizon framework, and providing an explicit solution in a special case of the exponential demand. We also give conditions under which our generalizations of the (s,S) policy reduce to the standard (s,S) policy.

■ VWC18

Virtual Room 18

Pricing and Revenue Management I

Contributed Session

Chair: Carlos Henrique Cardonha, University of Connecticut, Storrs, CT, 06269-1041, United States

1 - On-time Express Delivery Service Design And Planning: Dynamic Pricing And Capacity Allocation

Yundong Feng, Tsinghua University, Beijing, China, f

We analyze a joint pricing and capacity allocation problem in an on-time express delivery service network over a finite planning horizon. The objective is to find a joint pricing and capacity allocation policy so as to maximize the total expected profit taking into account linear holding cost and time delay penalty cost. We reformulate the model as a dynamic programming with a constant number of states. We show some monotonicity properties of the optimal policies in special cases such as single-leg problem, 2-deadline problem and 2-leg problem respectively. Moreover, we apply Lagrangian relaxation to decompose the network problems in more general forms and propose two approximate algorithms.

2 - Ticket Pricing Via Prescriptive Model Distillation

Wei Sun, Researcher, IBM Research, Yorktown Heights, NY, United States, Max R. Biggs, Shivaram Subramanian, Youssef Drissi, Markus Ettl

Powerful blackbox machine learning models often lead to complex policies which are difficult to verify and manage. Biggs et. al 2021 proposed a decision tree approach to extract revenue-maximizing pricing policies which are also interpretable by separating the counterfactual estimation and policy learning steps. We implement and test this method on airline ticket sales data. Results show that this method is capable of achieving significant improvement over current pricing policies with just a few rules.

3 - Price Discrimination With Robust Beliefs

Jun Han, EPFL, Lausanne, Switzerland, Thomas A. Weber

We consider the problem of price discrimination when the type distribution is unknown or specified by an ambiguity set. 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. For a standard linear-quadratic 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.

4 - Appointment Scheduling With Customer Preferences And Service Constraints

Carlos Cardonha, Assistant Professor, University of Connecticut, Storrs, CT, United States, Miao Bai

In this problem, we have a set of service providers, each associated with a service capacity, a revenue per service and overcapacity penalty, and a set of customers choosing providers according to multinomial logit choice models. Our goal is to identify a probabilistic assortment offering that maximizes the overall revenue. The assortment offering may be restricted by service constraints, such as the number of selected providers and service level among customers' demand. We prove the NP-hardness of the problem, characterize the optimal solutions of the appointment scheduling sub-problem, and present a fully polynomial-time approximation scheme to solve the problem.

■ VWC19

Virtual Room 19

Advances in stochastic convex and non convex optimization algorithms

Sponsored: Applied Probability Society

Sponsored Session

Chair: Digvijay Boob, Southern Methodist University, Dallas, TX, 30318, United States

1 - Complexity Of A Dampened Proximal Admm For Linearly-constrained Nonseparable Nonconvex Composite Optimization

Weiwei Kong, Georgia institue of Technolgy, Atlanta, GA, 30318, United States

This talk presents a dampened proximal ADMM for finding approximate stationary points of linearly-constrained nonseparable nonconvex composite optimization problems. Using an under-relaxed multiplier update and several recent techniques from the analysis of nonconvex proximal augmented Lagrangian methods, we establish a complexity bound that significantly improves on the state-of-the-art. Some important properties of the method are that: (i) it can be started from any point where the objective function is finite (and hence, not necessarily a feasible point), (ii) it does not require any regularity conditions on the linear constraint, and (iii) it can be applied to a large class of nonconvex, nonsmooth, and nonseparable objective functions.

2 - A Proximal Bundle Type Method For Smooth And Nonsmooth Convex Optimization And Stochastic Programming

Jiaming Liang, Georgia Institute of Technology, Solace Atlanta, GA, 30308-1214, United States, Renato D. C Monteiro

This talk presents a proximal bundle (PB) method for solving convex smooth and nonsmooth composite optimization problems. Like other proximal bundle variants, PB solves a sequence of prox bundle subproblems whose objective functions are regularized composite cutting-plane models. Moreover, PB uses a novel condition to decide whether to perform a serious or null iteration which does not necessarily yield a function value decrease. Iteration-complexity bounds for PB are established for a large range of prox stepsizes. We further extend PB to the stochastic setting where the objective function only has stochastic first-order oracle. To the best of our knowledge, this is the first time that a proximal bundle variant has been shown to be effective to solve convex stochastic programming problems.

3 - Minibatch And Momentum Model-based Methods For Stochastic Non-smooth Non-convex Optimization

Qi Deng, Shanghai University of Finance and Economics, School of Information, Shanghai, 201900, China

Stochastic model-based methods have appealing robustness to the stepsize and efficiency guarantee for non-smooth non-convex optimization. We improve the performance of these methods further. First, we present a minibatch extension which takes a set of samples to approximate the model function in each iteration. For the first time, we show that these stochastic algorithms can achieve linear speedup over the batch size even for non-smooth and non-convex problems. Second, we propose a new stochastic extrapolated model-based method to possibly improve the convergence further. We obtain complexity guarantees for a fairly flexible range of extrapolation terms. Finally, we use experiments to show the empirical advantage of our proposed methods.

4 - Stability Implies Generalization For Variational Inequalities And Application To Differentially Private Vis

Digvijay Boob, Southern Methodist University, Dallas, TX, 30318, United States, Cristobal Guzman

In this talk, we provide the first systematic study of stochastic variational inequality (SVI) and stochastic saddle point (SSP) problems under the constraint of differential privacy (DP). We propose two algorithms: Noisy Stochastic Extragradient (NSEG) and Noisy Inexact Stochastic Proximal Point (NISPP). We show that sampling with replacement variants of these algorithms attain the optimal risk for DP-SVI and DP-SSP. Key to our analysis is the investigation of algorithmic stability bounds, both of which are new even in the nonprivate case, together with a novel "stability implies generalization" result for the gap functions for SVI and SSP problems. The dependence of the running time of these algorithms, with respect to the dataset size n, is n2 for NSEG and O(n3/2) for NISPP.

5 - Finite-time Convergence Rate Of Two-time-scale Stochastic Approximation And Its Applications In Reinforcement Learning

Thinh Doan, Virginia Tech, Blacksburg, VA, 30332, United States

We study nonlinear two-time-scale stochastic approximation and focus on characterizing its finite-time performance in a Markov setting, which often arises in stochastic control and reinforcement learning problems. In particular, we consider the scenario where the data in the method are generated by Markov processes, therefore, they are dependent. Under some fairly standard assumptions on the operators and the Markov processes, we provide a formula that characterizes the convergence rate of the mean square errors generated by the method to zero. Our analysis is mainly motivated by the classic singular perturbation theory for studying the asymptotic convergence of two-time-scale systems, that is, we consider a Lyapunov function that carefully characterizes the coupling between the two iterates.

■ VWC20

Virtual Room 20

New Applications of Queueing Theory

Sponsored: Applied Probability Society

Sponsored Session

Chair: Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

1 - Algorithms For Queueing Systems With Reneging And Priorities Modeled As Quasi-birth-death Processes

Amir Rastpour, Assistant Professor, Ontario Tech University, Oshawa, ON, Canada, rArmann Ingolfsson, Burhaneddin Sandikci

We develop an iterative algorithm for a class of infinite level-dependent quasi-birth-and-death (LDQBD) processes. These LDQBDs can model the Erlang A system with two priority classes of impatient customers with different arrival, service, and abandonment rates. Our algorithm provides bounds for the level-dependent rate matrices and uses these bounds to endogenously truncate the system and to provide bounds on system performance measures. We show that existing algorithms for this class of LDQBDs either suffer from low accuracy or from long solution times.

2 - Stochastic Models for Community Bail Funds

Jamol Pender, Cornell University, Ithaca, NY, 14850, United States

Bail funds have a long history of helping those who cannot afford bail in order to wait for trial at home. Not only have bail funds help release those who cannot afford their bail, but it also has had an immeasurable impact on the decision of the defendant. In this paper, we consider the first stochastic model for a community bail fund. To build our stochastic model, we uniquely combine insurance models and infinite server queues to model the bail fund. As a result, we are able to not only model the bail fund, but also assess the impact that a bail fund will have on a community. In this regard, we determine the amount of money a county might save by implementing a bail fund. Although, we cannot measure the impact on the human spirit, we can start to understand in a rigorous way, the impact of the bail fund on the community.

3 - Queues with Updating Information

Philip Doldo, Cornell University, Ithaca, NY, 14853, United States

Many service systems provide customers with information about the system so that customers can make an informed decision about whether to join or not. Many of these systems provide information in the form of an update. Thus, the information about the system is updated periodically in increments of size . It is known that these updates can cause oscillations in the resulting dynamics. However, it is an open problem to explicitly characterize the size of these oscillations when they occur. In this paper, we solve this open problem and show how to exactly compute the amplitude of these oscillations via a fixed point equation. We also compute closed form approximations via Taylor expansions and show that these approximations are very accurate, especially when is large. Our analysis provides new insight for systems that use updates as a way of disseminating information to customers.

■ VWC21

Virtual Room 21

Behavior-Aware Modeling of Service Systems

Sponsored: Applied Probability Society

Sponsored Session

Chair: Raga Gopalakrishnan, Smith School of Business at Queen's University, Kingston, ON, K7L 3N6, Canada

1 - Silent Abandonment In Contact Centers: Estimating Customer Patience From Uncertain Data

Antonio Castellanos, Technion – Israel Institute of Technology, Haifa, Israel, Galit B. Yom-Tov, Yair Goldberg

Contact centers are one of the favorite channels of communication with companies. However, they face operational challenges - common proxies for customer experience are subject to information uncertainty. A main source of such is silent abandonment by customers. These customers leave the system while waiting for a reply, but give no indication for doing so. As a result, agent capacity is wasted. In two case studies we show that up to 70% of the abandoning customers abandon silently, and that such behavior reduces system efficiency by up to 15%. We develop methodologies to identify silent abandonment and to estimate customer patience. We show how accounting for silent abandonments in a queueing model improves the estimation accuracy of key measures of performance. Finally, we suggest strategies to operationally cope with the phenomenon.

2 - The Impact Of Information On Strategic Customer Behavior In A Transportation Station

Antonis Economou, National and Kapodistrian University of Athens, RoAthens, 15772, Greece,

Nowadays, a transportation station can provide its potential passengers with information regarding the arrival times of the facilities, the congestion in the station and the space availability of future facilities. Such information influences the behavior of strategic passengers and the welfare generated by the system. In this talk, we will describe a general model of a transportation station where strategic customers decide whether to stay or balk based on their expected waiting costs and the probability of being served, conditioning on the information provided. The information may include the capacity of the next facility, the elapsed time from the previous visit of the facility and/or the number of waiting customers. We will show how the customer equilibrium strategies can be derived and will discuss the ideal level of information that should be provided.

3 - Behavior Aware Service Staffing

David D. Cho, Woodbury University, School Of Bus. CA, 91504-1052, United States, Kurt M. Bretthauer, Kyle D. Cattani, Alex Mills

Empirical studies of service systems have shown that workers exhibit different service rates depending on their assigned workload. We model two commonly observed behavioral effects, speedup and slowdown, then incorporate the model into a multi-period workforce staffing problem to study their joint impact on service staffing. Our results show that a workload that maximizes the service rate is typically not optimal. We also find that the effectiveness of the widely practiced single-ratio workload staffing policy depends on the strength of the speedup and slowdown effects.

4 - On Two Models Of Choice Between An Observable And An Unobservable Queue With Heterogeneous Servers

Jonathan Milo, Tel Aviv University, Tel Aviv, Israel, Refael Hassin

We consider a queueing system where customers arrive according to a Poisson process and select one out of two servers with exponentially distributed service durations. Customers observe the first queue length and make an irrevocable decision on whether or not to enter it, without observing the second queue. We analyze two models where the first server is slower than the second. In both models there is no queue in front of the first server. In one model there is also no queue at the second server and customers who reach it when it is busy are lost. In the second model, there is a queue in front of the second server. We characterize the equilibrium behavior and investigate the relation between the equilibrium and optimal strategies, including the price-of-anarchy.

■ VWC22

Virtual Room 22

Reliability and Maintenance Modeling: Classical and New Approaches

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Cristiano Cavalcante, Universidade Federal de Pernambuco, Recife Pernambuco, 52070-080, Brazil

Co-Chair: Alexandre Ramalho Alberti, Universidade Federal de Pernambuco, United States

1 - Opportunistic Maintenance Policy In The Context Of An Offshore Wind Farm.

Cristiano Cavalcante, Universidade Federal de Pernambuco, Recife Pernambuco, 52070-080, Brazil, Yan De Melo, Phil Scarf, Rodrigo Lopes

We model an opportunistic maintenance policy motivated by the context of wind turbines in an offshore wind farm. Due to the enormous logistical costs, most actions (inspections, preventive replacement and corrective maintenance) are limited to occur only within the planned timeframes (js, j=1, 2,...). However, opportunistic replacements may occur when the vessel is available in the vicinity of the turbine. These are the opportunities that are modelled by a Poisson process. The proposed policy produces good results and suggests a greater focus on opportunities rather than regular inspections. This is a very relevant finding, once the offshore wind context poses huge challenges to reduce the cost of inspection, which is quite high.

2 - Modelling An Adaptive Block Replacement Policy For Complex Systems With Componentes Organized In A Complex Configuration

Alexandre Ramalho Alberti, Universidade Federal de Pernambuco, Recife, Brazil, Rafaella Maria Pereira

We propose and model an adaptive block replacement policy for complex systems composed of identical components organized in a complex configuration. A heuristic approach is used to improve the performance of the proposed policy, and the results are compared with the performance of other policies. This study was motivated by a case study on manifold valves used in a production line of a food industry.

3 - A Preventive Maintenance Policy For A Steel Production Line: A Dep Reinforcement Learning Approach

Waldomiro A. Ferreira Neto, Universidade Federal de Pernambuco, Recife, Brazil, Cristiano Cavalcante, Phuc Do

In the industry 4.0 paradigm, to meet the trends of mass customization, the system's operating parameters are frequently changed, requiring maintenance strategies that allow a quick response to environmental changes. In addition, exploiting the large amount of data available on system conditions in maintenance planning can be beneficial. Therefore, Deep Reinforcement Learning (DRL) proved to be an efficient tool for maintenance decision-making due to its ability to deal with dynamic environments subject to uncertainties and with a large space of states. Thus, this paper proposes a DRL-based maintenance policy for online maintenance decisions, intervening in the system in real-time. The studied system was a steel production line, where the proposed policy presents better results than the traditional strategies commonly applied in this system.

■ VWC23

Virtual Room 23

Data Analytics for Quality Improvement in Manufacturing Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Juan Du,

1 - In-profile Monitoring For Multiple-sensor Data In Advanced Manufacturing System

Chen Zhang, Tsinghua University, Beijing, 117576, China,

Multi-channel profile monitoring has been extensively studied in past few years. However, all current studies treat each profile data as a whole, and construct monitoring schemes accordingly. This leads to two limitations. The first is long detection delay, especially if anomaly occurs in early sensing points of the profile. The second is profiles of different samples are required to be synchronized with the same length. To address this problem, we propose the novel idea of in-profile monitoring, i.e., detecting anomalies in profiles in real time without waiting for the whole profile, thus can also handle the non-synchronization problem. Our scheme is built upon state space model. To describe complex cross-profile correlations, further regularizations are imposed on model parameters. Then a monitoring statistic based on one-step-ahead forecasting error is constructed.

2 - Detection And Recognition Of Mixed-type Defect Patterns In Wafer Bin Maps Via Tensor Voting

Rui Wang, Assistant Professor, Harbin Institute of Technology (Shenzhen), Shenzhen, China, Nan Chen

Spatial defect patterns on semiconductor wafer bin maps (WBMs) provide valuable information on the root causes of process abnormality. The identification of these patterns is thus important for yield improvement. The recognition of mixed-type patterns is challenging as the patterns need to be separated into clusters and then each cluster is classified as a pre-defined defect pattern type. In this study, we propose a tensor voting-based method for mixed-type defect pattern detection and recognition in WBMs. Marching algorithms are developed to extract region and curve patterns based on the structural saliency information of the voting process. Our method is inherently robust to noise and flexible to deal with complex shapes of defect patterns. The results obtained using both real and simulated data demonstrate the effectiveness of the proposed method.

3 - Intelligent Operation and Maintenance (O&M) Policies for Multi-location Manufacturing Network based on Data Analytics

Tangbin Xia, Deputy Director, Shanghai Jiao Tong University, Shanghai, China, Guojin Si

Increasing machine investments and expensive operation and maintenance (O&M) costs have made manufacturing system leasing and maintenance service outsourcing gaining a momentum. Individual equipment degradations, complex system structures and global network layout bring challenges for real-time decision-making. It is parameter for decision makers to fully utilize the monitoring data to characterize and update the individual path of each equipment's degradation signals, thus developing timely and cost-effective schemes for geographically distributed factories. This speech addresses recent advances in O&M for service-oriented manufacturing paradigm to forecast health trends, avoid production breakdowns, reduce maintenance cost and achieve rapid decision-making.

4 - Location-scale Monitoring of Ordinal Categorical Processes

Kaizong Bai, Xi'an Jiaotong University, Xi'an, China, ian Li

In many applications, some process variables are measured by categorical data with some natural order among their attribute levels. They are known as ordinal categorical factors and determined by their latent continuous variables. We consider shifts in either location or scale parameters of latent variables, as well as in correlation parameters of multiple ordinal factors, but only the ordinal attribute levels are observable. To this end, univariate and multivariate location-scale log-linear models are first established to describe a single ordinal factor and multiple ones, respectively. Based on these, univariate and multivariate location-scale ordinal control charts are proposed.

15 - Reinforcement Learning For Process Control With Application In Semiconductor Manufacturing

Yanrong Li, Shanghai Jiaotong University, Shanghai, China, Juan Du, Wei Jiang

Process control is widely discussed in multistage manufacturing, especially for semiconductor manufacturing. In practice, various data is collected during manufacturing processes due to Internet of Things (IoT). This work introduces reinforcement learning (RL) process control methods based on sensor data and proposes model-based and model-free RL algorithms. Two simulation cases in semiconductor manufacturing are presented to validate the performance of RL controllers and compare them with traditional controllers. The results demonstrate that model-based RL is suitable when the process model is available; model-free RL addresses various disturbances when the process model is unclear.

■ VWC24

Virtual Room 24

International Session 2

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Yu Jin, Binghamton University, Binghamton, NY, 13902, United States

1 - A Deep Learning Based Data Fusion Method For Degradation Modeling And Prognostics

Juan Du, The Hong Kong University of Science and Technology (Guangzhou) Guangzhou, 511458, China, Feng Wang, Yang Zhao, Tao Tang, Jianjun Shi

Degradation modeling is a critical and challenging problem as it serves as the basis for system prognostics and evolution mechanism analysis. In practice, multiple sensors are used to monitor a system status. This paper proposes a novel data fusion method based on deep learning for health index construction for prognostic analysis. A pair of adversarial networks is proposed to enable the training procedure of neural networks. To guarantee the stability of the algorithm, we propose an RMSprop-based sampling algorithm to estimate model parameters. A case study is conducted by using a set of degradation signals of aircraft engines. The results demonstrate that the proposed method has a significant improvement on remaining useful life (RUL) prediction compared to existing data fusion methods.

2 - A Deep learning-based Prediction Model for In-situ Quality Inspection of Additive Manufacturing

Hao Wang, Binghamton University, Binghamton, NY, United States, Yu Jin

Limited geometric accuracy is one of the major challenges that hinder the broader application of additive manufacturing (AM). Due to the layer-wise fabrication nature of AM, online inspection is indispensable in reducing printing errors or out-of-control process variation. In this work, a deep learning-based spatial-temporal model is proposed to predict the deviation of subsequent toolpath based on the 3D scanning point cloud data and process parameters. The proposed model employs a sequence-to-sequence framework with an attention mechanism to map the spatial dependence and capture sequential evolution of shape deviation. Numerical experiments are conducted to demonstrate the effectiveness of the proposed framework by comparing it to the conventional spatial-temporal models.

■ VWC25

Virtual Room 25

Industry 4.0 and Operations Management

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Jeanette Song,

Co-Chair: Yue Zhang, Pennsylvania State University, Boalsburg, PA, 16827-1750, United States

1 - Volume Flexibility At Responsive Suppliers In Reshoring Decisions

Robert Boute, Vlerick Business School, Leuven, 3000, Belgium, Joren Gijsbrechts, Stephen M. Disney, Jan A. Van Mieghem

We investigate how volume flexibility, defined by a sourcing cost premium beyond a base capacity, at a local responsive supplier impacts the decision to reshore production. The buyer also has access to a remote supplier that is cheaper with no restrictions to volume flexibility.We show that when the lead time difference between both suppliers is one period, the optimal dual sourcing policy is a demand replacement policy.The optimal policy structure and related parameters allow us to derive analytical insights into the sourcing split between the responsive and the remote supplier, and to quantify the benefits of volume flexibility.

2 - Human And Machine: The Impact Of Machine Input On Decision-making Under Cognitive Limitations

Tamer Boyaci, ESMT Berlin, Berlin, 10178, Germany, Francis E. De Vericourt, Caner Canyakmaz

We study how machine-based predictions may affect the decisions of a human decision-maker (DM) with limited cognitive capability (using a rational inattention framework). In this setup, the machine provides the DM with accurate but sometimes incomplete information at no cognitive cost. We show that while the overall decision accuracy always improves, certain types of errors (e.g. false positives) may also increase. The machine can also induce the human to exert more cognitive effort, even though its input is highly accurate. Interestingly, this happens when the DM is most cognitively constrained (e.g. due to time-pressure). Our results provide critical guidance on when human-machine collaboration is likely to be most beneficial.

3 - After-Sales Service Contracting: Condition Monitoring and Data Ownership

Brian Tomlin, Tuck School of Business, Dartmouth College, Hanover, NH, United States, Cuihong Li

For uptime-critical assets, the Internet of Things (IoT) enables condition-based maintenance (CM) through sensor-generated data combined with advanced analytics. Oftentimes, the asset is designed, built, and maintained by one firm (the OEM) but operated by another firm (the user). In this research, we examine the value of CM in the supply chain, and the implications of data ownership (i.e., whether data owned by OEM or user) on the provision and adoption of CM.

4 - The Effect Of Multi-sensor Data On Condition-based Maintenance Policies

Heletjé Van Staden, KU Leuven, Leuven, Belgium, Robert Boute

Industry 4.0 promises reductions in maintenance costs through access to digital technologies such as the Internet of Things. Many of the promised benefits are, however, dependent on the quality of the data obtained. In this work, we consider the effect of access to different levels of deterioration data quality, resulting in partial information about the underlying state of the system being monitored, by means of sensors, on condition-based maintenance policies. We analyze the structure of the optimal policy, where the actions are either to perform maintenance, to pay for external sensor information or to continue system operation with internal sensor information only. We show that the optimal policy consists of at most four regions and numerically investigate a decision maker's willingness to pay for additional information.

5 - Predictive 3d Printing With IoT

Yue Zhang, Pennsylvania State University, University Park, PA, 16827-1750, United States, Jing-Sheng Song

We consider the context of a 3D printer supplying spare parts for a critical part installed in multiple machines that are embedded with sensors and interconnected via IoT. We demonstrate that 3D printing should be conducted predictively with the optimal policy described by a system-state-dependent threshold. Among all parameters, the printing speed is the key determinant for the optimal policy to exhibit a special mode, print-on-advance-demand (PoAD), that permits minimum inventory. In addition, the impact of IoT in enabling predictive 3D printing can be decomposed into one portion attributed to the advance information from embedded sensors, and another attributed to the real-time information fusion due to sensors interconnected via IoT. This information fusion amplifies the well-known complementary relationship between inventory and advance demand information.

■ VWC26

Virtual Room 26

Sustainability and Social Responsibility in Supply Chains

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Robert Swinney, Duke University, Durham, NC, 27708-9972, United States

1 - Are Fast Supply Chains Sustainable?

Ali Kaan Tuna, Duke University, Durham, NC, 27708, United States, Robert Swinney

We study the environmental implications of a firm's efficient (prioritizing cost) or responsive (prioritizing speed) supply chain choice. Using a model in which it increases costs but decreases leadtimes, we show that responsiveness is most likely to benefit the environment when it is least likely to be profitable. Thus, aligning firm and environmental preferences with responsiveness is challenging. We show that this can occur in settings with localized production and/or high demand variability, or if the product generates significant environmental impact during its use phase. We also discuss how competition changes our insights and how policymakers can influence firms to choose environmentally superior supply chains. In a numerical study, we determine the likely environmental performance of responsiveness in different industries.

2 - The Impact Of Variety On The Economic & Environmental Performance Of A Fashion Rental Business Model

Anna Saez de Tejada Cuenca, IESE Business School, A, Barcelona, 08034, Spain, Vishal Agrawal, Ekaterina Astashkina

Fashion rentals companies constitute a rapidly growing industry. Renting clothes allows consumers to enjoy a larger variety of products without purchasing them, thus potentially solving the problem of underutilization of garments and waste. In this paper we analyze the impact of variety on consumers' usage behavior and on the company's operational performance as a whole, using real data from a US-based clothing rental company. We find that higher variety leads to clients keeping their rented items shorter, renting substitute items sooner, and overall renting more items. This increases items' utilization: they get rented more times, and spend less time idle. However, when product variety is too high, item utilization starts to decrease. With these empirical results, we build a simple analytical model to quantify the economic and environmental impact of variety levels.

3 - Consumer Status Signaling And Nondeceptive Counterfeits

Shiqing Yao, Monash University, Melbourne, Australia, Li Chen, Zhen Lian

We study the effect of consumer status signaling on the market entry deterrence game between a status good firm and a nondeceptive counterfeiter. We show that a strong consumer status-seeking effect will always induce the noncedeptive counterfeiter's entry to the market in equilibrium. Such entry lowers the status good firm's profit, but may sometimes increase the overall social welfare.

4 - Low-skilled Labor Shortages Contribute to Forced Labor — Evidence from Myanmar and Thailand

Boyu Liu, Massachusetts Institue of Technology, Cambridge, MA, United States

Over 25 million people are victims of forced labor globally; the vast majority are low-skilled migrant workers who migrated from a different country or region. Evidence so far indicates that much of labor exploitation has roots in the recruitment process. This motivates the question of whether there are characteristics common to low-skilled labor recruitment that can serve as reliable indicators of forced labor risk in the workplace. Leveraging unique data sets from the Myanmar Government and the Issara Institute on weekly demand for Burmese migrant workers in Thailand by Thai companies, and on worker voice hot-line data from 2018-2020, we find that unexpected labor shortages in the workplace significantly increase migrant worker abuse. Using an Instrumental Variable (IV) approach, we find that an increase of one standard deviation in low-skilled labor shortages in the workplace leads to a 34.5% or higher increase in worker-reported labor abuse in the two to four weeks that follow. Shocks of such magnitude occur about 10% of the time. We also find a visible correlation between provinces whose labor markets are more stressed on average and the frequency of unexpected labor shortages in a province, suggesting that stressed labor markets are also more prone to unexpected shortages and abuse. Overall, this research suggests that inefficiencies in matching supply and demand for low-skilled labor play an important role in determining labor abuse outcomes, and that reducing these inefficiencies in the labor recruitment process could help mitigate labor abuse.

■ VWC27

Virtual Room 27

Operations Management I

Contributed Session

Chair: Cao Xuejing,

1 - Selling Online Display Advertising By Guaranteed Contracts Combined With The Real-time Bidding Auctions

Junchi Ye, Trinity College Dublin, Dublin, Ireland, Yufei Huang, Bowei Chen

There are mainly two selling channels for impressions of online display advertising: guaranteed contracts and the real-time biding (RTB). This paper focuses on the problem that how should the publisher pricing the guaranteed contracts with the presence of RTB to maximize her revenue. In the basic model, the publisher sells a certain number of impressions to a certain number of advertisers with unit demand during two periods. In each period only one channel available. We show that this mechanism combining guaranteed contracts and RTB is more flexible and profitable than only one channel. We also extend our model to a uncertain number of impressions.

2 - Organizational Challenges And Root Cause Interpretations: Evidence From A Longitudinal Study Of Business Executives

Robert N. Eberhart, Associate Director of Entrepreneurship and Society, Stanford University, Palo Alto, CA, United States, George Foster, Jim Andrew Best-Devereux

How managers respond to their challenges is central to studies of both strategy and organizational theory, but how challenges are interpreted is much less studied. Strategic literature examines managerial responses from a performance-oriented perspective, organizational scholars theorize that actions are selected to maintain legitimacy. We employ LDA topic modeling to analyze 1,648 written challenges and cause interpretations from CEOs and executive officers who attended executive education programs over a twenty-three-year period at Stanford University. We test how the type of challenge matches the type of interpretation and observe changes in these responses.

3 - Human Discretion In Automated Supermarket Replenishment And Self-inflicted Stockouts

Bengü Nur Özdemir, IE Business School, Madrid, Spain, Antti Tenhiala

In the retail industry, automatic store replenishment (ASR) systems balance inventory costs and shelf availability. Yet, decision-makers have the discretion to cut ASR order proposals to avoid excessive inventory when they expect deteriorating demand conditions. Using data from a supermarket chain, we analyze the effects of deviations from ASR orders. We investigate the implications of different cognitive biases. We employ two-stage econometric models to address endogeneity. Results show that cognitive biases predict deviations, and biased deviations lead to higher likelihood of stockouts. Based on the results,

counterproductive use of discretion can be identified and discouraged.

4 - Impact Of Vertical Integration In A Referral-based Healthcare System

We investigate how vertical integration influences the referral behavior in primary care and the corresponding service provision at specialists. We use a novel modeling feature to capture the level of integration and its impact on generalist and specialist decisions. We find that the system efficiency can be improved with a moderate integration level. However, aiming for a moderate level of integration is especially appropriate if congestion at the specialist stage becomes substantial or the generalist's ability to treat complex patients is limited. Our work also shows that physicians get higher payment without necessarily improving service quality when the integration level is higher.

■ VWC28

Virtual Room 28

Healthcare Analytics in action: using data-driven models to effect change

Sponsored: MSOM/Healthcare

Sponsored Session

Chair: Retsef Levi, MIT, MIT, Cambridge, MA, 02142-1320, United States

Co-Chair: A. Cecilia Zenteno, Massachusetts General Hospital, Boston, MA, 2114, United States

Co-Chair: Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, 02142-1508, United States

1 - Optimal Resource Pooling For Effective Use Of Future Operating Room Capacity

Seung-Yup Lee, Vanderbilt University Medical Center, Nashville, TN, 37212, United States, Vikram Tiwari

We investigate the optimal timing for release of unfilled operating room (OR) block capacity to improve the efficiency and effectiveness of OR use. A Markov decision process structure is designed that incorporates not only the number of remaining days until the day of surgery but also the remaining capacity of the OR block as well as historical demand for the block. In this presentation, we propose the decision-making modeling structures for both the single- and multi-OR block cases and discuss the applicability of the resulting polices in practice and expected improvements. Our results provide insights into pursuing proactive management of pooling limited resources in the healthcare setting where both system-wide efficiency and specialty-specific characteristics of resources should be considered.

2 - Evaluating Medical Disaster Planning Exercises Using Mathematical Programming

Derya Demirtas, University of Twente, Postbus 2Enschede, Netherlands, Gelbrich Holsbrink, Patricia Rogetzer, Nancy ter Bogt

During a mass casualties incident (MCI), treatment capabilities of the regional hospitals are overwhelmed. In the Netherlands, emergency care networks prepare their regions for an MCI by organizing analog simulation exercises called Emergo Train System (ETS) exercises. In 2019, two separate emergency medical teams simulated the allocation process of casualties to ambulances and hospitals using ETS. The results differed significantly between the teams. Although the ETS exercises are widely used in the world, the optimal solutions are not known before or after, leaving how much better a team could perform a mystery. In this research, we propose an ILP that allocates each casualty of an MCI to an ambulance and a hospital. We demonstrate the effectiveness of our models by comparing our results to the outputs of the ETS exercises of 2019 and provide sensitivity analysis.

3 - Predictive Analytics For Post-partum Hypertension

Jinxin Tao, UW Madison, Madison, WI, United States, Ramsey Larson, Yonatan Mintz, Kara Hoppe

Hypertensive disorders of pregnancy (HDP) complicate approximately 10% of pregnancies in the United States but account for the majority of postpartum readmissions. Postpartum readmission is costly both in financial terms and in quality of life measures for mothers and new families. However, using a predictive model to help predict postpartum readmission due to hypertension has not been proposed yet. In this study, we used a cost-sensitive random forest method to predict which patients would experience a hypertension-related postpartum readmission. With the records of 32,645 patients who delivered between 2009-2018 and 170 readmissions included, our model achieved a sensitivity of 85%, specificity of 79% and a balanced accuracy of 82% in predicting readmission.

4 - A Prescriptive Approach To Surgical Inpatient Discharges

Taghi Khaniyev, MIT Sloan School of Management, Cambridge, MA, 02142-1508, United States, Kyan Safavi, Martin Copenhaver, A. Cecilia Zenteno, Bethany Daily, Peter Dunn, Retsef Levi

We first trained a neural network model to accurately predict next-day's inpatient discharges using structured EHR data which was represented based on whether it indicated a clinical or administrative barrier to discharge which was defined as an event that may postpone the patient's discharge. Discharge predictions were categorized as NO/MAYBE/YES. An optimization model was developed to select the minimal subset of barriers for each patient that need to be resolved in order to move a patient to YES category. This minimal list was intended to serve as a prioritized action list for each patient. When we augmented the prediction model with free-text clinical notes using a recurrent neural network, the prediction accuracy was improved by up to 20%.

■ VWC29

Virtual Room 29

Financial Frictions and Operations Management

Sponsored: MSOM/iForm

Sponsored Session

Chair: Christopher J Chen, Indiana University Kelley School of Business, Indiana University Kelley School of Business, Bloomington, IN, 47405-1703, United States

1 - Trade Credit Late Payment And Industry Structure

Jing Wu, Chinese University of Hong Kong, Decision Sciences and Managerial Economics, Hong Kong, Hong Kong, Hsiao-Hui Lee, John R. Birge

Trade credit studies pay little attention to firms' late payment behavior due to the lack of extensive panel data. From the perspective of industry structure, this paper is the first to empirically study firms' trade credit late payment. We show that a firm's late payment behavior is positively associated with market power and downstream cost-shifting, and firms strategically choose to whom and for how long to delay their trade credit payment. We also examine several moderating factors, including a firm's capacity to borrow and speed to borrow, inventory turnover, and prior contract breach record.

2 - Using Digital Footprints To Understand American Covid Product Manufacturing

Alan Kwan, Hong Kong University, Hong Kong, Hong Kong, Ben Charoenwong, May Li

Using a dataset from North America's largest digital platform for B2B product sourcing, we study demand for Covid-related products and study supplier entry into the market for PPE. Manufacturers which produced closely-related products prior to the pandemic were more likely to repurpose production into Covid-related products when demand increased, but several market-level factors inhibited supplier entry. Demand and epidemiological forecast uncertainty negatively impacted supplier entry and suppliers eschewed labor-intensive products, especially in areas where labor supply was more constrained. Conversely, potential suppliers display significantly higher probability of entering when they expect stronger governmental support, highlighting the importance of government procurement for public health emergencies.

3 - Inventory Productivity In Manufacturing Networks

Nikolay Osadchiy, Emory University, Atlanta, GA, 30322-1059, United States, Deepak Agrawal

We identify drivers of inventory productivity in manufacturing networks, including traditional and novel ones based on the supply chain position, and discuss implications for performance benchmarking and valuation.

4 - A Data-driven Model Of A Firm's Operations: An Application To Cash Flow Forecasting

Vishal Gaur, Cornell University, Ithaca, NY, 14853-6201, United States, Kashish Arora

Financial variables reported in the financial statements of firms are essential for performance analysis. Yet, such analysis is made complicated by the fact that these variables are endogenous to the decisions made by firms. In this paper, we propose a generalizable and data-driven model of a firm's operations to disentangle this endogeneity and estimate cross-variable causal impacts among variables. We model the relationship between a firm's operational variables and its evolution over time. We estimate the model using public operational. Thereafter, we (i) quantify the contemporaneous and dynamic impacts of structural shocks in variables on the system, (ii) generate joint forecasts for cash flows and other operational variables. We show that the joint forecasts generated from the model are more accurate than those generated from univariate time-series models.

■ VWC30

Virtual Room 30

Applied Machine Learning in Operation

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Gad Allon, University of Pennsylvania, Philadelphia, PA, 19104-3615, United States

1 - Machine Learning And Prediction Errors In Causal Inference

Daniel Chen, University of Pennsylvania, Philadelphia, PA, United States, Gad Allon, Zhenling Jiang, Dennis J. Zhang

Machine learning is a growing method for causal inference. In machine learning settings, prediction errors are a commonly overlooked problem that can bias results and lead to arbitrarily incorrect parameter estimates. 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 - Learning To Recommend Using Non-uniform Data

Wanning Chen, Stanford University, Stanford, CA, United States, Mohsen Bayati

Learning user preferences for products based on their past purchases or reviews is at the cornerstone of modern recommendation engines. One complication in this learning task is that some users are more likely to purchase products or review them, and some products are more likely to be purchased or reviewed by the users. This non-uniform pattern degrades the power of many existing recommendation algorithms, as they assume that the observed data is sampled uniformly at random among user-product pairs. We design a theory-driven weighted matrix completion method that restores the non-uniformity and, using real data, we show that it boosts the prediction performance of user preferences.

3 - The Variational Method Of Moments: Efficient Estimation Of Structural Parameters Using Adversarial Machine Learning

Andrew Bennett, Cornell University, Ithaca, NY, United States,

Important structural or causal parameters in many clinical, operational, and economic settings can be described in terms of conditional moment problems. Prominent examples include treatment effects under noncompliance and demand curves in industrial organization. We propose the variational method of moments (VMM), which solves the conditional moment problem by reformulating it as a zero-sum game, which can be solved using either kernel methods or algorithms for smooth game optimization with deep neural networks. Unlike related machine-learning-based approaches, VMM is globally semiparametrically efficient due to a careful reweighting of the infinitely-many implicit moment conditions. Practically, it provides excellent estimates and valid confidence intervals, improving on both classic nonparametric methods and recent machine-learning-based methods.

4 - Can AI Impact What We Eat in a Restaurant?

Dmitrii Sumkin, INSEAD, 1 Ayer Rajah Avenue, Singapore, 138676, Singapore, Pavel Kireyev, Serguei Netessine

We analyze 920 outlets of restaurants in Southeast Asia observed for almost over 2 years. They replaced paper menus with tablets, installed kiosks for ordering, and facilitated mobile phone usage to place an order on the website. The check level panel data include the sequence of goods added in a cart with their customization options regarding the dish size and toppings added. Staggered timing of AI implementation that gives recommendations along the ordering process allows identifying the causal impact of AI on customer's choice. We study whether AI increases the check's size and assortment and how it depends on the type of recommendation, type of order, the device used for the order, and other factors.

■ VWC31

Virtual Room 31

Supply Chain Management II

Contributed Session

Chair: J. Kiarash Sadeghi, University of North Texas, Denton, TX, 76203, United States

1 - Reforming Global Supply Chain Operations Management Under Pandemics: The Great-3rs Framework And Research Agenda

Xiaoyan Xu, The Hong Kong Polytechnic University, Hong Kong, Hong Kong, Suresh P. Sethi, Sai-Ho Chung, Tsan-Ming Choi

To survive the outbreak of COVID-19, it is critical to rethink and reform global supply chain operations management (GSCOM). In this paper, we combine a careful literature review with real-world practices to examine the impacts and specific challenges brought by the COVID-19 pandemic to global supply chains. To achieve 3Rs (responsiveness, resilience, and restoration), we propose the "GREAT-3Rs" framework, which includes five critical domains to help global enterprises to survive the pandemic. The framework also shows various critical issues for proper GSCOM under different pandemic stages (i.e., pre, during, post-pandemic stages). We finally establish a future research agenda.

2 - Weather Rebate Contracts With Buyback Policy

Piyal Sarkar, PhD Candidate, Ryerson University, Toronto, ON, Canada, Mohamed Wahab Mohamed Ismail, Liping Fang

Firms dealing with weather sensitive products often face a problem with demand management. A class of contract for a supplier-retailer supply chain to address this issue is proposed. This contract provides an incentive to the retailer in the form of a weather rebate to induce the retailer to increase the ordering quantity and takes care of the inventory risk by an inventory buyback policy. The supplier uses weather derivatives to hedge risk depending on the risk attitude. CVaR is used to model the risk attitude. The results show that the designed contract performs better than a traditional buyback contract. The study designs a new class of contract that can be used to manage a supply chain under weather risk.

3 - Timeliness And Accuracy Of Visibility In Supply Chain Cyber-resilience

J. Kiarash Sadeghi, G. Brint Ryan College of Business, University of North Texas, Denton, TX, United States, Arash Azadegan, Divesh Ojha

Cyber-attack is a clear and present danger across the world. From supply chain and operations managers' perspectives, this research provides empirical evidence to examine how visibility is linked to supply chain cyber-resilience. Experimental results showed that timeliness is more effective than accuracy when it comes to building cyber resilience in times of supply chain attacks.

■ VWC32

Virtual Room 32

Collaborative Decision-making in Value Chains

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Abhishek Roy, Temple University, Fox School of Business, Temple University, Fox School of Business, Philadelphia, PA, 19122-6105, United States

1 - Solo Or Duo? Equilibrium Work Allocation In Team Production

Vladimir Smirnov, University of Sydney, Sydney, Australia

We examine a principal's preferred production mode - solo agent, solo principal or a joint effort - in a double moral-hazard model. In the model a principal chooses the agent's incentives and her own effort before the agent chooses his effort. The principal's preferred mode depends on how complementary (or substitutable) efforts are. We show that in order to encourage agent's effort, the principal's effort with joint production might be higher than when working alone and a principal might choose joint production even with substitute efforts. Applications include co-production and leadership.

2 - Trade-in Or Sell In My P2p Marketplace: A Game Theoretic Analysis Of Profit And Environmental Impact

Aditya Vedantam, Assistant Professor, State University of New York at Buffalo, Buffalo, NY, 14221, United States, Emre M. Demirezen, Subodha Kumar

Under manufacturer trade-in programs, consumers return used products for a discount on "new" product purchases. The returned products are often refurbished and remarketed by the manufacturer as "used" products. More recently, manufacturers are also setting up P2P resale marketplaces, where consumers can trade products directly with each other. We contrast these two resale strategies: a trade-in operation and a P2P resale marketplace, and show the implications of each business model on pricing, profit and the environment.

3 - Friend or Foe: Search Engine Advertising Strategies when Contracting with an Online Search Infomediary

Abhishek Roy, Temple University, Philadelphia, PA, United States, Siddharth Bhattacharya

The widespread growth of e-commerce has resulted in proliferation of online search infomediaries (OSIs), who provide consumers with information about products and services sold by different firms (Parents), while also referring interested consumers to the Parents' website. Very often, both Parent and OSI advertise and compete for a spot on sponsored search page on Parent's keyword. This leads to an interesting conundrum where Parent and OSI both compete and cooperate at same time. In this unique context, how equilibrium payment and advertising strategies affect factors such as traffic quality, advertising effectiveness, leakage, and nature of contract between two firms, is this study's focus.

4 - Financial Sustainability of Non-profit UGC Platforms: The Role of Content Creation and Donations
Ziqi Dong, Temple University, Philadelphia, PA, United States, Emre M. Demirezen, Subodha Kumar

User-Generated Content (UGC) online communities are gaining popularity since the mid-2000s. Among UGCs, Wikipedia is regarded as the most popular and successful example. This multilingual online UGC platform is created and maintained as an open collaboration project by a community of volunteer editors, with more than 300 language editions. Further, as users donate due to both altruism and service usage, Wikipedia's financial aspects are very similar to that in the pay what you want (PWYW) contexts. We fill the gap in the literature by studying PWYW and UGC concurrently to shed light on the business practices of organizations like Wikipedia and generate managerial insights.

■ VWC33

Virtual Room 33

Supply Chain Management VI

Contributed Session

1 - Supply Chain Contracting For Network Goods
Dawei Jian, University of California-Riverside, Riverside, CA, United States

How should manufacturers sell network goods through retail channels? We study this new supply chain 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.

2 - Order Batching And Driver Routing In An Uber Style Restaurant Delivery Operation
Wen Zhu, New Jersey Institute of Technology, Newark, NJ, United States, Marena Marco, Sanchoy Das

The time variant state of a restaurant delivery model is described by a set of customer orders and a set of available drivers. Order attributes are the associated restaurant, promised delivery time, and delivery location. Driver attributes are the available time and current location. We model a fixed cycle scheduling model with M orders, N drivers, and R restaurants. The batching and routing objectives are to minimize driver travel distance and order delivery tardiness. Drivers are capacitated but can pick orders from multiple restaurants.

3 - Economically Viable Sustainable Supplier And Route Selection For Food Supply Chains
Ranjini B. Guruprasad, Research Scientist, IBM, Bangalore, India, Kumar Saurav, Ivan Kayongo, Kedar Kulkarni

Decreasing GHG emissions of food supply chains in an economically viable manner is critical as they contribute to 26% of global GHG emissions. Existing methods carry out life cycle analysis (LCA) using emissions factors from databases. However, there are limitations in terms accuracy as emissions factors are averages and not current. We address this by proposing a framework that includes a collection of satellite data, physical models, static and LCA tools to estimate the GHG estimates. The framework jointly optimizes GHG emissions and costs while selecting suppliers and routes. We illustrate the working of this framework and the sustainability-cost tradeoffs using a global pizza supply chain.

■ VWC34

Virtual Room 34

MSOM/Sustainable Operations Cluster

Sponsored: MSOM/Sustainable Operations

Sponsored Session

■ VWC35

Virtual Room 35

Electrical Markets I

Contributed Session

Chair: Hsiao-Dong Chiang, Ithaca, NY, 14853, United States

1 - Potential Value Of Private Electric Vehicles On Distribution System Restoration: A Multi-agent Optimization Approach
Sina Baghali, University of Central Florida, Orlando, FL, United States, Zhaomiao Guo

We investigate the effects of private electric vehicles (EVs) on the restoration of distribution systems (DSs) after disruptions. We propose a framework of network-based multi-agent optimization problems with equilibrium constraints (N-MOPEC) to explicitly model the decentralized decision making of stakeholders in transportation and energy systems and their interactions during DS restoration. We further develop an exact convex reformulation for computation efficiency. The proposed modeling and computational strategies could provide a foundation for the future analyses of power system resilience with private EVs in coupled transportation and power networks.

2 - The Impacts Of Coupons On Crowdfunding
Xiahua Wei, University of Washington, Bothell, WA, United States, Weijia You

This paper studies the impact of coupons on the amount of funds raised in crowdfunding. Analyzing project-level panel data from a large crowdfunding platform, we find that coupons drive funds raised significantly for projects related to technology and design. Furthermore, the number of coupons issued and funds raised demonstrate an inversed U-shape relationship. Also, we find that coupons with a high requirement of minimum-purchase, a low discount, or in the early stage of the campaign, can hurt the fundraising. These findings offer useful insights into the design of pricing strategies for fundraisers and the crowdfunding platform.

3 - Spineopt - An Open-source Multi-energy Model Generator
Maren Ihlemann, KU Leuven, Heverlee, Belgium, Iason Kouveliotis Lysikatos

Open-source energy system models are integral to the formulation of new energy policies, and the advancement of research towards sustainable energy systems. SpineOpt is an open-source multi-energy system model generator, for performing operational and planning optimizations. SpineOpt provides a wide spectrum of novel tools and functionalities. The key features comprise a generic data structure that enables the implementation of highly diverse case studies, a flexible temporal and spatial structure, the representation of uncertainty, and model decomposition, as a way to reduce computational complexity. These features are presented in a designated case study.

4 - Variable Renewable Generation Participation in U.S. Ancillary Services Markets
James Hyungkwan Kim, Lawrence Berkeley National Laboratory, Berkeley, CA, United States, Fredrich Kahrl, Andrew Mills

Rising penetrations of variable renewable generation (VRG) are reducing VRG value and creating new challenges for system operators. Enabling VRG participation in ancillary services (AS) markets could provide additional revenue and allow system operators to access lower-cost integration solutions. Using profit-maximizing dispatch against 2015-2019 energy and AS prices in all seven U.S. ISOs/RTOs, we found that the average incremental value of AS market participation to hybrid (storage-paired) VRG owners is significantly higher than for standalone VRG. The value to system operators can be high, suggesting the need to consider expanding eligibility to participate in AS markets.

5 - High Performance Solution For Security Constrained Optimal Power Flow (sc-opf) For Grid Optimization
Hsiao-Dong Chiang, Professor, Bigwood Systems, Inc., Ithaca, NY, United States

Global Optimal Technology (GOT) seeks to solve the ACOPF problem by employing proprietary technology to define the feasible region for the problem and calculate feasible solutions. In Challenge 1, the initial algorithm using proprietary approaches (Quasi-Gradient Systems and Feasibility Regions) was developed to be high-performing, reliable, and scalable. Areas of improvement were also identified in contingency analysis, robustness, computation speed, price-response load demand, among others. GOT combined with Bigwood Systems to enhance the algorithm for Challenge 2 and develop a powerful tool for power markets.

■ VWC37

Virtual Room 37

Assessing the Impacts of Weather Extremes and a Changing Climate on the Energy Sector

Sponsored: ENRE/EnergyClimate

Sponsored Session

Chair: Konstantinos Oikonomou, Pacific Northwest National Laboratory, Salt Lake City, UT, 84108, United States

Co-Chair: Edward Byers, Switzerland

1 - Analytical Tool for Assessing Climate-related Risks for the Texas Power System
Lu Liu, Iowa State University, Ames, IA, United States, Ethan Yang, Hongyi Li, Xingpeng Li, Carlos Gamarra, Gavin Dillingham

An improved understanding of the climate-related risks is needed to support Texas power system planning given its failed performance during past climate disasters. This study develops a modeling framework - Pythias, that advances a systems-level understanding of climate and power system by combining physical and socioeconomic modeling. The novelty of Pythias lies in characterizing the feedback between power system and physical environment with the consideration of the adaptive capacity of power system under different climate and policy scenarios. Project phase I will produce a skeleton modeling framework for calibration and validation to be conducted in phase II.

2 - The Changing Sensitivity Of Power Systems To Meteorological Drivers: Variability, Extremes And Predictability.

Hannah Bloomfield, University of Reading, United Kingdom

Large quantities of weather-dependent renewable generation are expected in power systems under climate change mitigation policies. The impacts of these renewables on potential power system operation therefore requires significant attention. In this talk the importance of using multi-decadal time series of meteorological data for power system modelling will be demonstrated with a case study of Great Britain. Following this the impact of power system composition on the type of weather events most likely to cause extreme power system conditions will be explored. The predictability of weather-dependent power system components is of great importance for reliable system operation. The talk will conclude with a summary of the predictability of European national energy variables one to four weeks ahead using state-of-the-art sub seasonal forecasting methods.

3 - Implications Of Climate Change For Decarbonized Electricity System Planning: Examples From California

Brian Tarroja, Professional Researcher, University of California, Irvine, Irvine, CA, United States

Regional electricity systems are evolving to incorporate more zero-carbon energy resources and transform the infrastructure that underpins such electric grids. To ensure that these efforts are successful, these must be adapted to account for how climate change affects regional electricity supply, demand, and infrastructure. Here, we provide examples of how climate change affects decarbonized electricity system planning through effects on hydropower generation, water availability for thermally-based electricity resources, and building electricity demand. California is used as an example due to its combination of susceptibility to drought, temperature extremes, and policies to decarbonize their electricity system. Further, we explore the effectiveness of different solutions to mitigate undesirable impacts on decarbonized electricity system planning.

4 - Flexible Power Network Topologies for Multi-sector Grid Studies

Konstantinos Oikonomou, Pacific Northwest National Laboratory, Richland, WA, 84108, United States

We develop a systematic approach for designing reduced network configurations for power grid operation studies to explore multisector dynamics. The proposed approach introduces categories of strategic decision-making design criteria that dictate the optimal spatial resolution of the reduced network by assessing tradeoffs between computational needs and adequate model fidelity to address the desired science questions and compatibility with other sectoral models. We design and evaluate multiple reduced network topologies over the Western U.S. for addressing science questions around hydrometeorological variability, global change, and the adoption of new technologies.

■ VWC38

Virtual Room 38

Energy Policy and Planning I

Contributed Session

Chair: Jeffrey Lineberry, University of Oklahoma Gallogy College of Engineering, Stillwater, OK, 21402, United States

1 - Optimal Operation For Shared Mobility-on-demand Electric Vehicle Fleet Via Combined Reinforcement Learning And Operation Research Approach

Yimeng Sun, North China Electric Power University, Beijing, China, Yanchang Liang, Zhaohao Ding

Shared mobility-on-demand (MoD) electric vehicle fleet can meet a significant percentage of traffic demand by conducting order serving and rebalancing. Meanwhile, it can provide dispatch-able charging demand for power system in both spatial and temporal manner by flexible routing and charging. Thus, it becomes a critical issue to find the optimal operation scheme for MoD fleet under the coupled power and transportation system. We propose a method combining deep reinforcement learning with binary linear programming to develop a near-optimal operation policy for MoD fleet operator. The simulation experiments with real-world data from Haikou City verify the effectiveness of the proposed method.

2 - Co2 Infrastructure Planning For Fossil - And Bio-energy With Carbon Capture And Storage

Emma JAGU, IFP School, Rueil-Malmaison, France, Olivier Massol

BioEnergy with Carbon Capture and Storage (BECCS) is a critical technology to limit global warming. However, its up-scaling requires the installation of a costly CO2 transportation infrastructure, which will likely be shared between BECCS plants and fossil Carbon Capture and Storage (CCS) plants. We examine the conditions for the deployment of such an infrastructure using an adapted cooperative game theoretic framework. We then apply this model to a contemporary project in Sweden. Our results support pragmatic policy recommendations to organize the deployment of the BECCS technology.

3 - Optimization-based Analysis Of Decarbonization Pathways And Flexibility Requirements In Highly Renewable Power Systems

Alvaro Lorca, Pontificia Universidad Catolica de Chile, Santiago, Chile, Felipe Verastegui, Daniel Olivares, Matias Negrete-Pincetic

This paper develops a planning model including an effective representation of the operational aspects of the power system to understand the key role of flexible resources under strong decarbonization processes in highly renewable power systems. A case study is developed for the Chilean power system.. The results show that highly renewable generation mixes are feasible, but rely on an effective balance of the key flexibility attributes of the system.

4 - Long-term Joint Capacity Expansion Planning For Highly Renewable Power And Hydrogen Networks

Javier Jorquera, MSc Student, Pontificia Universidad Catolica de Chile, Santiago, Chile, Alvaro Lorca, Enzo E. Sauma, M atias Negrete-Pincetic

Coupled power-hydrogen networks will lead to highly decarbonized systems. Existing capacity expansion models either are monoperiod, simplify a network or preset if hydrogen will be produced off-grid. We propose a multiperiod linear optimization model that plans for the least-cost coupled system, models electricity and hydrogen flows, allows for on and off-grid hydrogen production and models various hydrogen transport modes. We conduct a Chilean case study over a 30 year horizon. Our results show its capabilities to study centralized and decentralized hydrogen production trade-offs, and highlights hydrogen-renewable integration synergies, subject to policy and operational constraints.

5 - Sensitivity Analysis of the Market Penetration in China's Passenger Vehicle Market Through Monte Carlo Method

Mohamed Ali Saafi, Lab Scientist, Aramco Services Company, Novi, MI, United States, Shiqi Ou, Zhenhong Lin, Xin He

This study uses the python version of the New Energy and Oil Consumption Credits (NEOCC) model - a tool integrated consumer discrete choice and optimization methods - to quantify the impact of fuel price, battery cost, markup and fast-charging power on the electric vehicle market success as well as the industry profit in 2020-2050. Through integrating the Monte Carlo Simulation, it tests the robustness of the NEOCC model, and highlights the parameters that could affect the market penetration projection. The results show that markup affects the market the most, while the market becomes more sensitive to the fuel price and battery cost after 2035 which is explained by less policy constraints.

6 - Economic Analysis Approach to Critical Infrastructure Resiliency Investment

Jeffrey Lineberry, University of Oklahoma Gallogy College of Engineering, Norman, OK, United States

Critical infrastructure resiliency is an imperative global concern. The consideration of critical infrastructure interdependencies complicates the identification of resilience optimality. Many nations are faced with budgeting constraints and the need to optimally determine infrastructure resilience investment. The ability to identify critical infrastructure essential node vulnerability is paramount to decision makers. Determining overall economic impacts associated with critical infrastructure disruptions is a desirable approach. Real data consisting of Sweden's rail network, power supply network, and associated economic commodity data is implemented in a tri-level model approach utilized to pinpoint vulnerability considering critical infrastructure interdependencies. This Defender-Attack-Defender model representative of vulnerability reductions, network disruptions, and recoverability enhancements is used to determine vital interdependent nodes associated with the rail and power supply networks. The analysis from this model gives insight into associated economic impacts, thus providing the framework necessary to link economic sectors to critical infrastructure interdependencies in order to determine optimal resilience investment. This model results in an overall ability to guide resilience investment based on overall economic sector considerations.

■ VWC39

Virtual Room 39

Production & Scheduling I

Contributed Session

Chair: Michael Geurtsen,

1 - An Agent-based Approach To The Job Shop Scheduling Problem With Order Rejection

Omar Abbaas, Graduate Assistant, Pennsylvania State University, University Park, PA, United States, Jose Antonio Ventura, Sara Abu Aridah, Kevin Bunn

This study considers the job shop scheduling problem with order rejection and earliness and tardiness penalties using an agent-based approach with a combinatorial auction mechanism. A set of jobs is offered. Each job has a revenue, ready time, due date, deadline, and consists of a set of operations with unique precedence relationships. A mathematical model is presented, then Lagrangian relaxation is used to decompose the problem into a set of job-level scheduling problems. Profitable jobs at the individual level submit their bids to an auctioneer. Then, the auctioneer resolves conflicts to reach a feasible solution, records the profit upper and lower bounds, and updates the dual variables.

2 - Overhaul Planning And Exchange Scheduling For Maintenance Services With Rotable Inventory

Ameen Alshikh, University of Miami, Coral Gables, FL, United States, Murat Erkoc

We study joint optimization of scheduling and rotable inventory management in overhaul operations with a primary focus on the MRO aviation industry. In this setting, an incoming equipment set that requires overhaul is exchanged with a ready-to-go set from the MRO service provider's inventory. When the overhauling for the former set is completed, it is placed in the service provider's inventory for a future exchange. The service provider's available capacity and exchange inventory may necessitate that early arrivals of MRO orders with respect to their requested dates. We propose a mixed integer programming model that minimizes total earliness and inventory costs for the service provider.

3 - A Novel Problem Of Scheduling Resource Constrained Preventive Maintenance And Production Simultaneously For The Unrelated Parallel Machine Environment

Michael Geurtsen, Eindhoven University of Technology, Eindhoven, Netherlands, Jelle Adan

This study proposes a new mathematical formulation and a Memetic Algorithm for a novel integrated maintenance and production scheduling problem. The novelty lies in the combination of two constraints, i.e. (1) a single maintenance activity can only be scheduled in one of its set of available time windows, and (2) a maintenance activity demands additional scarce resources. A case study is performed with real-world production data from a semiconductor manufacturer, where production and maintenance are currently scheduled separately. It is shown that scheduling production and maintenance activities simultaneously enables significant improvements.

■ VWC40

Virtual Room 40

Machine Learning for Power Systems

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Pascal Van Hentenryck, ISyE Georgia Tech, ISyE Georgia Tech, Atlanta, GA, 30318, United States

1 - Learning A Good Chance-Constraint Approximation From Data: A Tuning-based Approach To Chance-Constrained Optimal Power Flow

Line Roald, University of Wisconsin - Madison, Los Alamos, NM, United States, lineroald@gmail.com, Ashley Hou

Chance constrained optimization is a popular approach to ensure secure and economic operations of power systems with renewable energy. Chance constrained optimization can be challenging and typically involves a trade-off between solution quality (solution cost and feasibility guarantees) and numerical tractability (e.g., number of considered scenarios). In this talk we describe a tuning-based approach which utilizes intentionally simplistic chance-constraint formulations combined with data-driven tuning to obtain high quality solutions at low computational effort. We further discuss why a naïve implementation of such methods does not provide probabilistic performance guarantees, and propose a two-step approach with a solution generation step and solution verification step to restore such guarantees.

2 - Speeding Up Power Systems Optimization Problems With Deep Learning

Kyri Baker, University of Colorado Boulder, Boulder, CO, 80309, United States, Mostafa Mohammadian

As more fast-fluctuating renewable energy is being introduced into power grid operations, the need for computationally efficient solutions to optimize the operation of these resources is increasing. In this talk, we discuss ways that neural networks can be used to greatly speed up AC optimal power flow (OPF), distributed DC OPF, and economic dispatch problems with inter-temporal constraints, pursuing optimality while preserving feasibility of the resulting solutions.

3 - Removing Barriers For Machine Learning Applications In Power Systems

Spyros Chatzivasileiadis, Associate Professor, Technical University of Denmark, Elektrovej, Denmark, Andreas Venzke

In this talk, we introduce methods that remove the barriers for applying neural networks in real-life power systems, and unlock a series of new applications. We introduce a framework for (i) verifying neural network behavior in power systems and (ii) obtain provable worst-case guarantees of their performance. So far, neural networks have been applied in power systems as a black-box; this has presented a major barrier for their adoption in practice. Using a rigorous framework based on mixed integer linear programming, our methods can determine the range of inputs that neural networks classify as safe or unsafe; and also obtain provable worst-case guarantees of the neural network performance. Such methods can build the missing trust of power system operators on neural networks, and unlock a series of new applications in power systems and other safety-critical systems.

4 - A Distributed Learning Algorithm For AC Optimal Power Flow

Minas Chatzos, United States

This work proposes a novel machine learning approach for predicting AC-OPF solutions that features a fast and scalable training. It is motivated by the two critical considerations: (1) the fact that topology optimization and the stochasticity induced by renewable energy sources may lead to fundamentally different AC-OPF instances; and (2) the significant training time needed by existing learning approaches for AC-OPF. The proposed approach is a 2-stage methodology that exploits a spatial decomposition of the power network that is viewed as a set of regions. The first stage learns to predict the flows coupling the regions, and the second stage trains, in parallel, the learning models for each region. The predictions can then seed a power flow to eliminate the minor constraint violations. Experiments on test cases up to 9000 buses demonstrate the potential of the approach.

■ VWC41

Virtual Room 41

Data Analytics and Mathematical Optimization

Sponsored: Computing Society

Sponsored Session

Chair: Jinhak Kim, Northern Illinois University, IL, United States

1 - Fair Quantile Regression For Predicting Health Outcomes

Young Woong Park, Iowa State University, Ames, IA, 50011-2027, United States, Youyou Tao, Abhay Nath Mishra

There are significant disparities and inequities in health outcomes among people with different demographic, socioeconomic, and other characteristics. To reduce the disparities, we propose quantile regression with fairness constraints on the residuals. A mixed-integer linear programming model is proposed to estimate the coefficients, and an aggregation-based algorithm is developed to speed up the estimation procedure. We study the efficiency of the proposed models and effect of the fairness constraints for predicting the length of stay and time to readmission for patients in the USA based on a real-world dataset.

2 - On SDP Relaxations for Sparse Principal Component Analysis

Jinhak Kim, Northern Illinois University, Dekalb, IL, United States, Mohit Tawarmalani, Jean-Philippe Richard

We develop techniques to convexify a set that is invariant under permutation and/or change of sign of variables. We first convexify the intersection of the unit ball of a permutation and sign-invariant norm with a cardinality constraint. This gives a nonlinear formulation for the feasible set of sparse principal component analysis (sparse PCA). We develop various SDP relaxations based on this construction. Using these relaxations for sparse PCA, we show that our relaxation closes 98% of the gap left by a classical SDP relaxation for instances where the covariance matrices are of dimension up to 50×50.

3 - Exact Clustering And Ranking Of Ordinal Data Via Integer Programming

Romena Yasmin, Arizona State University, United States

Ordinal preference data are of great interest in a number of contexts and disciplines, such as Psychology, Politics, Marketing, etc. In these fields for evaluation purposes, individuals are asked to create a preference ordering of a given set of items. These ordered evaluations are then combined into a single consensus ranking that minimizes the extent of disagreement between the preferences. However, these orders can have inconsistent information due to conflicting preferences of the individuals. Aggregation of these evaluations without taking into account these differences leads to incomplete or often incoherent results. In this paper, we introduce a Kendall Tau correlation coefficient-based binary programming formulation that can be used for identifying segments comprising of different underlying beliefs which can lead to a better aggregation.

4 - Overcoming Anchoring Effects In Multimodal Input Elicitation To Extract More Accurate Crowd Estimates

Yeawon Yoo, Arizona State University, Tempe, AZ, 85281-0212, United States, Adolfo Raphael Escobedo

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. In fact, there is a longstanding debate whether it is better to use ranking or rating information in many of these contexts. This study considers the use of both of these types of inputs by conducting a crowdsourced experiment where participants are asked to estimate the number of dots within a set of images in two ways: ranking and numerical estimates. Also, it tests the anchoring effect on cardinal estimates from the ordinal estimates. We find that asking cardinal estimates independent from the ordinal estimates helps to achieve better collective accuracy. Moreover, improved ordinal and cardinal estimations are obtained when the inputs are aggregated via multimodal optimization models.

5 - Integrated Subset Selection And Bandwidth Estimation Algorithm For Geographically Weighted Regression

Hyunwoo Lee, Samsung Electronics, Hwaseong-si, Korea, Republic of, Young Woong Park

This study proposes a mathematical programming-based algorithm for integrated subset selection and bandwidth estimation of Geographically Weighted Regression (GWR). Unlike the standard approaches in the literature, where independent variable subsets of focal points may vary, and bandwidth and regression parameters are updated based on different criteria, our model presents a single objective function for the integrated estimation of regression and bandwidth parameters while selecting consistent subsets for all focal points. Numerical experiments are provided to validate our model.

■ VWC42

Virtual Room 42

Graphs and Networks

Contributed Session

Chair: YeongCheol Kim,

1 - A Network-based Approach to Evaluate the Impact of Environmental Changes on the Inland Water Transportation in Bangladesh

Sayyed Mohsen Vazirizade, Vanderbilt University, Nasvhille, TN, United States, Amirhassan Kermanshah, Tristan Kindig, Ken Rahman, Jonathan Gilligan, Hiba Baroud

Inland waterways are among the most environmental-friendly and cost-effective modes of transportation. These systems are constantly threatened by natural hazards that impact their operations. Specifically, the Inland Water Transportation (IWT) network in Bangladesh has been deteriorating due to natural and morphological processes in the Ganges delta, the world's largest river delta. This study presents a data-driven approach founded in graph theory to investigate the changes in the IWT network size, connectivity, and navigability. Assorted network-based performance metrics are developed to determine the system vulnerability.

2 - Graphing The Empirical Research Process

Aleksi Aaltonen, Assistant Professor, Fox School of Business, Temple University, Philadelphia, PA, United States, a

I use simple graph theory to propose an approach for modeling empirical research processes. The approach is based on minimal assumptions about empirical research and is as agnostic as possible to particular methods or fields of study. I merely assume that an empirical study consists of a series of operations that transform observations to analytical outputs and, consecutively, to more refined outputs. I demonstrate how such a process can be modeled as a directed acyclic graph. A simple way to formalize the progression of empirical research can help scholars to collaborate more effectively, and to develop information systems that offload administrative work to research infrastructures.

3 - Scaling Graph Neural Networks With Biased Random Walk Based Graph Sampling

Yeongcheol Kim, Graduate Student, Chungnam National University, Daejeon, Korea, Republic of, Sungsu Lim

Given a large-scale graph, how can we learn its representation efficiently? Graph Neural Networks (GNNs) have been successfully applied to various machine learning tasks. Recently, several sampling-based algorithms have been proposed for representation learning on large-scale graphs; however, scaling GNNs remains challenging. In this work, we propose a fast algorithm for efficient mini-batch training that samples a given graph via a biased random walk sampler and then build a full GNN on the sampled graph. We show that our proposed algorithm provides faster and more accurate node classification results compared to state-of-the-art algorithms.

■ VWC43

Virtual Room 43

Marketplace Design and Operations

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Wenchang Zhang, United States

1 - Empirical Studies of Network Effects

Chiara Farronato

This paper presents experimental results to answer the following questions: in the presence of geographic network effects, should a platform company spread their advertising budget homogeneously across geographies, or should it focus on a few geographies where network effects are strongest? Which underlying model of consumer behavior explains the network effects captured in the experiments?

2 - Price Competition And Assortment Display In Online Marketplace

Weiming Zhu, IESE Business School, Barcelona, Spain, Hanwei Li, David Simchi-Levi, Michelle Wu

In this study, we consider a platform where each seller provides a single-unit product and competes with each other through price. We investigate sellers' optimal pricing decisions and how the pricing strategy gets affected by the platform's assortment display policies. In addition, we also study the optimal assortment rotation scheme that maximizes the platform's revenue. Using data from a leading online marketplace, we gauge the revenue gain from adopting the optimal policy.

3 - Consuming Misinformation In Online News

Jiding Zhang, Wharton School, U. Penn, Philadelphia, PA, 19104, United States

we study the trade-off and preference for consumption of news items. We are particularly interested in the consumption behavior and its consequences related to misinformation. From a practical perspective, it is also essential to measure the difference in consumption behaviors among people, and tie such difference to their preference.

■ VWC45

Virtual Room 45

Analytics III

Contributed Session

Chair: Kemal Gursoy, Rutgers University, Highland Park, NJ, 08904-3627, United States

1 - Data-driven Optimization For Performance-based Replenishment Systems

Alireza Sheikh-Zadeh, Texas Tech University, Lubbock, TX, United States, alireza.zadeh@ttu.edu

Performance-based replenishment refers to supply systems that are constrained by target multi-item service levels. We propose a general framework that integrates prediction and optimization in a data-driven decision-making system. Our solution utilizes an objective-driven approach for prediction algorithms that directly captures the learning loss regarding the decision optimization problem.

2 - A Model Theoretic Approach To Categorization Of Projects

Kemal Gursoy, Associate Professor of Professional Practice, Rutgers Business School, Piscataway, NJ, United States, t

In this work, we consider a model theoretic approach to classify ensembles of influential projects to be activated together.

3 - Economic Policy Research For Problems From Increased Polarization Of Wealth In South Korea

Donghun Yoon, Professor, Kyonggi University, Suwon, Korea, Republic of, nature@kyonggi.ac.kr

South Korea has achieved high economic growth but the polarization of wealth continues to intensify. It is becoming a very serious social problem in South Korea. In this study, we conduct an analysis of economic trends and the polarization of wealth in South Korea. We discuss the economic policy research based on analysis results.

■ VWC46

Virtual Room 46

AI for Cybersecurity

Sponsored: Artificial Intelligence

Sponsored Session

Chair: Tung Cu, Northeastern Illinois University, Northeastern Illinois University, Chicago, IL, 60625-4625, United States

1 - Practical Applications Of AI For Cybersecurity - Case Studies

Bonnie Holub, Vice President, Data Science and Analytics, NTT DATA, Sunfish Lake, MN, 55118-4700, United States,

This presentation will cover several case studies in which AI has been fielded in operational commercial settings to enhance cybersecurity. These cases include: Improving quality control, consistency and quality in online transactions in a financial services company; Automated data mining for improved regression-testing in asset portfolio balance; Operational risk assessment using predictive analytics to prioritize case risk for audits. Each of these cases will include technical discussions of the fielded solutions and results of their operational roll out.

2 - How We Browse: Measurement And Analysis Of Digital Behavior

Yuliia Lut, Columbia University, New York, NY, United States, Michael Wang, Elissa Redmiles, Rachel Cummings

In this work, we design and conduct a user study to collect browsing data ($n=31$) continuously for 14 days and self-reported browsing patterns. We combine self-reports and observational data to provide an up-to-date measurement study of online browsing behavior. We use these data to empirically address the following questions: (1) Do structural patterns of browsing differ across demographic groups and types of web use?, (2) Do people have correct perceptions of their behavior online?, and (3) Do people change their browsing behavior if they are aware of being observed? In response to these questions, we find significant differences in level of activity based on user age, but not based on race or gender. We also find that users have significantly different behavior on Security Concerns websites, which may enable new behavioral methods for detection of security concerns online.

3 - AI Driven Cybersecurity: An Assessment Of Cybersecurity Defense Systems

Tung Cu, Northeastern Illinois University, Chicago, IL, 60625-4625, United States

Cybersecurity is simply classified into four popular categories including Data Security, Information Security, Network Security, and Internet/IoT Security. To solve these cybersecurity problems, people usually use popular AI techniques involving machine learning and deep learning methods, the concept of natural language processing, knowledge representation and reasoning, as well as the concept of knowledge or rule-based expert systems modeling. Based on these AI methods, in this paper, I present a comprehensive assessment on how these AI Cybersecurity methods can play an important role in cybersecurity defense systems. In conclusion, I also highlight several research directions within the scope of our study, which can help researchers do future research in the area.

■ VWC47

Virtual Room 47

Equilibrium and Games in Mathematical Finance

Sponsored: Finance

Sponsored Session

Chair: Moritz Voss, University of California, Los Angeles

1 - Continuous-time Hierarchical Principal-Agent Problems

Emma Hubert, Imperial College London, London, United Kingdom

We study continuous-time optimal contracting in a hierarchy which generalises the model of Sung (2015). The hierarchy is modeled by a series of interlinked principal-agent problems, leading to a sequence of Stackelberg equilibria: the principal can contract with the managers to incentivise them to act in her best interest, and managers in turn subcontracts the agents below them. Both agents and managers each control a stochastic process representing their outcome. We will see through a simple example that even if the agents only control the drift of their outcome, the managers control the volatility of the agents' continuation utility. This justifies the use of recent results on optimal contracting for drift and volatility control, and thus the theory on 2BSDEs. We also discuss some extensions of this model, in particular to a larger-scale principal-agent hierarchy.

2 - Learning About Latent Dynamic Trading Demand

Kasper Larsen, Rutgers University, New Brunswick, NJ, United States,

This paper presents an equilibrium model of dynamic trading and learning by strategic investors with trading targets and price impact. Since trading targets are private, rebalancers and market makers filter the child order flow over time to estimate the latent underlying parent trading demand imbalance and its expected impact on subsequent price pressure dynamics. We prove existence of the equilibrium and solve for trading strategies and prices in terms of the solution to a system of coupled ODEs.

3 - EQUILIBRIUM ASSET PRICING WITH TRANSACTION COSTS: THEORY AND NUMERICS

Xiaofei Shi, Columbia University, New York, NY, United States, xs2427@columbia.edu

In a risk-sharing economy we study how the price dynamics of an asset depends on its “liquidity”. An equilibrium is achieved through a system of coupled forward-backward SDEs, whose solution turns out to be amenable to an asymptotic analysis for the practically relevant regime of large liquidity. We also discuss how to leverage deep-learning techniques to obtain numerical solutions, and compare them with our asymptotic approximations.

4 - Phase Transitions In Kyle's Model With Market Maker Profit Incentives

Eyal Neuman, Imperial College-London, London, United Kingdom

We consider a stochastic game between three types of players: an insider, noise traders and a market maker. We assume that the insider first chooses the size of her market-order and then the market maker determines the price by observing the total order-flow resulting from the insider and the noise traders transactions. In addition to the classical Kyle framework, a revenue term is added to the market maker's performance function, which is proportional to the order flow and to the size of the bid-ask spread. We derive the maximizer for the insider's revenue function and prove sufficient conditions for an equilibrium in the game. Then, we use neural networks methods to verify that this equilibrium holds. We show that the equilibrium state in this model experience interesting phase transitions, as the weight of the revenue term in the market maker's performance function changes.

5 - Trading With The Crowd

Moritz Voss, UC Los Angeles, Los Angeles, CA, United States,

We study a multi-player stochastic differential game between financial agents who seek to liquidate their position in a risky asset in the presence of jointly aggregated transient price impact on the asset's execution price along with taking into account a general price predicting signal. The unique Nash-equilibrium strategies reveal how each agent's policy adjusts the predictive trading signal for the accumulated transient price distortion induced by all other agents' price impact; and thus unfolds a direct link in equilibrium between the trading signal and the agents' trading. We also formulate and solve the limiting mean field game and show how the finite-player Nash equilibrium strategies converge to the mean field game solution.

■ VWC48

Virtual Room 48

Finance - Risk Management

Contributed Session

Chair: Takuji Matsumoto, Central Research Institute of Electric Power Industry, Saitama-Shi, 330-0846, Japan

1 - The Dispersion Bias

Alexander Shkolnik, University of California-Santa Barbara, Santa Barbara, CA, United States,

We identify and correct excess dispersion in the leading eigenvector of a sample covariance matrix, when the number of variables vastly exceeds the number of observations. Our correction is data-driven, and it materially diminishes the substantial impact of estimation error on weights and risk forecasts of minimum variance portfolios. We quantify that impact with a novel metric, the optimization bias, which has a positive lower bound prior to correction and tends to zero almost surely after correction. The sample eigenvalues are used to correct excess dispersion in the leading eigenvector. We illustrate the result with case studies in equity investments.

2 - Effect Of Logistics Performance On Economic Growth: Evidence Based On A Regularized Regression Approach
Youqin Pan, Salem State University, Salem, MA, United States, Jian Gu

This paper examines the impacts of logistics performance on economic growth using regularized regression. The findings show that infrastructure is a key factor that affects all economies while other identified significant variables including international shipment and logistics quality are specifically important to economic growth of countries in Europe and Asia. The results highlight the need for countries to prioritize specific logistics indicators and trade polices to boost their economic growth.

3 - Pricing Electricity Day-Ahead Cap Futures Using Multifactor GAMLSS Density Forecasts
Takuji Matsumoto, Central Research Institute of Electric Power Industry, Tokyo, Japan, Derek W Bunn, Yuji Yamada

Motivated by the increasing need for retailers to hedge the volatility of the day-ahead electricity price, this study analyses a flexible hedging product, day-ahead cap futures. For pricing, we forecast the density of day-ahead prices using the parametric multifactor skew-t density, estimated with the Generalized Additive Model for Location, Scale and Shape (GAMLSS). Weather forecasts and calendar information are used as explanatory variables. We find that this higher-order moment model is superior to several lower-order models such as the normal distribution in terms of fairness in pricing, underwriting risk of the risk taker, as well as reducing the variance risk for the hedger.

■ VWC49

Virtual Room 49

Health Care, Public Health I

Contributed Session

Chair: Emine Yaylali, Istanbul Technical University, Decatur, GA, 30033-3822, United States

1 - Impact Of Digital Health Interventions On The Quality Of Care For Children With An Autism Spectrum Disorder
Hannah Mulroe, University of Southern California, Los Angeles, CA, United States

Due to the COVID-19 pandemic, there has been a sharp increase in the number of virtual visits. As this becomes the new normal for non-emergent behavioral healthcare appointments, there currently lacks defined strategies to monitor the quality of these visits. This study focuses on virtual visits for pediatric patients with an Autism Spectrum Disorder (ASD). The study identifies variables present in a virtual visit as they relate to the six areas of quality of care. Borrowing from research in Environmental, Health, & Safety management systems, the study identifies a set of leading indicators to evaluate the impact the transition to virtual visits has had on the quality of care for pediatric ASD patients.

2 - Deadline Effect In Door-to-needle Time Of Ischemic Stroke Patients
Brandon Lee, Assistant Professor, University of Dayton, Dayton, OH, United States, Seokjun Youn, Lawrence Fredendall

TPA (Tissue Plasminogen Activator) for stroke patients should be administered within 4.5 hours of symptom onset. The clinicians' time for the administration of TPA depends on how much time is remaining before the 4.5 hours are fully spent (i.e., deadline effect). We examine the circumstances that mitigate such deadline effect.

3 - Optimal Resource Allocation In Hiv Self-testing Secondary Distribution Among Chinese Msm: Data-driven Integer Programming Models
Fengshi Jing, Guangdong Second Provincial General Hospital, Guangzhou, China,

In this study, we considered a resource constrained situation for testing kits in HIV self-testing (HIVST) secondary distribution and two data-driven integer linear programming models were proposed to maximize the overall economic benefits of HIVST secondary distribution based on our real implementation data from Chinese MSM. The objective function took expansion of normal alters and detection of positive & newly testing alters into account. Greedy algorithms were developed to find the optimal solutions of our linear programming models. Results show that our proposed data-driven approach could improve the total health economic benefits of HIVST secondary distribution.

4 - Health Disparities and COVID-19
Fiona Shafer, Rutgers University, New Brunswick, NJ, United States, Christie Nelson, Karen Bemis

As the COVID-19 pandemic progresses across the nation and the world, data suggests the virus disproportionately impacts marginalized communities (KKF, 2020). Specifically, disparities exist in infection rates and disease outcomes by race and ethnicity in the United States. However, it is unknown to what degree these differences have impacted specific communities across the country. During this research project, I researched various avenues related to COVID-19 including but not limited to long term care facilities and education systems.

5 - Injuries In Israeli Schools: An Advanced Retrospective Nationwide Six-year Analysis For Policymakers
Michael Khalemsky, Head of Management Information Studies, Hadassah Academic College, Jerusalem, Israel, Eli Jaffe, Anna Khalemsky

Child injury is a global public health problem. A nationwide dataset of 36,002 school injury events in Israel between 2013 and 2019 was analyzed. Exploratory research based on cluster analysis combined with advanced statistical tools revealed injury patterns. Games were identified as the prevailing cause of school injuries in Israel. Gender and age differences, and seasonal and circadian trends were observed. Comparison to international data is provided. Understanding the patterns and the trends of school injuries can enable the development of effective prevention policies on the national, municipal, and local levels, focusing the efforts on the key factors affecting injury incidence.

6 - Mathematical Models For Estimating Hiv Incidence In Turkey
Emine Yaylali, Assistant Professor, Istanbul Technical University, Istanbul, Turkey, Zikriye M. Erdogan

The number of HIV patients has been decreasing in the world, however HIV incidence has been significantly increasing in Turkey in the last decade. We developed mathematical models to analyze the spread of HIV in Turkey. First, we utilized a Bernoulli model and estimated annual incidence for high risk groups. Then, we developed a dynamic compartmental model of HIV transmission and progression in Turkey to estimate HIV incidence from 2019 to 2030 and to determine continuum of care levels which represent diagnosed and treated persons. Our results suggested that both incidence and HIV-related deaths could continue to rise in the next decade, placing a significant burden on the Turkish healthcare system.

■ VWC50

Virtual Room 50

Simulation I

Contributed Session

Chair: Michail Katsigiannis,

1 - Wafer Lot Scheduling In A Real-world Semiconductor Photolithography Bay
Patrick Deenen, University of Technology-Eindhoven, Eindhoven, Netherlands

A semiconductor wafer fabrication facility (fab) consist of many different bays, one of these is the photolithography bay. Since this bay often forms the bottleneck of the fab, scheduling lots in this area is of key for the overall fab's performance. A real-world case study at Nexperia is presented, to demonstrate the benefit of scheduling opposed to current dispatching operations. A simulation model which accurately represents represents the real fab. This model is used to analyze different production control techniques and access their performance (1) the throughput of the photolithography bay, (2) the realization of the operational due-date of jobs and (3) the WIP balance of the downstream bays.

2 - Consumer Rental Intentions For Electric Vehicles: Are Green Consumers Quality-conscious Or Price-conscious?
Adeela Gulzari, University of North Texas, Denton, TX, United States, Yuchen Wang, Victor R. Prybutok

Research has demonstrated that green consumers who have a positive attitude towards environmental protection are inclined to purchase an eco-friendly car such as an Electric Vehicle (EV). However, individuals who are interested in using an EV without purchase intention can also be concerned about the environment. Renting a car is a low-involvement decision and explores a different dimension of a consumer's thought process. In this research, we study consumer rental intentions for EVs and evaluate whether price or quality-related constructs significantly affect rental intentions using a covariance-based structural equation model.

3 - Evaluating The Effect Of Flood Insurance Subsidies With An Agent-based Model
Valerie Washington, University of Michigan, Ann Arbor, MI, United States, Seth Guikema, Joi-Lynn Mondisa, Gina Tonn

The National Flood Insurance Program's plans to move to risk-based rates may increase the financial burden of purchasing flood insurance for some households. In this study, we use an agent-based model to evaluate the effect that income-based flood insurance subsidies have on communities in high-risk flood areas and the flood mitigation strategies employed. We apply this model to the city of Fargo, ND. We compare the effects of insurance subsidies on mitigation decisions, damages incurred, move out rates, and the number of active flood insurance policies held. These results may help us to evaluate the value of flood insurance and insurance subsidies for communities.

4 - Improving Neonatal Transportation Process Through Multi-Method Simulation

Tiffany Yam, University of Washington, Seattle, WA, United States, tiffanyc.yam@gmail.com, William Zhao, Christopher Lo, Ye-Eun Kim, Rachel Umoren, Prashanth Rajivan

Transporting critically ill newborns from one hospital to another with a higher level of care has to be quick and safe. However, this transportation process is complex, risky, resource-constrained, and involves coordination among stakeholders in different hospitals. Using a multi-method simulation approach, we modeled the coordination and transportation process in a regional hospital network in Northwest America. The model was developed by analyzing the current workflow processes and using historical transportation records. The model will be used to redesign the current process with a focus on efficiency and safety, which may be used by similar facilities regionally and globally.

5 - A Hybrid Simulation Study For Assessing Lean Manufacturing Techniques In A Lego Car Manufacturing Facility

Michail Katsigiannis, Auburn University, Auburn, AL, United States, Minas Pantelidakis, Konstantinos Mykoniatis

Modeling and Simulation is primarily used as a decision support tool to analyze, understand, and assess the behavior of complex systems. This work investigates a hybrid simulation approach to model a Lego car automotive assembly line. We developed a hybrid discrete-event and agent-based simulation model of the production line to analyze the system's performance. The simulation experiments involved two scenarios (i.e., Mass Production and Just-in-time with Heijunka) to assess their impact on production line performance metrics. The Just-in-time and Heijunka techniques significantly improved the overall system's performance in terms of throughput and reduced total time in the system.

■ VWC51

Virtual Room 51

Economic Modeling I

Contributed Session

Chair: Gabriel Bahr, Stillwater, 74074, United States

1 - Analysis Of Platformer Economy With Network Externalities - Theoretical Pathway To Sharing Economy

Katsuya Hihara, Tokyo Metropolitan University / University of Tokyo, Tokyo, Japan,

Thanks partly to the network externalities, platformers attract vast amount of users with huge profit, hence causing a number of public policy debates. Despite platformers' high profile, we found very limited number of rigorous researches specifying exact content of externalities and other market elements involving platformers. We use simple Cobb-Douglas type externality model and derive the exact conditions for optima with concrete results about the impact of platformer's capacity or profit level on social welfare. Also, analytical results show concrete linkages to sharing economies, involving Airbnb or Uber, from our platformer externality modelling.

2 - The Causal Impact Of Market Competition On Product Variety: A Deep Neural Network Representation Learning Approach

Ying-Chin Chen, University of Washington-Seattle, Seattle, WA, United States, Qifan Huang, Chen Zhuang

We study the causal effect of dynamic competition on product variety in a live streaming platform, where anchors can sell products to the audience. Our data has about 2 million products. We use a mean-max attention autoencoder neural network to get the embedding of the anchor's daily sales record. Competition index is defined as the summation of inner products of embedding vectors. The attention mechanism allows us to capture (1) implicit substitution or complementary relationship across product categories (2) time dependency of daily sales. We leverage a natural experiment to identify treatment effect: some top anchors with strong market power quit the platform by accident

3 - Establishing Material Recovery Facility: Quantitative Cost-Benefit Analysis

Joon-Yeoul Oh, Texas A&M University-Kingsville, Kingsville, TX, United States, Isaac Teye Nuetey

Recycling retrieves wastes into usable materials and catalyzes economic security by reusing depleted resources and creating jobs. Most small-sized cities have no recycling process facility, hence there is no recycling collection program. This research aims to perform economic analysis for setting up a material recovery facility for small-sized cities. This research, first, estimates the costs associated with building and operating the facility. This research also estimates the generated benefits such as hiring employees, generating products, etc. The results show that building a new recycling facility will add an economic value of more than $300,000 a year with a recovery rate of 30%.

4 - Optimal Price Subsidy For Plant-based Meat Toward A Differential Game Model

Jie Qu, University of Wisconsin-Milwaukee, Milwaukee, WI, United States

Dealing with environment and food crisis, popularize the fake meat is a possible solution. However, the high production cost made fake meat lack of competitiveness. High cost will be overcome by technology advancement and economics of scale if it, in early market, received subsidy and help from government to become economically competitive. This paper deals with the determination of optimal pricing policy for the firm and optimal subsidy for the government in the monopoly and oligopoly market using differential game.

5 - HIT Spillovers And Sustained Cooperation

Ankita Srivastava, Oklahoma State University, Tulsa, OK, United States, Chenzhang Bao, Dursun Delen

Based on the proposed referral network model we study IT spillover effects from ambulatory facilities to hospitals. Using a panel of 13 years with 2,768 US hospitals matched with approximately 30,000 ambulatory facilities, we find a 1% increase in the average EMR adoption of the regional ambulatory clinics can reduce the inpatient cost of the focal hospital by 0.031% (savings of $51,000) in one year and by 0.059% (savings of $98,000) in four years. Our model is robust to endogeneity issues. We also find support for mechanisms where spillover effects are expected to be stronger. The referral network model and empirical evidence can propagate a culture of sustained cooperation among healthcare providers.

6 - Digital Borders, Spatial Trade Spillovers, And Development

Gabriel Bahr, Oklahoma State University, Stillwater, OK, United States, Bryan Hammer, Andy Luse

The purpose of this paper is to expand ICT4D literature by investigating the associations between international trade of technology merchandise and development across countries. Using a spatial autoregression model and data on 45 upper-middle and high income countries from 2009 to 2018, we examine the effects of imports and exports of technology driven trade on two measures of development (GDP and HDI). Additionally, we define spatial borders through a trade partner network and discover spillover effects of trade-development on neighboring countries.

■ VWC52

Virtual Room 52

Novel Behavioral Models in Social Networks

Sponsored: Social Media Analytics

Sponsored Session

Chair: Tauhid Zaman, Yale University, New Haven, CT, United States

1 - The Categorical Imperative in Networked Collective Intelligence

Douglas Guilbeault, University of California-Berkeley, Berkeley, CA, United States

In this talk, I argue that collective intelligence dynamics differ qualitatively based on whether people exchange numeric or categorical information. I discuss two studies which show that the social exchange of binary judgments can amplify the spread of inaccurate views, whereas the social exchange of numeric judgments, in identical task environments, can reliably improve belief accuracy. I conclude by discussing a third study which shows that the social exchange of category systems can promote coherence and consensus in novel task environments that preclude the exchange of numeric judgments. Implications for organizational decision making and cultural evolution are considered.

2 - Social Media Sentiment And Cryptocurrencies

Khizar Qureshi, MIT, Cambridge, MA United States

We conduct a study of social media activity surrounding cryptocurrencies. We collect tweets from Twitter for multiple cryptocurrencies. We also construct measures to quantify the sentiment of the tweets using transformer neural networks. We model social media interactions surrounding tweets of the coin and then fit a Poisson Regression to this data and use the estimated model parameters to construct features that quantify the virality of the coin and its long-term potential for growth. Finally, we attempt to predict which coins have massive future price movements using these virality features.

3 - Online Communication Shifts In The Midst Of The Covid-19 Pandemic: A Case Study On Snapchat

Qi Yang, Massachusetts Institute of Technology, Cambridge, MA, 02139-4204, United States

We study research questions around the impact of Covid-19 on online public and private sharing propensity, its influence on online communication homophily, and correlations between online communication and offline case severity in the United States. To do so, we study the usage patterns of 79 million US-based users on Snapchat. Our findings suggest that Covid-19 has increased propensity to privately communicate with friends, while decreasing propensity to publicly share content when users are out-and-about. Moreover, online communications have observed a marked decrease in baseline homophily across locations, ages and genders. Finally, we observe that increased offline positive Covid-19 case severity is associated with widening gaps between across-state and within-state communication increases after the onset of Covid-19.

4 - The Impact of Bots in the (First) Impeachment of Donald Trump

Michael J Rossetti, Adjunct Professor, Georgetown University, Washington, DC, United States,
Michael J Rossetti, Adjunct Professor, New York University, New York, NY, United States, Tauhid Zaman

We study manipulation of the social media discussion surrounding the first impeachment of U.S. President Donald Trump by automated accounts, known as bots. Our dataset includes 50 million posts from 2.7 million Twitter users, covering a 60 day period from impeachment to acquittal. We identify 24,000 bots using an algorithm based on the Ising model from statistical physics. Analysis shows the bots are 100 times more active than normal users, and their follower network structure is polarized along political lines. Language analysis shows pro-Trump bots using terms related to the Qanon conspiracy theory. After quantifying bot impact using a network centrality measure we developed known as generalized harmonic influence centrality, we find that although pro-Trump bots are more numerous and active than anti-Trump bots, the anti-Trump bots have a larger daily impact.

5 - Understanding and Reducing the Spread of Misinformation Online

Mohsen Mosleh, University of Exeter Business School, New York, NJ, 07093, United States

Why do people share misinformation, and how can social media platforms reduce the sharing of misinformation? Here, we address these questions. First, we find that the veracity of headlines has little effect on sharing intentions, despite having a large effect on judgments of accuracy. This dissociation suggests that sharing does not necessarily indicate belief. However, most participants say it is important to share only accurate news. To shed light on this apparent contradiction, we carried out four survey experiments and a field experiment on Twitter; the results show that subtly shifting attention to accuracy increases the quality of news that people subsequently share. This indicates that people often share fake news because their attention is focused on factors other than accuracy—and therefore they fail to implement a strongly held preference for accurate sharing.

■ VWC53

Virtual Room 53

Auctions/Mechanism Design II

Contributed Session

Chair: Manxi Wu, University of California, Berkeley, Medford, MA, 02155, United States

1 - Optimal Bundling For Truthful Auctions

Adithya Patil, Indian School of Business-Hyderabad, Hyderabad, India, Milind Sohoni

We study the problem of computing the revenue-maximizing item-bundling in a VCG auction setting where bundle values are additive with negative item value externalities. We propose a class of truthful auctions called the Pairwise Bundler Auction (PBA), whose parameters can be manipulated to obtain item bundlings in item allocation. We show that the problem of computing the optimal bundling is identical to the problem of optimizing the PBA parameters, which can be done using a linear program. We also describe an algorithm that involves solving a sequence of LPs optimize the PBA parameters. The duals of each of these LPs quantify the marginal gain of having a given pair of items in the same bundle.

2 - Scarcity And Waste In Allocation Mechanisms

Junxiong Yin, University of Southern California, Los Angeles, CA, United States, Peng Shi

Variants of wait-lists are used to allocate scarce resources such as cadaver kidneys. However, around 20% of successfully procured cadaver kidneys are discarded. In this paper, we study the wastage problem from a theoretical perspective with a focus on the wait-list with choice, which is an approximation to the current mechanism for cadaver kidney allocation. We find that 1) it is not always possible to Pareto improve upon the wait-list with choice even when there is waste; and 2) it is impossible to Pareto improve upon the wait-list with choice using a mistake-tolerant mechanism. The findings suggest that reducing waste requires hard discussions among stakeholders.

3 - Efficient Carpooling And Toll Pricing For Autonomous Transportation

Manxi Wu, Massachusetts Institute of Technology, Cambridge, MA, United States, Saurabh Amin, Patrick Jaillet

How can autonomous transportation technology be utilized to reduce road congestion? We analyze a carpooling market, where a transportation authority sets tolls on road segments, and riders are incentivized to organize autonomous carpooled trips and split toll prices. We characterize sufficient conditions on the network topology and riders' heterogeneous utilities, under which the market equilibrium implements a socially optimal trip assignment. We also propose an algorithm for computing the market equilibrium. These results enable efficient implementation of market-based autonomous carpooling services.

■ VWC54

Virtual Room 54

Simulation Applications for Public Policy

Sponsored: Public Sector OR

Sponsored Session

Chair: Adam Schmidt, UW-Madison, Madison, WI, 53049-1408, United States

Co-Chair: Veronica White, University of Wisconsin Madison, University of Wisconsin Madison, Madison, WI, 53711, United States

1 - Discrete Event Simulation For Modeling Addiction Treatment Public Policy Changes In Dane County, WI

Veronica M. White, University of Wisconsin-Madison, Madison, WI, United States, Laura Albert

We create a discrete event simulation to model the cycle of opioid use disorder for individuals in Dane County, WI. We utilize multiple public data sources as inputs to our model. Observed outputs are number of overdoses, overdose deaths, opioid-related arrests, and starting treatment instances. We also test the effects of several policy level changes such as introducing an opioid-related arrest diversion program and strengthening the path to treatment following an overdose.

2 - Designing Pandemic-resilient Voting Systems

Adam Schmidt, UW-Madison, Madison, WI, United States, Laura A. Albert

The 2020 general election occurred while many parts of the nation were under emergency orders related to the COVID-19 pandemic, placing new requirements and considerations on voting systems. Using a discrete event simulation case study of Milwaukee, WI, we quantify the extent to which pandemic-related disruptions, such as health precautions and social distancing, disrupt normal operations. We then quantify the impact of early voting, queueing policy, the number of check-in booths, the number of ballot scanners, and the number of polling location on traditional voting metrics under the new operating conditions.

3 - A Customizable Agent-based Simulation Tool For Analyzing Infectious Disease Control Strategies In Metropolitan Areas

Ashkan Negahban, The Pennsylvania State University, Malvern, PA, United States

Non-pharmaceutical interventions such as social distancing, school/business closures, random testing and quarantines are crucial in controlling the spread of an infectious disease. We propose a customizable agent-based simulation and decision support tool that allows for any city to create a fine-grained simulation of the corresponding real-world population and their interactions to enable analysis of various control strategies. We illustrate the applicability and efficacy of the proposed tool for the case of Covid-19 outbreak in New York City.

4 - Simulating Covid-19 Risks Associated With Returning To In-person College Classes

Tessa Swanson, Industrial and Operations Engineering, Ann Arbor, MI, United States, Seth Guikema

As universities prepare for a school year following disruption from the COVID-19 pandemic, risk analysis can support decision-making for resuming in-person instruction. A simulation-based risk analysis approach enables scenario evaluation and comparison to guide decision making under uncertainty. We develop a simulation model to evaluate various scenarios involving in-person classes for the University of Michigan's College of Engineering. We estimate risks of infection, hospitalizations, and deaths, incorporating uncertainties in disease transmission as well as impacts of policies, such as masking and facility interventions, and population-level disease prevalence and immunity.

■ VWC55

Virtual Room 55

Disaster and Disruption Management II

Contributed Session

Chair: Maggie Chuoyan Dong,

1 - Multi-objective Community Resilience Optimization With CGE Modeling For Memphis Metropolitan Statistical Area

Rafia Bushra, University of Oklahoma, Norman, OK, United States

Natural hazards have the potential to cause billions of dollars of damage, create major disruptions in key elements of communities worldwide, and drive complex outcomes such as population dislocation, unemployment rates, threats to household income, etc. In this presentation, we consider the Memphis Metropolitan Statistical Area lying within the New Madrid seismic zone. We implement a community resilience multi-objective optimization model that leverages a reversed engineered computable general equilibrium model derived information to capture system-wide impacts to enhance decision-making.

2 - Disaster Relief Distribution Location-allocation With Discrete-time Planning Periods And Beneficiaries' Choice

Sofia Perez-Guzman, Rensselaer Polytechnic Institute, Troy, NY, United States

Previous research on disaster relief distribution in post-disaster environments has assumed that demand at Points of Distribution (PODs) can be assigned purely based on distance. This research focuses on optimal location-allocation decisions under a discrete multi-period planning horizon, incorporating the beneficiaries' choices of PODs. Such choice depends on POD's attractiveness, based on metrics such as POD's capacity, inventory level, travel time, and crowdedness. Furthermore, the problem's objective is to minimize social costs, i.e., logistic and deprivation costs.

3 - Escaped Wildfire Response Planning

Brittany Segundo, Texas A&M University, College Station, TX, United States, Lewis Ntaimo

In this work we allocate resources to an escaped wildfire that is 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. Our results will demonstrate the impact of dynamic resource allocation, endogenous and exogenous uncertainty, and a rolling horizon framework on the containment of an extreme wildfire.

4 - Rapid Product And Production Adaptation In A Social Emergency: Does It Pay Off?

Wei Sun, City University of Hong Kong, Hong Kong, Hong Kong, Maggie Chuoyan Dong, Bin Yang, Jack Cadeaux

This study focused on an emerging phenomenon amid the COVID pandemic—COVID-relieving product adaptation (CRPA), where manufacturers adapted production facilities to produce medical supplies that were essential for addressing the crisis and in short supply. We use an event study to examine whether CRPA actually improved manufacturers' financial performance. The results revealed that under severe pandemic circumstances, CRPA significantly boosted stock returns, and this effect was stronger for firms with low political connectedness, low media coverage, and high operational uniqueness. An experiment offers further insights into the underlying mechanisms through which CRPA helps or hurts.

■ VWC56

Virtual Room 56

Retail Management II

Contributed Session

Chair: Mert Cetin, Barcelona

1 - The Impact Of Online Product Reviews On Retailer's Pricing And Return Policy Decisions

Mehmet Sekip Altug, Associate Professor, George Mason University, University Dr, VA, United States

Customers feel increasingly more comfortable with posting and using on-line product reviews. In a two-period setting, we explore the impact of product reviews on customer's valuation uncertainty for an experience-type product and how that in turn affects a monopolist retailer's pricing and refund decisions. Surprisingly, we find that the retailer makes its return policy even more lenient. In a duopolistic competition, the overall sentiment of the on-line reviews are influenced by the refund and pricing decisions of both retailers. Interestingly, we show that the retailers make their returns more lenient compared to the monopolist case when they collectively determine the review sentiment

2 - Store Network Design For Omnichannel Retailing

Mert Cetin, IESE Business School, Barcelona, Spain, Victor Martinez de Albeniz, Laura Wagner

Using customer level data, we seek to explore the effect of store network on sales for omnichannel retailers. We geolocate customers and consider the stores within close proximity, including covariates of point of sales, assortment, service level, and characteristics of the closest store. We model purchase propensity, basket size and average price per product through channels online, storeNear-buying from a store nearby, and storeFar-a further away one. We draw conclusions for each channel and present a counterfactual analysis to demonstrate how store network effects the revenue.

■ VWC57

Virtual Room 57

New Business Models

Sponsored: Technology, Innovation Management and Entrepreneurship

Sponsored Session

Chair: Soudipta Chakraborty, University of Kansas, Lawrence, KS, 27708-9972, United States

1 - Delegating Production And Customization To Retail Stores: Influence Of Channel Structure And Buzz Effect On In-store 3d Printing

Nagarajan Sethuraman, Assistant Professor, University of Kansas, Lawrence, KS, United States, Ali Kemal Parlakturk, Jayashankar M. Swaminathan

We study the trade-offs involved in decentralized customization enabled by 3D printing at retail stores. We develop an analytical model that considers in-store 3D printing as a component of the firm's broader product line strategy. Managerial insights from our model can guide the adoption of 3D printing at retail stores.

2 - Contingent Stimulus In Crowdfunding

Jiahua Wu, Imperial College Business School, Office London, E17 8PG, United Kingdom,Longyuan Du, Ming Hu

Reward-based crowdfunding is a form of innovative financing that allows project creators to raise funds from potential backers to start their ventures. A crowdfunding project is successfully funded if and only if the predetermined funding goal is achieved within a given time. We characterize the dynamics of the project's pledging process, and show that there exists a cascade effect on backers' pledging, which is mainly driven by the all-or-nothing nature of crowdfunding projects. According to our data collected from the most popular online crowdfunding platform, Kickstarter, the majority of projects fail to achieve their goals. To address this issue, we propose three contingent stimulus policies, namely, seeding, feature upgrade, and limited-time offer.

3 - Is Kindness The Magical Spell? The Role Of Information And Reciprocity In Revenue-sharing Crowdfunding

Behrooz Pourghannad, University of Minnesota, Rochester, MN, 55901-4841, United States, Guangwen (Crystal) Kong, Laurens G. Debo

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. We investigate the effects of information asymmetry and reciprocity on various outcomes.

4 - Designing Rewards-based Crowdfunding Campaigns For Strategic (but Distracted) Contributors

Soudipta Chakraborty, University of Kansas, Lawrence, KS, 66045, United States, Robert Swinney, Anyi Ma

We study a model of rewards-based crowdfunding with the all or nothing funding mechanism. The creator of a campaign solicits pledges from contributors, and if total pledges exceed a pre-determined threshold, the campaign is successful, the creator receives all pledges and each contributor receives a non-monetary reward. Otherwise, the campaign fails and contributors are refunded their pledges. We determine how a creator should design her campaign when the uncertainty of receiving the reward makes contributors strategically decide whether and when to pledge.

■ VWC58

Virtual Room 58

Transportation-Planning I

Contributed Session

Chair: Navjyoth Sarma,

1 - A Novel Method In Assigning New York City Taxicabs Using Machine Learning And Optimization Algorithms

Zeinab Vosooghi, McMaster University, Hamilton, ON, Canada

With the increase in urban commuting, the efficient assignment of taxis to the demand areas becomes challenging. To tackle this problem, a machine learning based optimization framework for taxi assignment is proposed in this paper. Main contributions of this framework are location-based clustering of the trips, their fare amount prediction, drivers' revenue as well as passengers' demand coverage maximization, and service level equity. To demonstrate the effectiveness of the model, the experiments are conducted using NYC-Taxi dataset, which outperform the baseline state-of-the-art studies.

2 - An Efficient Algorithm For Continuous Bi-criteria Traffic Assignment

Qianni Wang, School of Transportation and Logistics, Southwest Jiaotong University, Chengdu, China, Jun Xie, Yu (Marco) Nie

This paper proposes a formulation and an efficient algorithm for the continuous bi-criteria traffic assignment problem. The formulation employs the value-of-time (VOT) boundaries as the main solution variables and replaces the conventional flow conservation conditions with simple box constraints. Thanks to these characteristics of the formulation, an efficient path-based algorithm that can simultaneously adjust path flows and VOT boundaries in the equilibration procedure is proposed. Numerical experiments indicate that the proposed algorithm converges much better and faster than the known alternative.

3 - Detecting Accident Prone Zones For Bicycles Using Machine Learning

Isil Koyuncu, Assistant Professor of Management Science, The University of Texas at San Antonio, San Antonio, TX, United States, Meserret Karaca

Using real-life bicycle accident data from various cities in the United States and image recognition techniques over the Google Maps street images we aim to shed a light on accident-prone zones and recommend possible improvements to make roads safer for two-wheelers.

4 - Planning For Alternative Fuel Vehicles Evacuation Using Spanning Trees

Denissa Sari Darmawi Purba, Graduate Student, University of Illinois at Urbana-Champaign, Champaign, IL, United States, dpurba2@illinois.edu, Eleftheria Kontou, Chrysafis Vogiatzis

For alternative fuel vehicle types, the evacuation route of conventional vehicles could be infeasible due to limited driving range and sparse refueling infrastructure. Thus, emerging vehicle technology travelers are more vulnerable during hazardous events. In this study, we formulate an evacuation routing problem using k-minimum spanning trees (every tree is rooted to the shelter) with hop constraints to model the refueling needs of each k vehicle fuel type on their way to reach a shelter. We develop a column generation method to solve the problem exactly and seek a minimum spanning tree that minimizes the evacuation time and satisfies the hop constraints.

5 - A Column Generation Approach With Cutting Planes For Location-allocation Of Respondent Vehicles Under Incident Severity Levels

Asya Atik, North Carolina State University, Raleigh, NC, United States, Leila Hajibabai

This study investigates optimal incident response planning in terms of the location of respondents and the availability considering the frequency and severity of incidents. A mixed-integer linear model is formulated to maximize the total expected demand covered and minimize the total travel time. A column-generation technique with cutting planes is proposed to solve the problem. A benchmark approach is proposed that integrates the Benders decomposition with a demand clustering technique. The algorithms are assessed using real-world incident data in Raleigh, North Carolina. The preliminary results suggest that the proposed algorithm solves the problem efficiently.

6 - Quantifying Shareability Potential In A Transportation Network: Introducing The Maximum Network Flow Overlap Problem

Navjyoth Sarma, University of California, Irvine, Irvine, CA, United States, Michael Hyland

The structure of transport networks and spatial distribution of demand vary across and within cities, affecting the viability of shared mobility modes ranging from fixed-route transit to on-demand ride-pooling. To inform the viability of shared mobility modes, this study proposes a modeling framework to quantify shareability potential within a city. The study introduces the 'flow overlap' metric to measure the number of trips sharing a path between an O-D pair. This concept is used to formulate the Maximum Network Flow Overlap Problem to assign person flows to paths that maximize shareability. The model output provides unique insights to support design of multi-modal shared mobility systems.

■ VWC60

Virtual Room 60

Game Theory I

Contributed Session

Chair: Thuy Bui, Newark, 07105, United States

1 - On the PTAS for Maximin Shares in an Indivisible Mixed Manna

Rucha Kulkarni, University of Illinois at Urbana-Champaign, Urbana, IL, United States, Ruta Mehta, Setareh Taki

We study fair allocation of indivisible items, both goods and chores, under the popular fairness notion of maximin share (MMS). The problem is well-studied when there are only goods (or chores), where a PTAS to compute the MMS values of agents is well-known. In contrast, for the mixed manna, a recent result showed that finding even an approximate MMS value of an agent up to any approximation factor in (0,1] is NP-Hard for general instances. In this paper, we complement the hardness result by obtaining a PTAS to compute the MMS value, when its absolute value is at least 1/p times either the total value of all the goods or total cost of all the chores, for some constant p valued at least 1.

2 - Social Welfare Maximization And Conformism Via Information Design In Linear-quadratic-gaussian Games

Furkan Sezer, PhD Student, Texas A&M University- College Station, College Station, TX, United States, Hossein Khazaei, Ceyhun Eksin

We consider linear-quadratic-gaussian (LQG) games in which players have quadratic payoffs that depend on the players' actions and an unknown payoff-relevant state, and signals on the state that follow a Gaussian distribution conditional on the state realization. An information designer decides the fidelity of information revealed to the players in order to maximize the social welfare of the players or reduce the disagreement among players' actions. Leveraging the semi-definiteness of the information design problem, we derive analytical solutions for these objectives under specific LQG games.

3 - Illegal Fishing In Congested Maritime Environments

Michael M. Perry, George Mason University Volgenau School of Information Technology and Engineering, Fairfax, VA, United States

A maritime environment is modeled where two countries in close proximity must delineate fishing rights. Countries issue fishing quotas and its shown one can benefit significantly from issuing excessive quotas, inducing illegal fishing in the other's legal waters. The costs imposed by patrol craft serve as a way of deterring this behavior, but patrols can be offset by employing martial assets onboard fishing vessels, a phenomenon of increasing regularity. The cost-effectiveness of each of these measures is assessed. The paper concludes that even if the countries can agree to cooperative combat illegal fishing, the potentiality of illegal fishing will significantly alter the terms of such a deal.

4 - A Proof Of The Optimality Of The E-patrolling Strategy For The Continuous Patrolling Game

Thuy Bui, Rutgers Business School, Newark, NJ, United States, Thomas Lidbetter

We consider the continuous patrolling game introduced in Alpern et al. (2016). This is a zero-sum game between an Attacker, who attacks a network at a particular time and place, and a Patroller, who patrols the network with the aim of intercepting the attack. Recently, Alpern et al. (2020) conjectured that a patrolling strategy called the E-patrolling strategy is optimal for all tree networks, and they proved this to be true in some special cases. In this paper, we settle the conjecture by providing -optimal strategies for the Attacker. We also give precisely optimal Attacker strategies for some previously unsolved star networks.

■ VWC63

Virtual Room 63

Optimization in Julia

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Joaquim Masset Lacombe Dias Garcia, PSR Inc, PSR Inc, Rio de Janeiro, 22250-040, Brazil

Co-Chair: Juan Pablo Vielma, Google, Cambridge, MA, 02142-1508, United States

1 - Conic Formulation Choice In Interior Point And Outer Approximation Algorithms

Chris Coey, Massachusetts Institute of Technology, Cambridge, MA, United States, Juan Pablo Vielma

Any (mixed-integer) convex problem can be reformulated as a (mixed-integer) conic problem. We introduce a variety of proper cones, which we use to write simple, natural formulations for many applied examples. We generate a diverse set of continuous and mixed-integer benchmark instances. We solve these instances using our new generic implementations of interior point and outer approximation algorithms. Our results may be helpful for practitioners deciding how to formulate conic models.

2 - Recent Advancements In Hypatia

Lea Kapelevich, Massachusetts Institute of Technology, 238 Prospect St Apt 2, Cambridge, MA, 02139-1784, United States, lkap@mit.edu, Chris D. Coey, Juan Pablo Vielma

We will discuss recent advancements in our interior point solver, Hypatia. In particular, we will look at some new cones, their barrier functions, and oracles.We will show that many advanced oracles that make our interior point algorithm more efficient are available in analytic form, which reduces the gap in the efficiency of oracles between standard and exotic cones.

3 - Exploiting Sparsity In Semidefinite Programming With Chordal.jl

Theo Diamandis, Massachusetts Institute of Technology, Cambridge, MA, United States

We introduce Chordal.jl, a package for decomposing sparse matrices that have a chordal sparsity pattern. We survey the algorithms in this package and showcase their use in large-scale semidefinite programming. As an example, we apply these techniques to the maximum variance unfolding dimensionality reduction technique. We demonstrate a speedup of several orders of magnitude.

4 - A Method For Large Scale Sum Of Squares Optimization

Chenyang Yuan, Massachusetts Institute of Technology, Cambridge, MA, United States, Benoît Legat, Pablo A. Parrilo

Determining if a polynomial is a sum of squares involves solving a large semidefinite program, which quickly runs into scalability issues. We propose applying the Burer-Monteiro method to a sampled version of the problem, where equality constraints are enforced by evaluating the polynomial at random points. This method is easily parallelizable and scalable, and the problem can be solved using stochastic gradient descent.

5 - Symmetry Reduction in Semidefinite Optimization

Marek Kaluba, Karlsruher Institute of Technology, Karlsruhe, Germany, Benoit Legat

Semidefinite programming arises naturally as exact or approximate formulation in many practical applications.The limiting factor is usually the size of semidefinite constraints due to algorithmical complexity and the numerical conditioning.In this talk we discuss how group symmetry can be used to simplify semidefinite problems, notably these originating from Sum-of-Squares programs.Such symmetry allows to search for an invariant solution and block-diagonalize semidefinite constraints, which considerably decreases the complexity of the problem.We will showcase SymbolicWedderburn.jl package and its integration with the SumOfSquares extension of JuMP.

■ VWC64

Virtual Room 64

Federated learning and Multi-task Learning-II

Sponsored: Opt/Machine Learning

Sponsored Session

Chair: Kaizheng Wang, Columbia University, Washington, United States

1 - Presenter

Honglin Yuan, Stanford University, Stanford, CA, 94305-7161, United States

Federated Learning is a distributed learning paradigm that scales on-device learning collaboratively and privately. Standard FL algorithms such as FedAvg are primarily geared towards smooth unconstrained settings. In this paper, we study the Federated Composite Optimization (FCO) problem, in which the loss function contains a non-smooth regularizer. Such problems arise naturally in FL applications that involve sparsity, low-rank, monotonicity, or more general constraints. We first show that straightforward extensions of primal algorithms such as FedAvg are not well-suited for FCO since they suffer from the "curse of primal averaging," resulting in poor convergence. As a solution, we propose a new primal-dual algorithm, Federated Dual Averaging (FedDualAvg), which by employing a novel server dual averaging procedure circumvents the curse of primal averaging.

2 - Linear Convergence In Federated Learning: Tackling Client Heterogeneity And Sparse Gradients

Aritra Mitra, University of Pennsylvania

We develop a general algorithmic framework called FedLin to tackle some of the key challenges intrinsic to federated learning, namely statistical heterogeneity, systems heterogeneity, and infrequent and imprecise communication. Notably, FedLin exploits past gradients, client-specific learning rates, and error feedback. For smooth and strongly convex losses, we show that FedLin guarantees linear convergence to the global minimum, despite arbitrary objective and systems heterogeneity. We then establish matching upper and lower bounds on the convergence rate of FedLin. Finally, we show that FedLin preserves linear convergence rates under aggressive gradient sparsification. Our work is the first to provide tight linear convergence rate guarantees along with a comprehensive analysis of gradient sparsification in a federated setting.

3 - A Theorem Of The Alternative For Personalized Federated Learning

Weijie Su, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19104-3615, United States

A widely recognized difficulty in federated learning arises from the statistical heterogeneity among clients. In this talk, we show how the excess risks of personalized federated learning with a smooth, strongly convex loss depend on data heterogeneity from a minimax point of view. Our analysis reveals a surprising theorem of the alternative for personalized federated learning: there exists a threshold such that (a) if a certain measure of data heterogeneity is below this threshold, the FedAvg algorithm [McMahan et al., 2017] is minimax optimal; (b) when the measure of heterogeneity is above this threshold, then doing pure local training (i.e., clients solve empirical risk minimization problems on their local datasets without any communication) is minimax optimal.

■ VWC65

Virtual Room 65

Bridging Discrete and Continuous Optimization

Sponsored: OPT/Integer and Discrete Optimization

Sponsored Session

Chair: Hassan Mortagy, Georgia Institute of Technology, Atlanta, GA, 30308-1007, United States

1 - Structured Learning At Scale: First Order Methods Within A Branch-and-bound Framework

Rahul Mazumder, Massachusetts Institute of Technology, Sloan School Of Man. Cambridge, MA, 02142-1508, United States, Hussein Hazimeh

Mixed Integer Programming (MIP) methods provide a systematic framework to model and solve (to optimality) sparse learning problems. I will discuss our recent line of work to solve a family Mixed Integer Conic Optimization problems by using a tailored nonlinear branch-and-bound method. A key aspect that sets our approach different from existing approaches is the use of specialized structure-aware first order methods to solve the node relaxations with duality certificates. Preliminary experiments show that our framework can lead to 5000X speedups over commercial solvers for the sparse regression problem.

2 - Linear Regression With Mismatched Data: Local Search With Theoretical Guarantees

Haoyue Wang, Massachusetts Institute of Technology, Cambridge, MA, United States, Rahul Mazumder

Linear regression is a fundamental modeling tool in statistics and related fields. In this paper, we study an important variant of linear regression in which the predictor-response pairs are partially mismatched. We use an optimization formulation to simultaneously learn the regression coe cients and the permutation corresponding to the mismatches. The combinatorial structure of the problem leads to computational challenges. In this paper, we study a simple greedy local search algorithm. We prove that under a suitable scaling of the number of mismatched pairs compared to the number of samples and features, and certain assumptions on the covariates; our algorithm converges to a solution with residue bounded by a constant multiple of the noise. In particular, in the noiseless case, our algorithm converges to the global optimal solution with a linear convergence rate.

3 - A Numerical Analysis Approach To Convex Optimization

Rasmus Kyng, Assistant Professor, ETH Zurich, Zurich, Switzerland

In convex optimization, we can usually obtain O(1)-approximate solutions much faster than high accuracy (1+1/poly(n))-approximate solutions. One major exception is L2-regression, where low accuracy algorithms can be converted into high-accuracy ones via iterative refinement. I will present generalizations of iterative refinement to p-norms, which lead to high-accuracy algorithms based on crudely solving only a polylogarithmic number of residual problems. I will also discuss several results that build on this new approach, including p-norm regression using m^{1/3} linear system solves, and p-norm flow in undirected unweighted graphs in almost-linear time. Finally, I'll mention how our solvers have been used to build faster algorithms for finding directed maximum flows in unit capacity networks.

4 - Revisiting Priority K-center: Fairness and Outliers

Maryam Negahbani, Dartmouth College, Hanover, NH, United States, Tanvi Bajpai, Deeparnab Chakrabarty, Chandra Chekuri

Clustering is a well-studied unsupervised learning and facility location problem. In this talk we focus on the k-center objective: Given a set of points in the metric space and a parameter k, cover the points using k balls with minimum radius. We discuss two definitions of fair k-center, individual fairness (introduced by Jung et al. FORC '20) and the lottery model (introduced by Harris et. al. NeurIPS '18) and show how they are connected to a previously studied problem called the priority k-center problem (Plesnik '87). Our main contribution is approximating priority k-center with outliers and providing a framework for approximation the problem with general constraints on the set of solution centers.

5 - Electrical Flows Over Spanning Trees

Hassan Mortagy, Georgia Institute of Technology, Atlanta, GA, 30308-1007, United States,Swati Gupta, Ali Khodabakhsh, Evdokia Velinova Nikolova

The network reconfiguration problem seeks to find a rooted tree T such that the energy of the (unique) feasible electrical flow over T is minimized. The tree requirement on the support of the flow is motivated by operational constraints in electricity distribution networks. We give the first provable approximation guarantees for this problem. We provide novel lower bounds and corresponding approximation factors for various settings ranging from min{O(m − n), O(n)} to O(1) for grids with uniform edge resistances and demands. To obtain the result for general graphs, we propose a new spectral graph sparsification approach, which may be of independent interest. Using insights from our theoretical results, we propose a general heuristic that is orders of magnitude faster than existing methods in the literature, while obtaining comparable performance.

6 - Leveraging Continuous Relaxations To Solve Densest Subgraph Problems

Manuel R. Torres, University of Illinois, Urbana-Champaign, Urbana, IL, United States, Chandra Chekuri, Kent Quanrud

The densest subgraph problem (DSP) is a canonical problem in the field of graph mining. Although the problem can easily be solved in polynomial time, given the proliferation of data, there is a desire for simple algorithms with near-linear running times. We discuss ongoing work where we consider a generalization of the DSP based on supermodular functions. The insights gained from the generalization can be used to understand existing simple algorithms for the DSP. We also give a fast algorithm to solve the generalization, which leads to fast algorithms for all the natural variations captured by the generalization including the k-clique DSP.

■ VWC66

Virtual Room 66

A session on discrete-conts optimization

Sponsored: OPT/Network Optimization

Sponsored Session

■ VWC67

Virtual Room 67

Algorithms for Deep Learning

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Bugra Can, Rutgers University, Newark, NJ, 07102, United States

Co-Chair: Yuanhan Hu, Rutgers Business School, United States

1 - Asymmetric Heavy Tails And Implicit Bias In Gaussian Noise Injections

Xiaoyu Wang, Florida State University, Tallhassee, FL, United States, Alexander Camuto, Lingjiong Zhu, Chris Holmes, Mert Gurbuzbalaban, Umut Simsekli

Gaussian noise injections (GNIs) are widely used to train neural networks, where one injects Guassian noise to the network activation at every iteration of the optimization procedure, which is typically chosen as stochastic gradient descent (SGD). In this work, we focus on the so-called "implicit effect" of GNIs, which is the effect of the injected noise on the dynamics of SGD. We show this effect induces an asymmetric heavy-tailed noise on SGD gradient updates. To model this dynamics, we first propose a Langevin-like stochastic differential equation driven by asymmetric heavy-tailed noise. We then formally prove and quantify an "implicit bias" induced by GNIs, which varies depending on the heaviness of the tails and the level of the asymmetry. Empirical results confirm the "implicit effect" of GNIs induces an "implicit bias" that degrades networks performances.

2 - Robust Deep AUC Maximization And Applications In Medical Image Classification

Tianbao Yang, University of Iowa, Iowa City, IA, United States

In this work, we will present deep AUC Maximization for solving interesting real-world applications (e.g., medical image classification). First, we propose a new margin-based surrogate loss function for the AUC score (named as the AUC margin loss). It is more robust than the commonly used AUC square loss, while enjoying the same advantage in terms of large-scale stochastic optimization. Second, we conduct empirical studies of our DAM method on difficult medical image classification tasks, namely classification of chest x-ray images for identifying many threatening diseases and classification of images of skin lesions for identifying melanoma. Our DAM method has achieved great success on these difficult tasks, e.g., the 1st place on Stanford CheXpert competition (by the paper submission date).

3 - Fractional Moment-preserving Initialization Schemes For Training Deep Neural Networks

Yuanhan Hu, Rutgers Business School, United States

A traditional approach to initialization in deep neural networks (DNNs) is to sample the network weights randomly for preserving the second moment of layer outputs. On the other hand, recent results show that training with SGD can result in heavy-tailedness in the distribution of the network weights with potentially infinite variance. Motivated by this, we develop initialization schemes for fully connected feedforward networks that can provably preserve any given moment of order s 2 (0; 2] over the layers for a class of activations including ReLU, Leaky ReLU, Randomized Leaky ReLU and linear activations.

4 - On The Sample Complexity, Generalization, And Tail Index Of Policy Search In Continuous Control

Alec Koppel, U.S. Army Research Laboratory, Silver Spring, MD, 20910-3771, United States

Reinforcement learning is a framework for decision-making with incentives sequentially revealed without a dynamics model. In tabular settings, persistent exploration and softmax policies yields recent global optimality results via gradient dominance. By contrast, in continuous space, non-convexity poses a pathological challenge: existing convergence results are limited to stationarity or arbitrary local extrema. We seek to nearly satisfy persistent exploration in continuous space through heavy-tailed policy parameterizations, which invalidates several smoothness conditions common to the analysis of PG to date. Thus, we focus on weaker conditions (Holder continuous gradients with finite fractional moments), and illuminate that policies defined by heavy-tailed distributions converge to wider peaks recently associated with improved generalization.

■ VWC68

Virtual Room 68

Accelerated solutions in convex/non-convex optimization

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Anastasios Kyrillidis, Rice University, Houston, TX, 77005-1827, United States

Co-Chair: Ioannis Mitliagkas, University of Montreal, University of Montreal, Montreal, QC, H2S 2P4, Canada

1 - Accelerated Linear Convergence of Stochastic Momentum Methods in Wasserstein Distances

Burgra Can, Rutgers University, Piscataway, NJ, United States, Mert Gurbuzbalaban

Momentum methods such as Polyak's heavy ball (HB) method, Nesterov's accelerated gradient (AG) as well as accelerated projected gradient (APG) method have been commonly used in machine learning practice, but their performance is quite sensitive to noise in the gradients. We study these methods under a first-order stochastic oracle model where noisy estimates of the gradients are available. We obtain several state-of-the-art convergence guarantees for these methods in Wasserstein distances that shed light into their performance and shortcomings.

2 - Average-case Acceleration And Universal Asymptotic Average-case Optimality Of Polyak Momentum

Damien Scieur, Samsung - SAIT AI Lab, Montreal, QC, Canada, Fabian Pedregosa

We develop a framework for the average-case analysis of random quadratic problems and derive algorithms that are optimal under this analysis. This yields a new class of methods that achieve acceleration given a model of the Hessian's eigenvalue distribution. These methods have a simple momentum-like update, in which each update only makes use of the current gradient and the previous two iterates. Moreover, we establish a novel link between the Polyak Heavy-ball algorithm and the average-case analysis. Our contribution is to prove that any optimal average-case method converges in the number of iterations to Polyak Heavy-ball, under mild assumptions. This brings a new perspective on this classical method, showing that Polyak Heavy-ball is asymptotically both worst-case and average-case optimal.

3 - Stochastic Polyak Stepsize with a Moving Target

Robert Mansel Gower, Telecom, Edinburgh, EH10 4SB, United Kingdom

We propose a new stochastic gradient method that uses recorded past loss values to reduce the variance. Our method can be interpreted as a new stochastic variant of the Polyak Stepsize that converges globally without assuming interpolation. Our method introduces auxiliary variables, one for each data point, that track the loss value for each data point. We provide a global convergence theory for our method by showing that it can be interpreted as a special variant of online SGD. The new method only stores a single scalar per data point, opening up new applications for variance reduction where memory is the bottleneck.

■ VWC69

Virtual Room 69

Advances in resource allocation under uncertainty

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Sebastian Perez-Salazar, Georgia Institute of Technology, GA, United States

Co-Chair: Alfredo Torrico, Polytechnique Montreal, Montreal, QC, H2V 4G9, Canada

1 - Submodular Optimization Under Endogenous Uncertainty: An Application To Complex System Reliability

Tanveer Hossain Bhuiyan, Graduate Research Assistant, University of Tennessee, Knoxville, Knoxville, TN, 37902-3126, United States, Hugh Medal

We study a complex systems reliability allocation problem where a decision-maker with a limited budget seeks to optimally invest resources to the components of a complex network to maximize reliability. We assume that the decision-maker does not know whether a component survives for a given time horizon as it is difficult to accurately estimate the effects of numerous environmental factors on the component's performance. But, if the decision-maker invests more resources on a component, the survival probability of that component increases. We formulate the problem as a stochastic program with endogenous uncertainty (SPEU). We prove that the reliability maximization objective function is submodular when components' lifetimes follow an exponential distribution. This submodular problem can be solved for large problem instances using an approximation algorithm.

2 - Order Fulfillment Under Pick Failure In Omnichannel Ship-from-store Programs

Sagnik Das, Carnegie Mellon University, Pittsburgh, PA, United States, R. Ravi, Srinath Sridhar

We consider the order fulfillment problem in omnichannel retailing, where in-store and online demand channels cause inventory inaccuracy leading to pick failure at stores. We propose order fulfillment models for every sparse/dense combination of online and in-store demands to optimize labor, shipping, cancellation, and lost-sales costs while accounting for pick failure at stores. We establish structural results for our models and exploit them to optimize over fulfillment policies efficiently. We demonstrate the value of modeling pick failure on data from our collaborating solutions provider to top North American omnichannel retailers.

3 - Dynamic Project Expediting: A Stochastic Shortest-Path Approach

Riccardo Mogre, Durham University, Durham, DH1 3LB, United Kingdom, Luca Bertazzi, Nikolaos Trichakis

We study the sequential problem of expediting the activities of a project with random progress to minimize the expected sum of expediting costs and a cost linear in the project completion time. We model this problem as a stochastic shortest-path problem, a class of infinite-horizon Markov decision processes. The complexity of this problem renders impractical the use of existing solution algorithms. For this reason, we devise exact, computationally-efficient algorithms to identify all the feasible states of the problem and calculate optimal expediting policies.

4 - Multiagent Assortment Optimization In Sequential Matching Markets

Alfredo Torrico, Polytechnique Montreal, Montreal, QC, H2V 4G9, Canada, Margarida Carvalho, Andrea Lodi

We study a general version of the two-sided sequential matching model. The setting is the following: we (the platform) offer a menu of suppliers to each consumer. Then, every consumer selects, simultaneously and independently, to match with a supplier or to remain unmatched. Suppliers observe the subset of consumers that selected them, and choose either to match a consumer or leave the system. Finally, a match takes place if both the consumer and the supplier sequentially select each other. Each agent's behavior is probabilistic and determined by a regular discrete choice model. Our objective is to choose an assortment family that maximizes the expected revenue of the matching. We show several provable guarantees for the general model, which in particular, significantly improve the approximation factors previously obtained.

5 - Adaptive Bin Packing With Overflow

Sebastian Perez Salazar, Georgia Institute of Technology, Atlanta, GA, 30309-4245, United States

Driven by the allocation of VMs into servers, we consider the online problem of packing items with random sizes into unit-capacity bins. Upon an item's arrival, it's actual size is unknown and only its probabilistic information is available to us. We must irrevocably pack the item into an available bin or pack it in a new bin. After this, we observe the item's size, and a bin overflow can occur. An overflow incurs a penalty cost and renders the corresponding bin unusable. The goal is to minimize the expected cost given by the sum of the number of opened bins and the overflow penalty. We give an algorithm with expected cost at most a constant factor times the cost incurred by the optimal packing policy when item sizes comes from an i.i.d. sequence.

■ VWC70

Virtual Room 70

Exploiting Structure in Zeroth-order Optimization

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Daniel Mckenzie, University of California, Los Angeles, United States

Co-Chair: Wotao Yin, United States

Co-Chair: HanQin Cai, University of California, Los Angeles, United States

1 - Zeroth-order Regularized Optimization (zoro): Approximately Sparse Gradients And Adaptive Sampling

HanQin Cai, University of California, Los Angeles, Los Angeles, CA, United States

We consider the problem of minimizing a high-dimensional objective function, which may include a regularization term, using only (possibly noisy) evaluations of the function. Such optimization is also called derivative-free, zeroth-order, or black-box optimization. We propose a new Zeroth-Order Regularized Optimization method, dubbed ZORO. When the underlying gradient is approximately sparse at an iterate, ZORO needs very few objective function evaluations to obtain a new iterate that decreases the objective function. Under a novel approximately sparse gradient assumption and various different convex settings, we show the convergence rate of ZORO is only logarithmically dependent on the problem dimension. Numerical experiments show that ZORO outperforms existing methods with similar assumptions, on both synthetic and real datasets.

2 - Curvature-Aware Derivative Free Optimization

Bumsu Kim, University of California, Los Angeles, Los Angeles, CA, United States

In this work, we present new algorithms for derivative-free optimization which exploit approximate curvature information. The first algorithm, coined Curvature-Aware Random Search (CARS), uses an estimate of the curvature along a search direction to approximate the optimal step size in the given direction. Furthermore, we propose a novel stochastic estimator of the Hessian inverse to construct a new search direction whose expectation is parallel to the Newton vector. This estimator is employed by our second algorithm, coined Stochastic Hessian Inverse Projected Search (SHIPS), to yield a derivative-free approximation to Newton's method. We benchmark CARS and SHIPS on the MuJoCo control problems and the adversarial attack. The numerical results compare favorably with the other state-of-the-art methods.

3 - Hessian Estimation Based On Stein's Identity In Black-box Problems

Jingyi Zhu, Alibaba Inc., Bellevue, WA, United States

When the available information is noisy zeroth-order (ZO) oracle, stochastic approximation methods are popular for estimating the root of the multivariate gradient equation. Inspired by the Stein's identity, this work establishes a novel Hessian approximation scheme. We compare it alongside second-order simultaneous perturbation stochastic approximation (2SPSA). On the basis of the almost sure convergence and the same convergence rate, 2SPSA requires four ZO queries, while ours requires three ZO queries. Moreover, 2SPSA requires two statistically independent perturbations and two differencing stepsizes, while ours requires generating one perturbation vector and tuning one differencing stepsize only. Besides, the weighting mechanism for the Hessian estimate is generalized and the smoothness restriction on the loss function is relaxed compared to 2SPSA.

4 - Adaptive Finite-difference Methods For Noisy Derivative-free Optimization

Hao-Jun Michael Shi, Northwestern University, Evanston, IL, 60201-2717, United States, Yuchen Xie, Melody Xuan, Jorge Nocedal

The choice of the finite-difference interval for noisy derivative-free optimization is tedious, requiring careful balancing of the truncation and measurement error. In particular, it requires knowledge of both the noise level and bound on the higher-order derivative, which may be unavailable. To address this, we propose a practical finite-difference interval estimation procedure that is robust and generalizable to finite-difference schemes with higher-order accuracy. We integrate this approach into our finite-difference L-BFGS method, and propose practical criteria for determining when re-estimation or refinement of the finite-difference interval is necessary. The numerical reliability and efficiency of this approach is demonstrated on a subset of noisy CUTEst problems, and theoretical justification is provided for each component of the algorithm.

■ VWC72

Virtual Room 72

SOLA Student Panel

Sponsored: Location Analysis

Sponsored Session

Chair: Reem Khir, Georgia Institute of Technology, Atlanta, GA, United States

Co-Chair: Omer Burak Kinay, University of Waterloo, Waterloo, ON, N2L 3G1, Canada

■ WB40

CC - Room 211B

In Person: Managing Uncertainty and Scarcity in Energy Systems: Part II

General Session

Chair: Sebastian Souyris, University of Illinois Urbana-Champaign, Champaign, IL, 61820, United States

1 - Network Effects and Incentives in Solar Panel Diffusion: A Dynamic Discrete Choice Approach

Sebastian Souyris, University of Illinois Urbana-Champaign, Urbana, IL, 61801-4860, United States, Anantaram Balakrishnan, Jason Duan, Varun Rai

As the price of residential photovoltaic (PV) solar panels and government incentives decline intandem, rendering the net cost relatively flat over the years, the annual new solar capacity hasbeen increasing significantly since 1998. In this paper, we study the PV solar panel market inAustin, Texas. We develop a dynamic discrete choice model that explores the neighborhoodnetwork effects and the results of various incentive policies on the diffusion of PV systems. Wefind the network effects are significant, and unobserved household heterogeneity isconsiderable. We use policy simulations to predict the potential impact of various rebateschedules and optimize rebates according to the policymaker objective.

Wednesday, 1:30PM - 2:30PM

■ WK01

CC - Ballroom A /Virtual Theater 1

Keynote: Boundary-Expanding OR/OM Research

Keynote Session

1 - Boundary-Expanding OR/OM Research

Rachel Q. Zhang, The Hong Kong University of Science & Technology, Dept of IEEM, Clear Water Bay, Kowloon, Hong Kong

OR and OM have brought about significant improvements to operations in diverse domains, including military, manufacturing and service, and the knowledge economy. Every technological advance in the modern world has been met with the pursuit of new models by the OR/OM community, often providing fundamental understanding of and significant improvements to its deployment. In this talk, the speaker will share her experience in pursuing research in the boundaries of operations and finance, wireless communications and blockchains, including the inspirations, execution, challenges and lessons learned. Pursuing such projects is not without risk, but is an effective way for a researcher to reinvent him/herself and have a fulfilling career.

■ WK02

CC - Ballroom B /Virtual Theater 2

Edelman Reprise: UN World Food Programme

Keynote Session

■ WK03

CC - Ballroom C /Virtual Theater 3

Keynote: Operational Data Driven Interventions to Decrease Adverse Events Associated with Opioid Overdose

Keynote Session

1 - Operational Data Driven Interventions to Decrease Adverse Events Associated with Opioid Overdose

Mahesh Nagarajan, University of British Columbia, Sauder School Of Bus. Vancouver, BC, V6T 1Z2, Canada

In this talk, we present a systematic data driven approach to decrease adverse events associated with overdose episodes. We take a three fold approach. First, we examine pathways that result in opioid use and devise protocols to decrease the number of new users. Second, we predict adverse occurrence of adverse episodes among current users and adopt timely interventions that will decrease the likelihood and severity of an event. Third, we focus on the care pathways for existing users and use simple operational techniques to increase the system's capacity as well as improve outcomes.

■ WK04

CC - Ballroom D /Virtual Theater 4

Keynote: Algorithms and Social Service Provisions

Keynote Session

1 - Algorithms and Social Service Provisions

Rediet Abebe, University of California-Berkeley, Berkeley, CA, 14853, United States

Bio: Rediet Abebe is an Assistant Professor of Computer Science at the University of California, Berkeley and a Junior Fellow at the Harvard Society of Fellows. Abebe holds a Ph.D. in computer science from Cornell University and graduate degrees in mathematics from Harvard University and the University of Cambridge. Her research is broadly in algorithms and artificial intelligence, with a focus on equity and distributive justice concerns. As part of this research agenda, Abebe co-founded and co-organizes the MD4SG initiative and is serving as a Program Co-Chair for the inaugural ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization (EAAMO '21). Her dissertation received the 2020 ACM SIGKDD Dissertation Award and an honorable mention for the ACM SIGEcom Dissertation Award for offering the foundations of this emerging research area. Abebe's work has informed policy and practice at the National Institute of Health (NIH), the Ethiopian Ministry of Education, and the United Nations Food Systems Summit. Abebe also co-founded Black in AI, a non-profit organization tackling equity issues in AI. Her work is influenced by her upbringing in her hometown of Addis Ababa, Ethiopia.

Wednesday, 2:45PM - 4:15PM

■ VWD01

Virtual Room 01

Machine Learning for Heterogeneous Data Fusion

Sponsored: Data Mining

Sponsored Session

Chair: Hyunsoo Yoon, SUNY Binghamton University, Binghamton, NY, 13902, United States

1 - A Novel Robust Coupled Tensor Decomposition Method Based On Alternating Direction Method Of Multipliers

Meng Zhao, University of Florida, Gainesville, FL, United States, Mostafa Reisi Gahrooei

Coupled matrix-tensor factorization (CMTF) is a powerful tool to extract a common hidden structure from a tensor and a matrix simultaneously. It has reached a crucial status in the areas of computer vision, signal processing, and neuroscience. However, to the best of our knowledge, most existing coupled canonical polyadic (CP) decomposition methods are sensitive to outliers and lack robustness. This has motivated us to propose a novel ADMM based robust coupled matrix-tensor factorization (RCMTF) method for simultaneously decomposing a pair of matrix and tensor with the presence of outliers. We compare our method with the classical CP decomposition method and the CMTF method. Experiments on both synthetical and real datasets show that the proposed RCMTF method can effectively handle outliers and jointly decompose the coupled matrix and tensor more accurately.

2 - Q-learning For Online Nonparametric Monitoring Of High-dimensional Heterogeneous Data Streams

Haoqian Li, PhD Student, University of Wisconsin-Madison, Madison, WI, United States

High-dimensional data streams are becoming common in various applications nowadays. Meanwhile, the resource constraints often restrict the observability of data streams which poses challenges for statistical process control and quality improvement. In this article, we propose an algorithm based on Q-learning to monitor and quickly detect abnormalities 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. This algorithm also promotes a wide range of applicability based on the reward scheme. Both simulations and a case study are comprehensively conducted to evaluate the performance and demonstrate the superiority of the proposed method.

3 - Eigen-entropy: A Metric For Sampling Design

Jiajing Huang, Arizona State University, Sch Compt Infor & Dec Sys Engr, Tempe Campus, Mail, Tempe, AZ, 85281, United States, Hyunsoo Yoon, Ojas Pradhan, Teresa Wu, Jin Wen, Zheng O'Neill

Sampling is to identify a representative data subset capturing characteristics of the whole dataset. Existing sampling algorithms have some limitations including required assumptions on data distributions or models. In this study, a new metric, termed Eigen-Entropy, based on information entropy for multivariate dataset is proposed. The entropy is derived based on eigenvalues extracted from correlation coefficient matrix on multivariate data. We prove Eigen-Entropy is a metric to measure the heterogeneity of dataset theoretically, thus it can be used to assist sampling decision. The performance of the proposed method is evaluated using real building case studies. Evaluation results indicate that the proposed method outperforms the method from existing literature in terms of accuracy while maintaining smaller number of samples.

4 - Robust Deep Clustering Guided Adversarial Unsupervised Domain Adaptation

Jun Kataoka, Vestal, NY, 13920, United States

We propose a novel unsupervised domain adaption (UDA) method to predict unlabeled data on the target domain, given labeled data from the source domain. Mainstream UDA models learn aligned features from the two domains, but such methods intrinsically have a potential risk of misclassifying target domain data due to the lack of labeled samples from the target domain. To alleviate this problem, we propose an accurate pseudo-labeling strategy based on deep clustering, combined with a deep adversarial domain adaptation algorithm.

■ VWD02

Virtual Room 02

Data mining and decision analytics

Sponsored: Data Mining

Sponsored Session

Chair: Sophie Zhai, University of Oklahoma, University of Oklahoma, Norman, OK, 73019-4038, United States

1 - Does When And How Matter? Information Disclosure Strategy In Online Crowdfunding

Yoonseock Son, University of Notre Dame, Notre Dame, IN, United States, Xinxue (Shawn) Qu, Daewon Sun

Crowdfunding has become an important financing model to help project creators get financial support from backers at an early stage. Most of the time, product quality is unknown to the backers, and this information asymmetry issue often leads to the failure of crowdfunding campaigns. To reduce the uncertainty of the backers, project creators can disclose project updates throughout the process. This study examines when and how the information disclosure timing influences the success of the crowdfunding project. Moreover, text analysis is conducted to understand the impact of information richness and content similarity on the funding results.

2 - Multi-modal, Multi-lingual, Multi-locale And Multi-task For Goal Oriented Dialogues

Yunji Wang, Amazon Alexa, Bellevue, WA, United States, Meiguo Wang, Benjamin Yao, Xiaohu Liu

Due to the high demand for conversational AI, goal-oriented dialogue system becomes a popular research topic. Dialogue structure analysis and automated evaluation are the crucial steps in goal-oriented dialogue system. We propose a multi-modal, multi-lingual, multi-task model for major natural language processing (NLP) tasks, such as domain classification, goal boundary detection. In this paper a universal representation is proposed with pre-trained RoBERTa and Wav2vec 2.0. Our multi-task model is a neural architecture consisting of two hierarchically connected transformer networks and it is easy to incorporate the side information at different levels, such as turn and session. We experiment with different setups and datasets, and the proposed model yields state-of-the-art performance on a collection of benchmark datasets from a commercial voice service.

3 - Personalized Recommendation Based On Consumer Price Preferences

Wenhao Guo, Tianjin University, Tianjin, China, wh_guo@tju.edu.cn, Jin Tian, Xiaoyu Shi, Minqiang Li, Haiyang Feng

Recommendation methods usually use consumers' historical ratings to predict their preferences for products. Moreover, price plays a significant role in consumers' purchase decisions. We propose a novel recommendation method based on matrix factorization with the consideration of consumers' price preferences. We determine the consumers' price preferences from ratings in a framework of matrix factorization. The final predicted ratings are calculated by adding an additional term of price effect into the matrix factorization framework. The experimental results show that the proposed method has superior performance than several existing methods in both rating prediction and Top-N recommendation.

4 - The Power of Behavioral Hings: FOMC Press Conference and Market Expectations

Yanzhen Chen, HKUST, Austin, TX, 78712, United States Yanzhen Chen, HKUST, Hong Kong, Hong Kong, Ruixue Zhao, Ruixue Zhao

In this study, we focus on the unintended behavioral hints during FOMC press conferences and their market reactions - expectation, surprise, and uncertainty. Using FOMC video recordings from 2000 to 2019, we find that the financial market is responsive to the duration of lens that features the chairman of FOMC during press conferences. To be more specific, a longer focus on the chairman and a higher rate of direct eye contact during responses reveal a high expectation of interest rate and uncertainty on the monetary policy. Our paper posits novel machinery for financial investors' expectation formation process and sheds light on a careful design of information disclosure.

5 - What's Next? Harnessing AI To Forecast Firm Material Event Sequences

Sophie Zhai, University of Oklahoma, Norman, OK, 73019-4038, United States, Drew Zhang

In this paper, we formulate a unique business problem previously considered unapproachable, and we propose a novel solution that considers the real-business scenario for the task. In particular, we propose a Transformer model to forecast the firm's material event series, based on its SEC 8-K current reports. Our proposed model demonstrates forecasting improvements over traditional sequence-to-sequence models and task-specific Markov Chain Monte Carlo simulations.

■ VWD03

Virtual Room 03

Computational Social Science

Sponsored: Data Mining

Sponsored Session

Chair: Tengteng Ma, United States

Co-Chair: Moh Hosseinioun, IL, United States

1 - Predictability Of Art Auction Price Without Seeing The Art Piece

Jaehyuk Park, Northwestern University, Chicago, IL, 60626, United States,
Jaehyuk Park, School of Public Policy and Management, Korea Development Institute (KDIS), Sejong-si, Korea, Republic of, Kangsan Lee, Yong-Yeol Ahn

2 - Understanding The Relationship Between Communication Purposes And Privacy Behaviors On Social Media

Yuanxia Li, University of Arizona, Tucson, AZ, United States, Sudha Ram

As social media evolves, its usage is no longer restricted to personal purposes of connecting with friends or topics of interest. Organizations are using social media for many different purposes, including branding and customer support. Individuals use social media to share specific information for business or political purposes, which we term as public communication purposes. Examples include highlighting or advertising one's own music or written works. There are few extant studies on how the communication purposes (personal or public) influence users' information revealing behaviors and their implications on privacy. In this empirical study, we aim to fill this gap by analyzing users from social media (specifically Twitter) and comparing the privacy behaviors among users who have different communication purposes.

3 - Skill Complexity And The Resilience Of Urban Labor Markets

Morgan Frank, PhD, University of Pittsburgh, Pittsburgh, PA, 15260, United States

Cities are the innovation centers of the US economy, but disruptions, including technology, can exclude workers unless policy promotes the jobs and skills that increase worker pay, create employment, and foster economic resilience. In this talk, I model labor market resilience with an ecologically-inspired job network constructed from the similarity of occupations' skill requirements. The economic resilience of cities is universally determined by the connectivity within a city's job network. US cities with greater job connectivity experienced lower unemployment during the Great Recession. Further, cities that increase their job connectivity see increasing wage bills, and workers of embedded occupations enjoy higher wages than their peers elsewhere. Finally, I show how job connectivity may clarify the augmenting and deleterious impact of automation in US cities.

4 - InnoVAE: Patents, Generative Algorithms, and Innovation Frontiers

Zhaoqi Cheng, Carnegie Mellon University, Pittsburgh, PA, 15206-3747, United States

Can AI recognize innovation? We operationalize the philosophy of creativity to argue that three different types of scientific innovation — combinational, exploratory, and transformative — can be distinguished by generative algorithms in an unsupervised manner. We apply a customized variational autoencoder on a data set of "computing systems" patents to generate and situate patents in an interpretable vector space, consisting of factors of innovation. We explore correlations with economic measures of patent impact as measured by market value changes and forward citations. Combinational innovations have grown at an exponential rate while creative innovations remain steady. Our paper demonstrates that generative algorithms can identify different categories of innovation, and underscores the potential utility of generative AI methods for business applications.

■ VWD04

Virtual Room 04

Data-driven Smart Transportation

Sponsored: Data Mining

Sponsored Session

Chair: Ziyue Li, The Hong Kong University of Science and Technology, Hong Kong, Hong Kong

Co-Chair: Hao Yan, Tempe, AZ, 85281-3673, United States

1 - Real-world Ride-hailing Vehicle Repositioning Using Deep Reinforcement Learning

Zhiwei Qin, DiDi Labs, Mountain View, CA, United States, Yan Jiao, Xiaocheng Tang, Shuaiji Li, Fan Zhang, Hongtu Zhu, Jieping Ye

We present a new practical framework based on deep reinforcement learning and decision-time planning for real-world vehicle repositioning on ride-hailing platforms. Our approach learns the spatiotemporal state-value function using a batch training algorithm with deep value networks. The optimal repositioning action is generated on-demand through value-based policy search. For the large-fleet problems, we develop several algorithmic features that we demonstrate to induce coordination among the vehicles. We benchmark our algorithm with baselines in a simulation environment and have designed and run a real-world field experiment with regular drivers on a major ride-hailing platform. We have observed significantly positive results on income rate comparing our method with experienced drivers who performed idle-time repositioning based on their own expertise.

2 - Tensor Short Text Model With Graphs For Individual Passenger Clustering

Ziyue Li, PhD, The Hong Kong University of Science and Technology, Kowloon, Hong Kong, Hao Yan, Chen Zhang, Fugee Tsung

Passenger clustering is of significant research value since the abundant information from individual trajectory data could help to discover useful insights about passenger mobility patterns. However, this task is rather challenging given the data nature of being high-dimensional and spatiotemporal. To tackle these challenges, this work proposed a novel framework based on a short text model, namely, a graph-based tensor Dirichlet Process Multinomial Mixture model: Trips and passengers are formulated as tensor words and tensor documents respectively to preserve data nature. Finally, a preliminary experiment is conducted on real passenger travel data to display the learned passenger cluster.

3 - Graph Based Approach To Real Time Metro Passenger Anomaly Detection

Weiqi Zhang, Hong Kong University of Science and Technology, Hong Kong, Hong Kong,

Real-time anomaly detection of passenger flows in the metro system is very important to maintain the metro system's normal operation and ensure passengers' safety. We propose a novel abnormal passenger flow detection method based on smart card data. The method constructs a graphic model whose topological structure can capture the spatial distribution of anomalous passenger flow. It further incorporates external information (e.g. geographical information) to depict the latent passenger flow's spatial dependence. A detection statistic is constructed by using graph community detection, which can be used for further signal selection and noise filter. It can be efficiently solved via a Min-Cut-based algorithm and can provide real-time solutions to anomaly detection and diagnosis. Preliminary experimental results demonstrate the efficiency of our method.

4 - Coordinating Ride-sourcing And Public Transport Services With A Reinforcement Learning Approach

Siyuan Feng, The Hong Kong University of Science and Technology, Hong Kong, China, Peibo Duan, Jintao Ke, Hai Yang

In this paper, we model the ride-sourcing order dispatching in a multi-modal transportation system as a large-scale sequential decision-making problem. A centralized algorithm is proposed to dispatch idle drivers to arriving customer orders and determine whether to advise customers to use a combined mode of ride-sourcing and public transit services. In particular, our proposed algorithm contains a reinforcement learning approach that estimates the long-term expected rewards, and an Integer Linear Programming (ILP) that matches idle drivers and waiting customers in real-time based on both immediate revenue and the estimated long-term rewards. By evaluation on the real-world on-demand data and metro system in Manhattan, the proposed method shows remarkable improvement on the system's efficiency under different density of supply and demands.

5 - Public Transportation Analysis Via Tensor Decomposition And Spectral Clustering

Nurettin Dorukhan Sergin, Arizona State University, 3705 S. Terrace Rd, Tempe, AZ, 85282-5544, United States, Hao Yan

Automated fare collection systems record millions of transactions every day in major cities. These transactions, when analyzed, yield tremendous insight to public transportation decision-makers. We propose a model that undertakes two important analyses: discovering station similarities and detecting rare events in terms of hourly passenger inflow into stations. Our method combines tensor decomposition with spectral clustering and trains on a spatiotemporal tensor. We present our findings on smart card data collected over several months from Hong Kong's subway system.

■ VWD05

Virtual Room 05

Optimization Methods for Learning from Data

Sponsored: Data Mining

Sponsored Session

Chair: Paul Brooks, Virginia Commonwealth University, Richmond, VA, 23284-4000, United States

Co-Chair: Jose H Dula, University of Alabama, Tuscaloosa, AL, 35487, United States

1 - Better Fitting Hyperplanes

John W Chinneck, Carleton University, Systems And Computer Eng. Ottawa, ON, K1S 5B6, Canada, Paul Brooks

Most hyperplane fitting techniques try to optimize some type of distance measure, e.g. minimize the sum of the squared distances to the data points, which often skews the hyperplane towards any outliers and away from the mass of points. This conflicts with the intuitive understanding that the best fitting hyperplane is closer to more points than other hyperplanes. We present the Relative Better Measure and associated algorithm which works towards this cardinality goal and show experimentally that it provides better fits in the face of outliers, especially clusters of outliers. The algorithm has short running times even for large data sets.

2 - Nearest Convex Hull Classification with Linear Programming

Jose H. Dula, University of Alabama, School of Business,, Tuscaloosa, AL, 35487, United States, Anatoly Nemirko

The multi-class classification problem aims at assigning a test point to one of several classes that partition a data set. Nearest Convex Hull Classification uses the point's distance to the convex hulls of the class's data for this assignment. This presents a special challenge when the test point is interior to two or more hulls. We propose a lazy supervised machine learning method based on linear programming that locates internal and external test points and approximates distances. Advantages include that the same formulation is used for interior or exterior points, necessary and sufficient conditions for classification, the absence of user-defined parameters, and excellent scalability. Tests on health care data show the method performs well.

3 - Processing Large Scale DEA: The State-of-the-art

Jose H. Dula, University of Alabama, School of Business,, Tuscaloosa, AL, 35487, United States, Dimitris K Despotis, Gregory Koronakos

Dula's 2012 algorithm, BuildHull, was the fastest way to process DEA when it came out. Since then there has been an interest in analyzing and testing the algorithm's performance. We report on a study comparing BuildHull with a recent competing approach for DEA using a well-structured data suite which includes massive data sets and allows insights into the effects of dimensionality, cardinality, and extreme-efficient DMU density.

4 - Dynamic L1 Regression

Botan Citil, University of Alabama, Tuscaloosa, AL, United States, Jose Dula

The objective of this project is to apply L1 regression to streaming data. L1 regression is considered to be more robust than ordinary least squares and is indicated when the data contain outliers such demand spikes, etc. We report on results that enhance and accelerate resolving the special LP formulation for this problem. We present numerical results from our tests.

■ VWD06

Virtual Room 06

Data Analytics and Optimization

Sponsored: Data Mining

Sponsored Session

Chair: Tulay Flamand, Colorado School of Mines, Golden, CO, 80401-1878, United States

1 - Sports Analytics for an NBA Team to Optimize Team-Building Decisions

Megan Muniz, Colorado School of Mines, Golden, CO, United States, Tulay Flamand

We address a team-building problem for a basketball team, where the team decides on players to draft, current players to trade and free agents to acquire. We develop a predictive model to predict the value of new players who can be drafted, and a methodology to create a new metric that encompasses the synergy potential for each player. A predictive method is also developed to predict the synergy potential between players who have not yet played together. These inform a 0-1 integer programming model for the team-building decisions that maximizes the total team value. A case study is conducted using 2018-2019 NBA data. Results show that prescribed decisions are comparable with actual decisions, and we provide insights to the General Managers based on these decisions.

2 - An Expandable Learning-optimization Framework For Sequentially Dependent Decision-making

Dogacan Yilmaz, New Jersey Institute of Technology, Newark, NJ, 07029-2444, United States

Here, we present a deep learning-optimization framework to solve sequentially dependent optimization problems. We utilize an attention-based encoder-decoder neural network architecture to learn from the optimal solutions of time-dependent optimization problems. Then, the required level of predictions is optimized to reduce the infeasibility of the predictions generated, which is used with a commercial solver to achieve a substantial solution time reduction. We demonstrate our approach in two different MIP problems: multi-item capacitated lot sizing and multi-dimensional knapsack. Our results show that models trained on shorter instances can be successfully used to predict longer instances. The solution time can be reduced by several orders of magnitude with a small optimality gap. Our framework can be advantageous to solve NP-hard problems quickly.

3 - Retail Analytics for Store-Wide Shelf Space Allocation

Tulay Flamand, Colorado School of Mines, Division Of Economics And Bus. Engineering Golden, CO, 80401-1878, United States, Ahmed Ghoniem, Bacel Maddah

We address a store-wide shelf-space allocation problem that seeks to maximize the profit from shoppers' impulse buying. By analyzing thousands of customer baskets, we build a predictive model for in-store traffic, as a function of the space allocation and the store layout and then embed it in a non-linear mixed-integer programming model. The latter is linearized by using linear equivalent constraints and piecewise linear approximations. This helps prescribe improved store configurations and yields managerial insights for retailers.

■ VWD07

Virtual Room 07

The Interplay Between Optimization and Statistics II

Sponsored: Data Mining

Sponsored Session

Chair: Lijun Ding, Cornell University, Cornell University, Ithaca, NY, 14850-2842, United States

Co-Chair: Yingjie Fei, Ithaca, NY, 14850, United States

1 - Importance Sketching For Fast Low-rank Matrix/tensor Learning: Algorithm And High-order Convergence

Anru Zhang, Duke University, Durham, NC, 53562, United States

We consider the matrix/tensor rank constrained least-squares optimization. This problem covers many specific examples arising from applications, including matrix/tensor regression, completion, PCA/SVD, and phase retrieval. We propose a new algorithm RISRO based on a new sketching framework, recursive importance sketching. Several existing algorithms can be reinterpreted under the new sketching framework and RISRO offers clear advantages over them. RISRO is easy to implement and computationally efficient, where the core procedure in each iteration is only solving a dimension reduced least-squares. We establish a local quadratic rate of convergence for RISRO under mild conditions. We also discover a deep connection of RISRO to Riemannian manifold optimization. The effectiveness of RISRO is demonstrated in applications in machine learning and statistics.

2 - A Geometric Analysis Of Neural Collapse With Unconstrained Features

Zhihui Zhu, University of Denver, Denver, CO, 80208, United States

We study the recently observed neural collapse, an intriguing empirical phenomenon that arises in the last-layer classifiers and features of neural networks, based on a simplified unconstrained feature model. We show that the classical training problem has a benign global landscape: the only global minimizers are the Simplex ETFs while all other critical points are strict saddles whose Hessian exhibit negative curvature directions. These findings could have profound implications for optimization, generalization, robustness, etc. For example, our experiments show that one may set the feature dimension equal to the number of classes and fix the last-layer classifier to be a Simplex ETF for network training, leading to substantial cost reductions on memory and computation without sacrificing the performance. Joint work with Ding, Zhou, Li, You, Sulam, and Qu.

3 - Partial Recovery For Top-k Ranking: Optimality Of MLE And Sub-optimality Of Spectral Method

Anderson Ye Zhang, University of Pennsylvania, Philadelphia, PA, United States,

Given partially observed pairwise comparison data generated by the Bradley-Terry-Luce (BTL) model, we study the problem of top-k ranking. That is, to optimally identify the set of top-k players. We derive the minimax rate with respect to a normalized Hamming loss. We also derive the optimal signal-to-noise ratio condition for the exact recovery of the top-k set. The maximum likelihood estimator (MLE) is shown to achieve both optimal partial recovery and optimal exact recovery. On the other hand, we show another popular algorithm, the spectral method, is in general sub-optimal. Another contribution that may be of independent interest is the analysis of the MLE without any penalty or regularization for the BTL model. This closes an important gap between theory and practice in the literature of ranking.

■ VWD08

Virtual Room 08

Project Management

Contributed Session

Chair: Conghan Wang,

1 - Perturbations In Stochastic Project Networks

Anand Paul, University of Florida, Gainesville, FL, United States,

We investigate the conditions under which it can be claimed that 'delays at the activity level adversely impact average project completion time, while controlling for variability.' We categorize probability distributions of activity duration for which the expected adverse impact on project completion time is guaranteed to occur or not; we show that distributional asymmetries can warp the expected cause-effect relationship between activity delay and project delay. We also make some remarks on activity slack in PERT networks, and on almost sure bounds for project completion time in large scale project networks.

2 - Interrelationships Among Project Attributes And Time-phased Resource Patterns In A Project Portfolio

Vishwanath Hegde, Professor, California State University-East Bay, Hayward, CA, United States, Zinovy Radovilsky

We analyze the interrelationships among project attributes, durations, and time-phased resource allocation patterns in a portfolio of engineering projects. We estimate parametric models that capture unique duration/resource usage patterns from a longitudinal dataset spanning eleven years and analyze the link between the patterns and project attributes. Our research enhances the macro estimation of duration and resource requirements for incoming projects.

3 - A Continuous-time Linear Programming Formulation For Resource-constrained Project Scheduling With Multiple Sites

Norbert Trautmann, Full Professor, University of Bern, Bern, Switzerland, Mario Gnaegi

We present a continuous-time mixed-integer linear programming formulation for scheduling the activities of a multi-site project subject to precedence and renewable-resource constraints. As a consequence of the distribution of the renewable-resource units among the multiple sites, transportation times must be considered for moving some mobile resource units or the output of some precedence-related activities.

4 - A Revised PERT Model Using Log-Normal Activity Times

Eric Logan Huggins, Professor of Management, Fort Lewis College, Durango, CO, United States, Ivan G. Guardiola

The standard PERT model assumes that activity times follow Beta distributions and that completion time for the entire project is Normally distributed. We consider several revisions to this model; specifically, we assume that the activity times follow Log-Normal distributions instead which we believe may improve the model. While the Log-Normal can be similarly skewed like the Beta, it has an infinite right tail which puts no limit on how long an activity can be delayed; further, our model allows estimating the worst case scenario with a given confidence level.

5 - Influence Of Pre-Conflict Relationship On Socio-Emotional Reconciliation In Construction Subcontracting: Moderating Role Of Shadow Of The Future

Conghan Wang, Tianjin University, Tianjin, China, Shuibo Zhang, Ying Gao

Once one conflict occurs, the removal of conflict-related negative emotions (i.e., socio-emotional reconciliation) have pragmatic significance in promoting relational resilience in construction subcontracting. This study distinguishes pre-conflict relationship into two types, and investigates their effects on socio-emotional reconciliation and the moderating role of shadow of the future on the effects.

■ VWD09

Virtual Room 09

Public Health Operations: From Hospitals to Vaccination Facilities

Sponsored: Health Applications Society

Sponsored Session

Chair: Lesley Meng, Yale University, New Haven, CT, 06519-2851, United States

1 - Ed Triage: An Empirical Study Of Fast-track Admission And Its Implication For Patient Outcomes

Shuai Hao, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Yuqian Xu, Zhankun Sun

As an effective way to improve emergency department throughput efficiencies, many hospitals have opened a separated fast-track service line that is dedicated to low acuity patients. However, these hospitals don't have consistent routing policies and systematic routing criteria. This largely due to the fact that the impact of fast-track routing decisions on patient outcomes for heterogeneous patients hasn't been well determined. Utilizing a unique data set from three urban hospitals in Canada, we first identified the behavior bias within fast-track routing decision-making process. We came up with an instrumental variable related to this bias to help us quantify the impact of routing decisions on patients with different severity levels whom we classified using a data-driven approach.

2 - Quality Improvement Spillovers: Evidence From The Hospital Readmissions Reduction Program

Mohamad Soltani, University of Alberta, N, Edmonton, AB, T6G 2R6, Canada, Robert Batt, Hessam Bavafa

Financial incentives are commonly used to encourage improvements in quality. However, the presence of spillovers can make managing these incentives difficult. We explore spillover effects of a national healthcare quality improvement policy, the Hospital Readmissions Reduction Program (HRRP), on patients and metrics not targeted by the policy. Whereas prior work has shown limited spillover of quality improvement initiatives in manufacturing settings, we find that in the healthcare setting, HRRP led to quality improvement for non-targeted patients. However, we show that hospitals' response to the policy is a function of their operational focus on target patients. We also find significant reduction in non-targeted measures such as hospitalization cost. These results shed light on how hospitals operationalized their quality improvement efforts in response to HRRP.

3 - Context Specific Recommendations For Community Health Worker Task Allocation In High Endemic Settings

Robert Montgomery, University of Chicago, Chicago, IL, United States, Baris Ata

We partner with the International Rescue Committee to study the current Community Health Worker (CHW) training and deployment plans in three different countries. We make recommendations for improving the CHW programs based on context-specific features including disease prevalence, population density, quality of and distance from the nearby health center, and treatment packages available to CHWs.

4 - Optimal COVID-19 Vaccination Facility Location

Jingyuan Hu, UCLA Anderson School of Management, Los Angeles, CA, United States, jin, Fernanda Bravo, Elisa Frances Long

Socioeconomic disparities in COVID-19 vaccine access have been partially attributable to inequitable allocation decisions and poor vaccination site selection. Partnering with several retail pharmacies has provided additional vaccine access points, yet these locations may be inefficiently selected. We consider an equitable vaccination site location problem where chain stores (pharmacies, dollar stores, etc.) are candidate locations and formulate it as a large-scale mixed-integer programming model with the objective of maximizing vaccination coverage. Results indicate that current vaccination sites (e.g., 4,000+ in California alone) could be replaced with significantly fewer, but optimally selected, store locations.

■ VWD10

Virtual Room 10

OR Methods for Health Policy Design

Sponsored: Health Applications Society

Sponsored Session

Chair: Andrew J. Schaefer, Rice University, Houston, TX, 77005-1827, United States

Co-Chair: Saumya Sinha, Rice University, Houston, TX, 77005-1827, United States

1 - Multi-year Optimization Of Malaria Intervention: A Mathematical Model

Susan E. Martonosi, Professor, Harvey Mudd College, Department Of Mathematics Claremont, CA, 91711-5901, United States, Harry Dudley, Abhishek Goenka, Cesar Orellana

Malaria is a mosquito-borne, lethal disease that affects millions and kills hundreds of thousands of people each year, mostly children. In this paper, we couple a susceptible-infected-recovered compartment model for the disease dynamics with an integer linear program to allocate malaria interventions across geographic regions and time, subject to budget constraints, with the aim of minimizing the number of person-days of malaria infection. The model provides a qualitative decision-making tool to weigh alternatives and guide malaria eradication efforts. A one-size-fits-all campaign is found not to be cost-effective; it is better to consider geographic variations and changes in malaria transmission over time when determining intervention strategies.

2 - Combination Chemotherapy Optimization

Temitayo Ajayi, Nature Source Improved Plants, Ithaca, NY, 77004, United States, Dave Fuller, Andrew J. Schaefer, Mohammad Hosseinian

Chemotherapy is one of the primary modalities of cancer treatment. Chemotherapy drug administration is a complex problem that often requires expensive clinical trials to evaluate potential regimens. One way to better inform future trials is to build reliable models that illustrate how a patient may react to specified drugs and doses. Previous chemotherapy optimization models have relied on optimal control, which does not lend itself to discrete considerations such as doses via pills and rest periods. In this paper, we develop mixed-integer linear programming models for combination chemotherapy that incorporate various important operational constraints. We also address uncertainty in the tumor heterogeneity with a chance constraint.

3 - A Resource Allocation Model To Optimize The Allocation Of HIV Prevention Funds For Local U.S. Jurisdictions

Md Hafizul Islam, Centers for Disease Control and Prevention, Atlanta, GA, 30333, United States, Paul Farnham

We used a linear programming model to identify the optimal allocation of the Centers for Disease Control and Prevention's HIV prevention funding for local U.S. jurisdictions. The model maximizes the number of cases averted while allocating a given budget among prevention interventions and populations stratified by gender and risk groups. Inputs to the model include budget and data on the costs and efficacy of HIV prevention programs. Model solutions report the number of new cases prevented and the corresponding funding allocation to each prevention intervention for different subpopulations.

4 - Incentives In Outcome-based Regulation For Organ Transplantation

Saumya Sinha, Rice University, Houston, TX, 77005-1827, United States, sDavid Mildebrath, Taewoo Lee, Andrew J Schaefer

Federal agencies use outcome-based regulatory criteria for oversight of transplant programs, aiming to incentivize programs to improve their post-transplant outcomes. However, clinical evidence indicates that the regulations may induce programs to reject medically suitable patients to avoid penalization. We present a game-theoretic model of transplant programs to analyze the incentives created by these regulations. We demonstrate that excessively harsh penalization, more so than other factors, incentivizes programs to engage in adverse patient selection. We propose an alternative pay-for-performance reimbursement scheme which penalizes underperforming programs and pays a bonus to programs with above-average outcomes. The proposed scheme can incentivize programs to improve post-transplant outcomes without inducing adverse patient selection.

■ VWD11

Virtual Room 11

Medical Decision Making

Sponsored: Health Applications Society

Sponsored Session

Chair: Narges Mohammadi, Imperial College Business School, United States

1 - Presenter

Erkin Otles

2 - Optimizing Inter-hospital Patient Transfer Decisions During A Pandemic: A Queueing Approach

Frances Pogacar, University of Toronto, Toronto, ON, Canada, Timothy Chan, Vahid Sarhangian

During the COVID-19 pandemic in Ontario, a province-wide initiative began to redistribute patients across hospitals. Our work demonstrates that redistributing patients can balance the COVID+ burden and have significant improvements on ward and ICU occupancy. Using queueing models and their fluid approximations, we develop linear and mixed-integer programs to find optimal transfers of incoming patients. We validate our queueing model with historical occupancy data and quantify the benefit of optimized transfer decisions in terms of the distribution of COVID+ burden and number of patient-days over ICU and ward occupancy thresholds.

3 - Optimal Hearing Loss Monitoring For Pediatric Patients With Cystic Fibrosis Disease

Narges Mohammadi, Imperial College Business School, London, United Kingdom, Mohammadreza Skandari

Cystic Fibrosis (CF) disease is a genetic disorder that mostly affects lungs. CF patients experience several pulmonary exacerbations during their lives. In order to treat severe pulmonary exacerbations, patients receive intravenous (IV) aminoglycosides (AG) that can affect their inner ear and cause hearing loss. In 2018, more than 20% of pediatric CF patients were treated with IV AGs for a pulmonary exacerbation. To detect possible hearing loss, there are several hearing assessment methods available that vary in accuracy. Despite the widespread use of ototoxic antimicrobial therapy in CF disease, there are no evidence-based guidelines on ototoxicity screening. The overarching aim of this research is to design cost-effective strategies for screening and monitoring patients with CF disease to detect hearing loss due to treatment ototoxicity at earlier stages.

4 - Scheduling Mobile Mammography Facilities For Community-based Care Considering Breast Cancer Risk

Samira Fazel Anvaryazdi, Washington University in Saint Louis--Olin Business School. Saint Louis, MO, United States, Ayca Erdogan, Michael G. Klein, Mahboubeh Madadi

Healthcare providers schedule mobile clinics to encourage participation in preventive care. We study the mobile facility location and scheduling problem for breast cancer screening. Considering that patients have different breast cancer risks, we propose a model to maximize health outcomes for a heterogeneous population and reduce disparities in the community.

■ VWD12

Virtual Room 12

Analytics for COVID and pandemic response

Sponsored: Health Applications Society

Sponsored Session

Chair: Spyros Zoumpoulis, INSEAD, Paris, 77305, France

Co-Chair: Dan Andrei Iancu, Stanford University, Stanford, CA, 94305-7216, United States

Co-Chair: Dragos Florin Ciocan, INSEAD, Fontainebleau, France

1 - Forecasting Covid-19 With Application To Vaccine Trial Design

Michael Lingzhi Li, Massachusetts Institute of Technology, Cambridge, MA, 02111, United States, mHamza Tazi Bouardi, Omar Skali Lami, Thomas Trikalinos, Nikolaos Trichakis, Dimitris Bertsimas

To help combat the COVID-19 pandemic and understand the impact of government interventions, we develop DELPHI, a novel epidemiological model. We applied DELPHI across >200 regions since early April 2020 with consistent high predictive power. DELPHI compares favorably with other models and predicted large-scale epidemics in areas such as South Africa and Russia weeks before realization. Furthermore, using DELPHI, we can quantify the impact of interventions and provide insights on future virus incidence under different policies. We illustrate how Janssen effectively accelerated the Phase III trial of the first single-dose vaccine Ad26.Cov2.S by selecting optimal locations using such analysis.

2 - Deploying A Data-driven Covid-19 Screening System At The Greek Border

Vishal Gupta, University of Southern California, Marshall School of Business, Los Angeles, CA, 90026, United States, Hamsa Sridhar Bastani, Kimon Drakopoulos

In the summers of 2020/2021 in the wake of the COVID-19 pandemic, many European countries sought to ease restrictions on non-essential travel to bolster its tourist economy, while still safeguarding public health. In collaboration with Greece, we deployed a data-driven COVID-19 testing system, which used real-time, bandit feedback to allocate scarce testing resources to I) identify asymptomatic, infected travelers ii) monitor different populations for potential spikes that merited adjusting border policies. We describe the system and document its effectiveness over summer of 2020; our data-driven system is able to prevent twice as many asymptomatic infections from entering the border than random, surveillance testing. We discuss some implications for the use of AI in managing the pandemic.

3 - COVID-19 Vaccine Allocation Optimization By Age And Risk Groups

Nazlican Arslan, Northwestern University, Evanston, IL, United States, Ozge Surer, David Morton, Lauren Meyers

Vaccines are the primary means for mitigating a pandemic, but mass vaccination does not typically begin until a pandemic is well underway. As various types of COVID-19 vaccines become available in the US, it is crucial to decide on a vaccine prioritization strategy. We present an age and risk structured epidemiological model that incorporates vaccine allocation. We apply a derivative-free optimization algorithm as well as a greedy heuristic into our SEIR-type simulation model to determine an optimal vaccine rollout to minimize an objective, which can incorporate expected mortality, infections, and hospitalizations, accounting for both general ward and ICU beds.

4 - Quantifying The Benefits Of Targeting For Pandemic Response

Dan Andrei Iancu, Stanford University, Stanford, CA, 94305-7216, United States, Sergio Camelo-Gomez, Florin Ciocan, Xavier Warnes, Spyros Zoumpoulis

The social-distancing measures implemented in response to COVID-19 have involved targeting specific groups or activities for confinement. Such targeting can be contentious, so rigorously quantifying its health and economic benefits is critical for designing effective and equitable policies. We propose a framework for computing interventions targeted by population group characteristics as well as the activities that individuals engage in, and showcase a full implementation using publicly available data. We find that optimized dual-targeted policies have a simple and explainable structure, and lead to substantial complementarities and Pareto improvements, reducing the overall number of deaths and the economic losses, and also reducing the time in confinement for each population group.

■ VWD13

Virtual Room 13

Health Care, Strategy and Policy

Contributed Session

Chair: Akshat Lakhiwal, Indiana University-Kelley School of Business, Bloomington, IN, 47405, United States

1 - Does Broader Sharing Improve Patient Outcomes? Analysis Of Share 35 Liver Allocation Policy

Shubham Akshat, University of Maryland, College Park, MD, United States, Liye Ma, Subramanian Raghavan

Broader sharing of organs is believed to mitigate geographic disparity in access to liver transplants. We build a structural model to study the impact of Share 35 policy, a variant of broader sharing introduced in 2013, on behavior changes and on patients' welfare. We find that Share 35 policy helped in reducing the geographic disparity. The sicker patients benefited from policy and became selective in accepting organs, however there was heterogeneity in behavior change across geographies in lesser sick patients. Collectively, not all geographies benefited from Share 35 policy. We conclude that the current acuity circles policy would result in lower patient welfare than the previous Share 35 policy.

2 - Examining The Influence Of Organizational Ambidexterity And Executive Diversity On Product Recalls For Medical Devices

Akshat Lakhiwal, Indiana University-Kelley School of Business, Bloomington, IN, United States, George Ball, Hillol Bala, Corinne Post

The complex consequences of product recalls call for a deeper understanding of their strategic and operational drivers. Addressing this research need, we examine why and how ambidexterity—i.e., an organization's ability to simultaneously explore new ideas and exploit existing processes and knowledge—along with executive level gender and racial/ethnic diversity influence recall related processes and decisions for medical devices.

■ VWD14

Virtual Room 14

Innovative Business Models

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Simone Marinesi, Wharton, Philadelphia, PA, 19103-6007, United States

1 - Intertemporal Content Variation With Customer Learning

Robert Swinney, Duke University, Durham, NC, 27708-9972, United States, Fernando Bernstein, Soudipta Chakraborty

We study a firm that sells repeatedly to a customer population over time. Motivated by new business models like streaming services, we assume that the price is the same in every period, but the firm varies the content available over time. Customers learn their utility on purchasing and decide whether to purchase again in subsequent periods. The firm faces a budget for the total amount of content available during a finite planning horizon, and allocates content to maximize revenue. We show that the optimal allocation policy is monotone: content value increases if customer heterogeneity is low and decrease otherwise. Furthermore, for the case of T = 2 periods, we show how two critical factors—the fraction of "new" versus "repeat" customers, and the size of the content budget—affect the optimal allocation policy and the importance of varying content value over time.

2 - The Role Of Dealer Demonstration In The Adoption Of Electric Vehicles

Ioannis Bellos, George Mason University, Fairfax, VA, 22030-4422, United States, Vishal Agrawal, Hang Ren

To date, electric vehicles represent a very small fraction of the total vehicle sales. One reason often cited as contributing to customers' hesitation to adopt electric vehicles is the uncertainty around their achievable range which depends on idiosyncratic factors that can be fully experienced only post-purchase. In this paper, we consider the role that car dealers can play in offering customers as close to a post-purchase experience as possible by providing demonstration services such as extended test drives. We study the dealer's decision whether to sell electric vehicles in addition to conventional ones and if so, whether to provide demonstration services. We characterize both the economic and environmental impact of these decisions.

3 - Implications of Worker Classification in On-Demand Economy

Zhoupeng (Jack) Zhang, Rotman School of Management, University of Toronto, Toronto, ON, M5S 3E6, Canada, Ming Hu, Jianfu Wang

Workers in the gig economy have long been treated as independent contractors, which disqualifies them from employee benefits. We evaluate the impacts of California Assembly Bill 5 (AB5), a statute that requires on-demand platforms to reclassify their workers as employees. We model the service process of such a platform as a queueing system with long-term (LT) and ad hoc (AH) workers. We show that AB5 does not always improve LT workers' welfare because, in the free market, the presence of AH workers can incentivize the company to pay a high piece-rate wage. While the company's profit always decreases, transaction volume can either increase or decrease due to AB5, rendering consumer welfare implications ambiguous. We propose a way to refine the current AB5.

4 - All-or-nothing Or Keep-it-all? Campaign Design Choice In Rewards-based Crowdfunding Platforms

Simone Marinesi, The Wharton School, University of Pennsylvania, Philadelphia, PA, 19103-6007, United States, Ekaterina Astashkina

We compare two popular, alternative campaign designs for rewards-based crowdfunding, Fixed Funding and Flexible Funding. In contrast to prior literature, which argues that Fixed Funding is superior to Flexible Funding, we show that each campaign mode can outperform the other, depending on the characteristics of the project, and we provide recommendations for how to choose between the two.

■ VWD15

Virtual Room 15

Models of choice-based RM

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Gustavo J. Vulcano, Universidad Torcuato di Tella, Buenos Aires, 1428, Argentina

1 - Assortment Optimization Under The Multinomial Logit Model In The Presence Of Endogenous Consideration Sets

Yicheng Bai, Cornell Tech, New York, NY, United States, Jacob Feldman, Huseyin Topaloglu, Laura Wagner

We study assortment optimization problems under a natural variant of the multinomial logit model where the customers form consideration sets by focusing only on a certain number of products that provide the largest utilities. We provide a recursion to compute the choice probabilities. We show that the assortment optimization problem under this model is NP-hard and give a polynomial-time approximation scheme. We show that the revenue-maximizing assortment under our variant includes the revenue-maximizing assortment under the standard multinomial logit model and conduct computational experiments to demonstrate that incorporating consideration sets can significantly improve the ability of the multinomial logit model to predict customer choices.

2 - The Mallows Model Of Discrete Choice In Operational Contexts

Gustavo J Vulcano, Universidad Torcuato di Tella, Buenos Aires, 1428, Argentina, Srikanth Jagabathula

We study the Mallows discrete choice model, which is relatively novel in the OM community and provides a fairly parsimonious representation of a rank-based model of choice. We illustrate how this model can be used to estimate choice behavior in retail settings where only transaction and product availability data are available. Then, we show how to extend the model to a setting where customers are described by partial orders, and the firm has access to individual panel data. Our numerical experiments on real-world panel data show that the model leads to competitively accurate, fine-grained predictions for individual purchase behavior compared to state-of-the-art alternative methods.

3 - Discrete Choice Via Sequential Search

Aydin Alptekinoglu, Pennsylvania State University, University Park, PA, 16802-3603, United States, Natalia Kosilova

This work considers the sequential search process of the consumer and derives the resulting choice probabilities. While the optimal search strategy was characterized by Weitzman (1979), to the best of our knowledge there is no work deriving the choice probabilities that result from the optimal search strategy.

■ VWD16

Virtual Room 16

Online Resource Allocation: New Models and Algorithms

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Vineet Goyal, Columbia University, New York, NY, 10027, United States

Co-Chair: Rajan Udwani, UC Berkeley, Berkeley, CA, United States

1 - Online Resource Allocation With Time-flexible Customers

Evan Yao, Massachusetts Institute of Technology, Cambridge, MA, United States

We study an online resource allocation model where certain arriving agents are time flexible, meaning that they are willing to wait a short period of time to receive the resource. For flexible agents, we must make an immediate and irrevocable commitment to accept them, but how exactly we allocate resources to satisfy their demand can be made in an offline manner after we have seen more of the input sequence. When there are 2 or 3 types of agents, we present algorithms that achieve the maximum possible competitive ratio, while for 4+ types, we present a simple algorithm which achieves at least 80% of the maximum competitive ratio.

2 - The Best Of Many Worlds: Dual Mirror Descent For Online Allocation Problems

Haihao Lu, University of Chicago, Chicago, IL, United States,

Online allocation problems with resource constraints are central problems in revenue management. 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. In this talk, 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 inputs models without knowing which type of input they are facing. In particular, our algorithms are asymptotically optimal under stochastic i.i.d. input model as well as various non-stationary stochastic input models, and they attain an asymptotically optimal fixed competitive ratio when the input is adversarial.

3 - Promoting Fairness in Online Resource Allocation

Pan Xu, New Jersey Institute of Technology, Newark, NJ, United States, Will Ma, Evan Xu

Matching markets involve heterogeneous agents who are paired for mutual benefit. During the last decade, matching markets have evolved into a new format, called \emph{Online Matching Markets} (OMMs), with examples ranging from crowdsourcing to online recommendations to ridesharing.In this paper, we propose online matching algorithms which optimize for either individual or group-level fairness among offline agents in OMMs. We present two linear-programming (LP) based sampling algorithms, which achieve online competitive ratios at least 0.722 for individual fairness maximization (IFM) and 0.719 for group fairness maximization (GFM), respectively.

4 - Asymptotically Optimal Competitive Ratio For Online Allocation Of Reusable Resources

Rajan Udwani, UC Berkeley, Berkeley, CA, 02446, United States, Vineet Goyal, Garud N. Iyengar

We consider the problem of online allocation (matching, budgeted allocations, and assortments) of reusable resources where an adversarial sequence of resource requests is revealed over time and allocated resources are used/rented for a stochastic duration, drawn independently from known resource usage distributions. We give an algorithm that obtains the best possible competitive ratio of (1−1/e) for general usage distributions and large resource capacities. At the heart of our algorithm are (i) a new quantity that factors in the potential of reusability for each resource by (computationally) creating an asymmetry between identical units of the resource and (ii) a relaxed online algorithm that is only subject to fluid approximations of the stochastic elements in the problem.

5 - Online Nash Social Welfare Maximization Via Promised Utilities

Billy Jin, PhD Student, Cornell University, Ithaca, NY, United States, Siddhartha Banerjee, Vasilis Gkatzelis, Artur Gorokh

We consider the problem of allocating a set of divisible goods to N agents in an online manner over T periods, with adversarially-chosen normalized valuations in each period. Our goal is to maximize the Nash social welfare, a widely studied objective which provides a balance between fairness and efficiency. On the positive side, we provide an online algorithm that achieves a competitive ratio of O(log N) and O(log T), and also a stronger competitive ratio of O(log k) in settings where the value of an agent in any period is no more than k times her average value. We complement this by showing this bound is essentially tight: no online algorithm can achieve a competitive ratio of O((log N)^{1- }) or O((log T)^{1- }) for any constant > 0.

■ VWD17

Virtual Room 17

Car-sharing and related topics

Sponsored: Revenue Management and Pricing

Sponsored Session

Chair: Gonzalo Romero, Rotman, University of Toronto, Toronto, ON, M4K 1Y5, Canada

Co-Chair: Mahsa Hosseini, United States

1 - Dynamic Relocations In Car-sharing Networks

Mahsa Hosseini, University of Toronto, Toronto, ON, Canada, Gonzalo Romero, Joseph Milner

We propose a dynamic car relocation policy for a car-sharing network with centralized control and uncertain, unbalanced demand. The policy is derived from a reformulation of the linear programming fluid model approximation of the dynamic problem. We project the full-dimensional fluid approximation onto the space of relocations only. The reformulation uncovers 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 relocation decisions. Our extensive numerical results show that our dynamic car relocation policy consistently outperforms the standard static policy in realistic instances from the literature. In fact, it reduces the static policy's optimality gap by more than 13% in all of these instances and up to 35% in some.

2 - Courier Sharing in Food Delivery

Arseniy Gorbushin, ON, Canada

The food delivery market is migrating to platforms. One of the platform's advantages is optimized routing by sharing couriers (SC) among many restaurants. We ask two questions: how SC reduces delivery costs and how it affects the market equilibrium. We consider a spatial queuing model in which couriers are the servers. We show that SC is preferable if restaurants maximize throughput in a big market. However, if they maximize profit then SC intensifies price competition and may decrease profit.

3 - Spatial Elasticity

Bobby Nyotta, UCLA Anderson School of Management, Los Angeles, CA, 91355-3203, United States, Fernanda Bravo, Keith Chen

Using transactions data from a popular downtown neighborhood in a large metropolitan city's mobile phone application for parking payments, we analyze customer behavior from a natural pricing experiment to estimate the "spatial elasticity," a measure of how individuals quantify the cost of walking an additional mile, in an urban mobility setting We find that customers require approximately $81 to walk an additional mile to their intended destination. The results are robust against several varying assumptions and when considering factors such as weather and time of day. Our estimates can be used in ride-sharing, bike-sharing, e-scooter-sharing settings to incentive users to end their trips at key locations to either ensure future availability or reduce congestion.

4 - Autonomous Vehicles For Ride-Hailing

Xiaotang Yang, University of Minnesota, Minneapolis, MN, 55442-4516, United States, Saif Benjaafar, Zicheng Wang

We consider a setting where a ride-hailing platform can operate with both autonomous vehicles (AVs) and conventional vehicles (CVs or drivers) over a spatial network. An important distinction between AVs and CVs is in the associated cost structure (drivers are paid only when they fulfill demand while AVs are purchased ahead of time and incur a fixed cost) and in the repositioning of vehicles upon the completion of service. The repositioning of AVs is under the control of the platform. In contrast, the repositioning of CVs is in the hands of the drivers who act strategically. We study the effect of introducing AVs to the ride-hailing market, including repositioning strategy, driver welfare, admission control and vehicle assignment policy.

■ VWD18

Virtual Room 18

Pricing and Revenue Management II

Contributed Session

Chair: Fan You, University of Colorado-Boulder, Boulder, CO, 80302, United States

1 - Investigating The Profit And Social Impact Of Product Return Leniency

Ehsan Elahi, Associate Professor, University of Massachusetts, Boston, Boston, MA, 02125, United States, Ali Shirzadeh Chaleshtari

We present a novel, inclusive analytical model capable of capturing the impacts of major factors affecting the customers' purchase and return behavior in retail markets, and using this model, we determine the optimal price and refund levels to optimize the expected profit of the retailer and social welfare. Based on numerical experiments, we demonstrate the impact of return leniency on the optimal refund and the resulting profit of the retailer, as well as the social welfare. Our analysis shows, among other results, that the return leniency can be both beneficial and harmful for the retailer, while it usually increases the social welfare up to some levels.

2 - Product Portfolio Decision Making Based On PnL Variant Analysis From Competitive Benchmarking With Regression And Supply Chain Health At Intel

Jason Megit, Intel, Chandler, ON, Canada, Elyse Hallstrom

Intel is expanding its graphics portfolio into further segments of the graphics market. Utilizing internal and competitive benchmarking with linear regression, cost projections, market hyper-segmentations, and implementing wholistic supply chain health approach to calculate prices, we analyze possible PnLs at multiple dimensions in order to make product decisions to best ramp our business into new segments.

3 - The Impact Of Order Fulfilment Services Provided By Online Marketplace Operators On Third-party Seller's Performance

Hao Su, University of Maryland-College Park, College Park, MD, United States, Martin E. Dresner

This paper examines the impact of order fulfilment services provided by marketplace operators on third-party sellers' competitiveness and product performance. We also examine factors that may moderate the relationship between using order fulfilment services provided by marketplace operators and a third-party seller's competitiveness: the cost of services, the shipment size/weight, and the product value.

4 - The Impact Of Uncertainty On A Broker's Optimal Bidding Decisions In B2B Markets

Ozden Engin Cakici, American University, Washington, DC, United States

We study a broker's problem of matching a buyer with stochastic suppliers. The broker bids at each supplier. After the suppliers evaluate the bids, the broker learns the procurement quantity and then ships the items from each supplier to the buyer. When there is a single supplier the problem reduces to a new type of newsvendor problem. We study the impact of uncertainty on the optimal bids. We prove that the broker may or may not increase the bid when faced with uncertainty compared to a case with no uncertainty. We provide conditions under which it is optimal for the broker to bid at multiple suppliers. We numerically find that the broker's expected profit decreases in the correlation between suppliers.

5 - Assortment Optimization For Online Multiplayer Video Games

Fan You, PhD Candidate, University of Colorado-Boulder, Boulder, CO, United States, Thomas Vossen

We consider the assortment optimization problem for a class of online multiplayer video games, where the in-game store has a unique structure with two sections, Featured and Just For You (JFY). All customers are offered the same Featured assortment whereas JFY is used for personalized recommendations. We model the choice of customers under the constrained mixture of nested logit model, and design a MILP formulation, as well as a FPTAS. We also propose a Lagrangian upper bound and a fast heuristic. We provide theoretical guarantees of the MILP formulation, the FPTAS as well as the heuristic algorithm. Numerical experiments show that our approaches perform well across a variety of settings.

■ VWD19

Virtual Room 19

Sequential Learning by Experimentation

Sponsored: Applied Probability Society

Sponsored Session

Chair: Daniel Russo, Columbia University, New York, NY, 10027, United States

1 - Online Advertising Via Bandit Experiments: An Efficient Method Suitable For High-dimensional Problems

Wenjia Ba, Stanford University, 5 Comstock Cir, Lieberman 420A, Stanford, CA, 94305, United States, Michael Harrison, Harikesh Nair

We consider models of sequential decision-making by an online advertiser. In a sequence of trials, the advertiser first chooses the audience segment to purchase an impression, then chooses the ad for display, and finally observes a binary outcome. The problem becomes high-dimensional if there exist many possible combinations of user and ad choices. Adopting the multi-arm bandit framework, we propose and evaluate an approach (PMDL) that is based on a Poisson regression model, using the debiased Lasso method of Javanard and Montenari (2017) to estimate parameters of that model. In numerical experiments, the performance of PMDL is comparable to that of leading alternatives in low-dimensional settings, and it continues to show good performance in high-dimensional as well as real-data settings where existing alternative methods are computationally infeasible.

2 - Adaptivity And Confounding In Multiarmed Bandit Experiments

Daniel Russo, Columbia University, New York, NY, 10027, United States

Abstract: Bandit algorithms minimize experimentation costs by adapting effort away from poorly performing arms as feedback is observed. But this feature makes them sensitive to confounding. For instance, popular algorithms can't address the problem of identifying the best action when day-of-week effects may confound inferences. In response, we propose deconfounded Thompson sampling, (DTS) which makes critical modifications to the way Thompson sampling is usually applied. Our results suggest DTS strikes a delicate balance between adaptivity and robustness to confounding. It attains asymptotic lower bounds on the number of samples required to confidently identify the best action --- suggesting optimal adaptivity --- but also satisfies strong performance guarantees in the presence of day-of-week effects and delayed observations --- suggesting robustness.

3 - Presenter

Xiuyuan Lu, Stanford University, Mountain View, CA, 94040, United States

4 - Regret Analysis Of A Markov Policy Gradient Algorithm For Multi-armbandits

Neil Walton, University of Manchester, Department of Mathematics, Manchester, M13 9PY, United Kingdom

We consider a policy gradient algorithm applied to a finite-arm bandit problem with Bernoulli rewards. We allow learning rates to depend on the current state of the algorithm, rather than use a deterministic time-decreasing learning rate. The state of the algorithm forms a Markov chain on the probability simplex. We apply Foster-Lyapunov techniques to analyse the stability of this Markov chain. We prove that if learning rates are well chosen then the policy gradient algorithm is a transient Markov chain and the state of the chain converges on the optimal arm with logarithmic or poly-logarithmic regret.

■ VWD20

Virtual Room 20

Management of Service Systems

Sponsored: Applied Probability Society

Sponsored Session

Chair: Vidyadhar Kulkarni, University of North Carolina-Chapel Hill, Chapel Hill, NC, 27599-3260, United States

Co-Chair: Wei Liu, University of North Carolina at Chapel Hill, United States

1 - Operational Linkages Between Covid-19 Testing Strategies And Patient Infections

Debjit Roy, Indian Institute of Management-Ahmedabad, Ahmedabad, India, Akash Gupta, Anand Nair, J. C. W. Van Ommeren

To limit transmission of virus and control outbreaks during pandemics such as COVID-19, rapid diagnostic testing is touted as an effective strategy. While health authorities have developed testing protocols, including testing priorities for vulnerable population, the effect of protocols on the volume of infections and the effective usage of swab analysis capacity at a public lab versus a private lab for testing mild and severe patient groups is unclear. Using stylized queuing models, we address the decision of appropriately allocating patient swab batches among analysis sites to minimize the spread of infections.

2 - Joint Staffing and Admission Control Problem Under Different Levels of Information

Wei Liu, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Vidyadhar Kulkarni

We consider a joint staffing and admission control problem in a multi-server queueing system under three different levels of information, namely minimal, partial and full information about the state of the queueing system. Our major contribution lies in the combination of the admission control, staffing problem, and information levels. The system earns a unit reward from serving a customer if her queueing time is no more than a fixed threshold and each server costs a fixed amount per unit time. Under each information case, we derive the optimal admission policy and optimal staffing level by maximizing the profit. We also study the criterion of maximizing the revenue rate per server and show the connection between these two criteria in determining the optimal staffing level. Finally, we compare the system performance under different levels of information.

3 - Dynamic Dispatch And Centralized Relocation Of Cars In Ride-hailing Platforms

Nasser Barjesteh, University of Toronto, Toronto, ON, M5S 2E8, Canada, Baris Ata, Sunil Kumar

We consider a ride-hailing platform that seeks to maximize its profit by dynamically dispatching cars to pick up customers and centrally relocating cars from one area to another. We model the platform as a closed stochastic processing network. We use an approximate analysis in the heavy-traffic regime and consider the resulting Brownian control problem. The Brownian control problem is equivalent to a lower-dimensional control problem referred to as the equivalent workload formulation. We propose an algorithm to solve the equivalent workload formulation numerically and a dynamic control policy for the ride-hailing platform by interpreting the solution to the equivalent workload formulation in the context of the original ride-hailing system. We demonstrate the effectiveness of the proposed policy using a simulation study.

4 - Advance Selling And Upgrading In Priority Queues

Yaolei Wang, University of Science and Technology of China, Hefei, China, Ping Cao, Jingui Xie, Dongyuan Zhan

In this paper, we study upgrading in a priority queue setting with advance selling that has emerged in the park industry. Customers who purchase advance fast-track tickets suffers the demand uncertainty later when they consume the service. At the park gate, customers can observes the demand and decide whether to purchase the regular or fast-track tickets. They can also purchase regular tickets in advance and upgrade to fast-track tickets on the spot. We find that when there is no demand uncertainty, advance selling only scheme is optimal; when the uncertainty is large, spot selling only scheme is optimal; only when the uncertainty is medium, advance selling with upgrading option scheme is optimal. We also find that allowing the upgrading option is no less profitable than forbiding upgrading option. Finally, we investigate the advance selling with downgrading option scheme.

5 - Engine Failure Forecast Model For Saving The Operating Cost: A Case Of American Airlines

Nicolas Rosal, University College London School of Management, London, United Kingdom, Lina (Dahye) Song

We quantify the impact of applying an engine failure forecast model on the airlines' maintenance operating cost. We first compare the performances of existing engine failure forecast models and find that: (a) a stacking model with an XGBoost estimator performs best with 99.9% accuracy and 0% no-fault-found rate, and (b) engine pressure ratio (epr) is a key variable for predicting the engine failure. We then use American Airlines as a case study, where we quantify that applying a failure forecasting model can save up to $1.16 billion per year on maintenance expenses.

■ VWD22

Virtual Room 22

Maintenance Modeling and Risk Assessment for Technical Systems

Sponsored: Quality, Statistics and Reliability

Sponsored Session

Chair: Cristiano Cavalcante, Universidade Federal de Pernambuco, Recife Pernambuco, 52070-080, Brazil

Co-Chair: Marcelo Hazin Alencar, Universidade Federal de Pernambuco, Recife, 52050100, Brazil

1 - Modeling The Impact Of Assets On Business Strategies

Roberta Barbosa da Silva, Federal University of Pernambuco (UFPE), Recife, Brazil, Adiel Teixeira de Almeida, Ana Paula Cabral Seixas Costa

A well-established strategy and an efficient monitoring of aspects that influence the achievement of the outlined goals of an organization, are essential to reach business success. This includes focus on the efficiency of Asset Management (AM). Even though researchers argue that asset-intensive organizations manage assets to maintain and improve competitive advantages, there isn't a structured procedure to evaluate and quantify this relation, remaining the impact of physical assets on business, a topic under explored in the literature. In this sense, this research proposes a model that relates assets, process and strategic goals of an organization, providing a structured way to evaluate the impact of assets on business strategy, making it possible to prioritize actions and allocate resources for assets.

2 - Using Data Mining for Knowledge Extraction in Maintenance Database

Rafael Gomes Nobrega Paiva, Universidade Federal de Pernambuco, Recife, Brazil, Yan Melo, Cristiano Cavalcante, Vinícius A.S. Tenório

Data mining has been used in many industrial applications in the search for knowledge extraction from large databases. In maintenance, such databases are still rare, but we can see the number of sensors and controllers in the machines growing over time. These devices collect data that can be extremely useful for maintenance management when treated properly. Therefore, this study seeks to apply data mining through two distinct techniques (Association Rules and Sequential Pattern Mining) in a manufacturing system maintenance database. We intend to find insights into the critical system and thus define the most appropriate maintenance actions for a maintenance policy based on the delay time model.

3 - A Deep Reinforcement Learning Based Model For Maintenance Optimization In Systems Subjected To Quality Degradation

Hanser Jiménez, Federal University of Pernambuco, Recife, Brazil, Cristiano Cavalcante, Phuc Do

We propose a model for the maintenance optimization of multi-state, multi-component systems subjected to quality degradation. The model is based on a Deep Reinforcement Learning (DQN) algorithm coupled to three Deep Neural Networks (DNN) that enables optimizing the long-term system performance. The associated DNNs allows uncovering the relation between maintenance actions, and expected quality and reliability performance from real data. The model fulfills a gap in the literature, in which models study one-single-component systems for which the quality degradation can always be explained by assignable causes, i.e., one-to-one defect and component association.

4 - A Novel Multi-Attribute Model For Enhancing Risk Prioritization In Networks Of Natural Gas Pipelines With Rank-Dependent-Utility

Lucas Borges Leal da Silva, PhD Student, Federal University of Pernambuco (UFPE), Recife, Brazil, Cristina Pereira Medeiros, Marcelo Hazin Alencar, Adiel Teixeira de Almeida

Promoting safety and efficiency when transporting or distributing natural gas in pipelines is a challenging task because this is a risky activity. Under a multidimensional perspective, this paper introduces a new multidimensional decision model that considers human, environmental, and financial aspects to assess NGP risks with non-expected utilities (non-EU). The new model explores deviations of linear preferences with Rank-Dependent-Utility, and covers the limitations usually found in EU-based models. An in-depth analysis that uses statistical and simulation tools is made of the results from a case study. This analysis indicates that the model generates recommendations that are more assertive than other models with regard to prioritizing NGP risks.

■ VWD23

Virtual Room 23

Quality Management

Contributed Session

Chair: Yanjun Qian, Virginia Commonwealth University, Glen Allen, VA, 23060, United States

1 - VAE-CUSUM: A New Feature-based Monitoring Chart To Monitor Vessel Voyages Using Ais Data

Kwonin Yoon, UNIST, Ulsan, Korea, Korea, Republic of, Sungil Kim, Jaemin Park

This paper proposes a feature-based monitoring chart, VAE-CUSUM, based on a novel monitoring statistic combining a feature extracted from a variational autoencoder (VAE) and a monitoring statistic from a cumulative sum (CUSUM) control chart. The proposed method was validated using simulated and real-world automatic identification system (AIS) data concerning the trajectory of a vessel captured by a satellite. A comparison study was carried out with the existing benchmarks, which revealed a superior detection performance and robustness of the proposed method.

2 - Modeling And Monitoring Of A Multivariate Spatio-temporal Network System

Di Wang, Shanghai Jiao Tong University, Shanghai, China, Fangyu Li, Kaibo Liu

With the development of information technology, various network systems are created to connect physical objects and people by sensor nodes or smart devices. However, network systems are vulnerable to attacks due to the integration of physical objects and human behaviors as well as complex spatio-temporal correlated structures of the network systems. To ensure information security, this paper develops a multivariate spatio-temporal modeling and monitoring methodology for a network system by using multiple types of sensor signals collected from the network system, in which we integrate a Multivariate Spatio-Temporal Autoregressive (MSTA) model and two spatio-temporal control schemes.

3 - A Sequence Graph Transform Based Method For Monitoring Discrete Sequence Processes

Meserret Karaca, University of Florida, Gainesville, FL, United States, Chitta Ranjan, Mostafa Reisi-Gahrooei, Michelle M. Alvarado, Panayote (Panos) M. Pardalos

A discrete sequence is an ordered series of discrete events. It is becoming customary to monitor the sequence processes for anomaly detection. In this study, we propose a monitoring methodology that uses sequence graph transforms (SGT). SGT is a feature extraction technique for sequences. It extracts the sequence pattern characteristics by utilizing the relative positions of alphabets in it. In this study, we bring our monitoring methodology to the experimentation using simulated and real-life datasets. Finally, we show our results in terms of accuracy and the anomaly detection time compared to existing methods such as Chi-Square monitoring and hidden Markov models.

4 - Automatically Monitoring Slug-flow Process Of Continuous Crystallization

Yanjun Qian, Virginia Commonwealth University, Richmond, VA, United States,

In this project, we investigated the slug-flow process of continuous crystallization in pharmaceutical manufacturing. This project consists of three parts. First, we applied the Gaussian mixture model for the foreground extraction to detect moving slugs inside a tube. Then, a neural network (U-Net) was trained to detect the locations of those crystals, and the overlapped crystals were segmented based on the Canny edge detector. At last, we obtained a robust size distribution from the measurement results and monitored the crystallization process.

■ VWD24

Virtual Room 24

Reliability

Contributed Session

Chair: Jingbo Guo, Metuchen, NJ, 08840, United States

1 - Towards Evaluating A Condition Monitoring System: Key Elements As Part Of Asset Risk Management

Mehdi Dadfarnia, National Institute of Standards & Technology, Chevy Chase, MD, United States

Knowledge of a tool's value to an industrial asset can dispel user hesitancy and facilitate the tool's adoption. Yet, this value is often difficult to assess. In the same vein, despite their increasing availability, the adoption of Artificial Intelligence-based (AI) condition monitoring systems (CMSs) suffers from their obfuscated internal logic. CMSs can mitigate asset risks and costs, but measuring this impact lacks any standard procedure. This presentation highlights the key elements that contextualize a CMS's role within the asset and its risk management processes. The context provides the means to evaluate the risk-reducing impacts that a CMS option has on the asset.

2 - Condition-based Maintenance Of Degradation-threshold-shock Model For Systems With Degradation Processes

Minjae Park, Professor, Hongik University, Mapo-Gu, Korea, Republic of,

A condition-based maintenance strategy is developed for systems subject to two dependent causes of a failure such as degradation and random shock. Degradation level may jump to the degradation limit for the replacement service or/ and may increase to the other degradation limit for repair service. In this study, we consider not only the degradation process but also random shock model and decision variables are determined for the degradation threshold shock model. Suppose that the system deteriorates with age, we illustrate the proposed approach using numerical applications and investigate the influence of relevant parameters on the optimal solutions for the maintenance policy.

3 - Time-to-event Analysis Of Product Reliabilities In The Discrete Two-dimensional Space

Young H. Chun, Professor of Decision Science, Louisiana State University, Baton Rouge, LA, United States, Seong-Jong Joo

As in the 5-year, 50,000-mile warranty plan in the US automobile industry, the product reliability is often measured in terms of more than one attributes. The number of failures of military aircrafts is dependent on the number of training and combat missions. In this paper, we propose a time-to-event model to measure the product reliability in the two-dimensional space. We consider various survival models such as the Kaplan-Meier estimation method, discrete-time Weibull model, and the proportional odds model. Finally, we measure and compare the product reliabilities of 33 military aircrafts in the US Air Force during 5,065 sorties of training and combat missions in the 38-month time period.

4 - Reliability Estimation Of Spherical Balanced Systems

Jingbo Guo, Rutgers University, Metuchen, NJ, United States, Elsayed A. Elsayed

Balanced systems with spherically distributed units are used in a wide range of industries. For example, Spherical Unmanned Vehicles (SUV) with rotors arranged on the spherical surface are used in oceanography and nuclear detections. In such systems, at least a certain number of rotors are required to work in a balanced arrangement for the system to operate properly. The system reliability depends on both individual rotors' reliability and spatial locations among them. In this presentation, we develop efficient algorithms to estimate the reliability of such systems.

■ VWD25

Virtual Room 25

Empirical Operations Management - Job Market Candidates

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Bradley R Staats, University of North Carolina at Chapel Hill, Chapel Hill, NC, 27599-3490, United States

Co-Chair: RJ Niewoehner, UNC Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States

1 - Mitigating The Negative Effects Of Customer Anxiety Through Access To Human Contact

Michelle A. Shell, Boston University, Dover, MA, 02030-1820, United States

Through a series of lab and field experiments, conducted in the high-anxiety domain of financial services, we document the negative effects of anxiety on customer performance and demonstrate how providing customers with access to human contact can improve customers' willingness to engage, elevate choice satisfaction and engender trust in companies.

2 - Searching for the Best Yardstick: Cost of Quality Improvements in the U.S. Hospital Industry

Jong Myeong Lim, The Wharton School, Philadelphia, PA, 19104, United States, jongmlim@wharton.upenn.edu, Kenneth Moon, Sergei Savin

The Hospital Value-Based Purchasing (VBP) Program is Medicare's implementation of yardstick incentives applied to hospitals in the U.S. Under the VBP Program, 2% of all Medicare payments, estimated to be US$1.9B in FY2021, are withheld and redistributed based on relative performance in the quality of delivered care. We develop a dynamic equilibrium model in which hospitals are engaged in a repeated competition under yardstick incentives. Using structural estimation methods, we recover key parameters that govern hospitals' decisions to invest in quality improvement, including the financial and non-financial costs and uncertain outcomes of investment. Our counterfactual analyses explore the benefits, on the one hand, of modifying the overall size of the yardstick incentives and, on the other hand, of implementing a more focused program tailored to hospital type.

3 - Effect of Workforce Fragmentation on the Erosion of Relational Care Continuity

Harshita Kajaria-Montag, University of Cambridge, Cambridge, CB3 0JE, United Kingdom, Michael Freeman

Primary care is facing a workforce crisis, which poses a critical challenge for primary care managers: how can a shrinking clinical workforce manage the increasing demand for primary care services? Most primary care practices have focused on improving daily throughput, but this has led to a decline in continuity of care (COC) which has the potential to improve clinical productivity and shown to drive better patient health outcomes. However, there is little understanding of the key levers to deliver COC. We fill this gap by empirically examining the workforce factors that explain the decline in COC by using a dataset consisting of all PCP consultations for approximately 10% of UK's population over 10 years. Using a system GMM approach, we show that workforce fragmentation and diversity can explain almost 40% of the decline in COC. We discuss the implications for practice managers.

4 - Focusing Provider Attention: An Empirical Examination Of Incentives And Feedback In Flu Vaccinations

RJ Niewoehner, UNC Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States, Bradley R. Staats

Influenza imposes heavy societal costs through healthcare expenditures, missed days of work, and numerous hospitalizations each year. Considering these costs, the healthcare and behavioral science literature offers suggestions on increasing patient demand for flu vaccinations. And yet, the adult flu vaccination rate fluctuated between 37% and 46% between 2010 and 2019. In this paper, we investigate how to improve clinic vaccination rates by altering provider behavior. We implement and study a flu vaccine intervention among 145 clinics from 9 different states. We find clinics that received relative performance feedback outperformed all others. Moreover, we also find clinics in this group exhibit rank response behavior, specifically Last-Place Aversion. Overall, we find that clinic-level performance feedback can effectively drive operational improvement.

■ VWD26

Virtual Room 26

Learning and Dynamic Pricing

Sponsored: Manufacturing and Service Operations Management

Sponsored Session

Chair: Jussi Keppo, National University of Singapore, National University of Singapore, Singapore, 119245, Singapore

1 - Incentive Design And Pricing Under Limited Inventory

Ruiting Zuo, National University of Singapore, 38Singapore, 138601, Singapore,Jussi Keppo, Tinglong Dai

We consider an airline company that sells tickets for its flight. To boost the demand, the company hires a sales agent who exerts unobservable effort over time in response to a dynamic compensation contract offered by the airline company. The company is concerned not only about utilizing its capacity, but also about loss of goodwill when the realized demand exceeds its capacity. We model the company's dynamic compensation and pricing problem using a continuous-time principal-agent framework. The dynamic strategy depends on the random demand, remaining capacity level, and the time to the departure. Under the estimated model parameters and optimal dynamic pricing, the optimal static compensation scheme provides the airline company with over 99% of the benefits derived from the corresponding optimal dynamic compensation scheme.

2 - Learning And Earning With Offline Data

Hong Ming Tan, National University of Singapore, Singapore, 127146, Singapore, Jussi Keppo, Chung-Piaw Teo, Minglong Zhou

We study the effect of offline data on online learning and pricing when the demand function is unknown. The decision maker uses Bayesian updating and seeks to maximize her total two period expected revenue. We show that the optimal price is greater or equal to the corresponding myopic price. We also show that higher prices improve learning. Finally, to show the effect of offline data, we study how the prior belief affects the optimal expected revenue.

3 - Diffusion Approximations For A Class Of Sequential Learning Problems

Rene A. Caldentey, The University of Chicago, Booth School Of Business Chicago, IL, 60637-1656, United States, Victor Araman

We consider a decision maker who must choose an action in order to maximize a reward function that depends also on an unknown parameter. The decision maker can delay taking the action in order to experiment and gather additional information on the unknown parameter. We model the decision maker's problem using a Bayesian sequential experimentation framework and use dynamic programming and diffusion-asymptotic analysis to solve it. For that, we scale our problem in a way that both the average number of experiments that is conducted per unit of time is large and the informativeness of each individual experiment is low. Under such regime, we derive a diffusion approximation for the sequential experimentation problem, which provides a number of important insights about the nature of the problem and its solution.

4 - Dynamic Pricing Under Risk Aversion And Demand Learning

Meichun Lin, University of British Columbia, Vancouver, BC, V6R 1V2, Canada, Woonghee Tim Huh, Michael Jong Kim

We consider a firm that sequentially sets prices and learns the unknown demand of a product from sales data over a finite selling season. A risk-neutral firm is typically assumed in the literature. In this paper, we study a risk-averse firm and investigate the effects of risk aversion and demand learning on the firm's pricing decisions. We measure risk aversion using conditional value-at-risk and adopt the concept of a dynamic risk measure to model the problem as a Bayesian dynamic program. Structural properties of the value function and the optimal policy are derived, which provide insights into the classical trade-off between learning and earning. Moreover, we show that there can be a negative value of learning under risk aversion, which is in contrast to the risk-neutral problem.

5 - Learning To Stop With Surprisingly Few Samples

Tianyi Zhang, Columbia University, New York, NY, United States, Daniel Russo, Assaf Zeevi

We consider a discounted infinite horizon optimal stopping problem. If the underlying distribution is known a priori, the solution is obtained via dynamic programming (DP) and is given by a threshold rule. When information on this distribution is lacking, a natural approach is "explore-then-exploit," whereby the distribution are estimated over an initial exploration phase, and this estimate is then used in DP to determine actions over the residual exploitation phase. We show: (i) this approach leads to performance comparable to the full information DP solution; and (ii) despite common wisdom on the sensitivity of such "plug in" approaches in DP, a "short" (logarithmic in the horizon) exploration horizon suffices to obtain said performance. In cases where the underlying distribution is heavy-tailed, it can be more pronounced: a single sample exploration phase suffices.

■ VWD27

Virtual Room 27

Operations Management II

Contributed Session

Chair: Yike Hu, United States

1 - Proposal Evaluation Approaches And Supplier Performance

Beverly Osborn, PhD Candidate, The Ohio State University, Columbus, OH, United States, osborn.259@osu.edu, John V. Gray

We use a matching design to study the effects of proposal evaluation procedures, criteria, and their relative weighting on supplier performance by combining U.S. government data on contract awards with data extracted from the corresponding RFP documents. Our performance measure, recontracting, captures subjective and difficult to measure aspects of supplier performance. Our results are relevant for policymakers, buyers, and potential suppliers.

2 - Dynamic Retail Network Expansion In A New Market

Hongmiao FAN, Tsinghua University, Beijing, China, Shizhan Gong, Chen Mavis Wang, Zuo-jun Max Shen

Expansion of retail networks in second-tier cities is a new trend, and the store opening strategy should make a trade-off between learning the market structure and maximizing the long-term sales. This task constitutes a dynamic subset selection problem, with the novel feature that once a store location is selected it cannot be removed from the subset. We propose an online learning and optimizing policy for the retail network expansion problem, and conduct regret analysis to ensure efficiency of the proposed policy. We further extend the modeling and algorithm to capture cannibalization effects between nearby stores.

3 - Robust Remanufacturing Planning With Parameter Uncertainty

Zhicheng Zhu, Texas Tech University, Lubbock, TX, United States, Yisha Xiang, Yue Shi, Tong Li

We consider the problem of remanufacturing planning in the presence of statistical estimation errors. We model this problem as a robust Markov decision process, where the true system transition probability is assumed to be unknown but lie in an ambiguity set that consists of all possible realizations. We further establish structural properties of optimal robust policies and insights for two types of ambiguity sets: phi-divergence and Wasserstein distance. A computational study on the NASA turbofan engine shows that our data-driven decision framework consistently yields better worst-case performances and higher reliability of the performance guarantee.

4 - Optimal Level Design in Video Games

Yifu Li, Assistant Professor, Xi'an Jiaotong-Liverpool University, Suzhou, China, Christopher Ryan, Lifei Sheng

Retention of players is a key of successful video games, which hinges on the quality of the game's design. An important design question is how to sequence game elements within a level of the game. Each element has two features: reward and difficulty. We study the sequencing problem to maximize the remembered utility of the level subject to accomplishment and stress. We find that the optimal design depends on the reward rate. When the reward rate is high, the optimal design mimics that of passive experiences. When the rate is low, it resemble a game with ``warm-ups'' and ``cool-downs''. Intermediate cases follow the ``mini-boss, end-boss'' design where one peak is in the middle and another is at the end.

5 - Operation-oriented Generative Model Of E-commerce Orders For Stowage In Mobile Fulfillment Systems

Yike Hu, Tsinghua University, Beijing, China, Chen (Mavis) Wang

The robotic mobile fulfillment system provides operational flexibility for storage of enormous and volatile e-commerce orders. Inspired by the topic modeling in natural language processing, we treat inventory pods carrying SKUs like topics composed of words. We introduce pod capacity constraints to the generative model of e-commerce orders, and show the duality between the pod visit minimization problem and the novel operation-oriented generative model. Furthermore, we design an online algorithm to capture the dynamics in order structure and validate our model using real e-commerce orders.

■ VWD28

Virtual Room 28

Commodity risk management with focus on agricultural operations

Sponsored: MSOM/iForm

Sponsored Session

Chair: Danko Turcic, University of California, Riverside, CA, 92521-9800, United States

Co-Chair: Panos Kouvelis, Washington University in St. Louis, St. Louis, MO, 63130, United States

1 - Blockchain Technology In Agriculture: Tipping The Farmers And Its Implications

Saed Alizamir, Yale University, New Haven, CT, 6520, United States, Basak Kalkanci, Foad Iravani

We examine an emerging financial innovation in agricultural supply chains that is enabled by the Blockchain technology. This innovation empowers socially-conscious customers to identify the individual farmers of their sustainably-sourced products and send them direct payments, or tips, through mobile apps. We investigate the implications of this new capability on farmers' and consumers' welfare and agricultural firm profits. We show that farmers' expected and actual income and consumer welfare may reduce in the presence of tipping if certain conditions on model parameters hold. In contrast, if tipping is implemented under the right conditions, it can create a triple win for agricultural firms, farmers, and consumers.

2 - Agricultural Networks In Emerging Markets: A Supply Chain Approach

Jian Li, Northeastern Illinois University, Chicago, IL, 60625-4625, United States, Panos Kouvelis, Maqbool Dada

We study the development of effective agricultural supply networks in emerging economies for better utilization of land and downstream processing resources for harvested goods. Using the cotton sector of Mozambique as a prototypical example, we study the decisions made by farmers, downstream processors and government officials in agribusiness supply networks (agri-networks). The structure and management of the supply network, associated sourcing rights of downstream processors, and government minimum price guarantees to farmers affect the performance of these chains and are in the domain of our study.

3 - Stochastic Capacity Investment In The Presence Of Production Resource Uncertainty And Its Implications For Hedging

Onur Boyabatli, Singapore Management University, Lee Kong Chian School Of Bus. Singapore, 178899, Singapore, Guiyun Feng

We consider a single-product firm that invests in capacity in anticipation of demand and production resource (e.g., working capital or product component) uncertainties. The firm can also use hedging to engineer the distribution of production resource at the capacity investment stage. We examine how production resource variability and the correlation between two uncertainties shape the optimal capacity level, hedging decision and profitability.

4 - Managing Operations Of A Hog Farm Facing Volatile Markets: Inventory And Selling Strategies Of The Maschhoffs

Ye Liu, Washington University in St. Louis, St. Louis, MO, 100081, United States, Panos Kouvelis, Yunzhe Qiu, Danko Turcic

We study the problem of a wean-to-finish hog farmer who gets to see how market-ready hogs she has available at the beginning each week for sale and the current market prices. Then, she must decide how many hogs to sell through to a meatpacker and on the open market. We view the farmer's problem as a dynamic, multi-item inventory model with random yields and prices. We show that there are two thresholds: one for the under-weight and the other for the regular-weight hogs. Whenever the number of animals in a particular weight pool is below that threshold, the farm should do nothing. When the number of market-ready animals exceeds that threshold, the farm should sell the excess on the open market or to the meatpacker, depending on the prevailing market prices. Calibrated numerical experiments show that the optimal policy has around 25% improvement over the existing practice.

■ VWD29

Virtual Room 29

Fintech and OM-Finance Interface

Sponsored: MSOM/iForm

Sponsored Session

Chair: Andrew Wu, Ross School of Business, University of Michigan, United States

1 - Blockchain Monitored Debt And Capital Structure Under Moral Hazard

Jie Ning, Case Western Reserve University, Cleveland, OH, 44106-3922, United States, Peter Ritchken

The unobservability of the borrower's action is a major reason that smaller enterprises face high financing costs and credit rationing. We show that bank loans, fully monitored by blockchain, allow poor firms with low working capital to eliminate the agency cost. Interestingly, this is achieved via financing all production using fully monitored debt and leaving all internal capital unused. The reason is that internal capital is unmonitored so the use of it creates unobservability and moral hazard, whereas all-debt financing provides full transparency of operations. Rich firms, however, find it costly to eliminate moral hazard via transparency and use a mix of internal capital and debt to finance production. We show that there exists a working capital level at which a firm is indifferent between using the all-debt or mixed strategy for financing production.

2 - Multi-tier Supply Chain Financing with Blockchain

Yoko Shibuya, Stanford, CA, United States, Volodymyr O. Babich

We compare Blockchain-based Supply Chain Finance (BCF) with traditional bank-based Supply Chain Finance (SCF). The key advantage of BCF is its ability to create claims to collateral assets at higher supply chain tiers, while SCF allows only claims to assets of the immediate buyer. Interestingly, BCF does not emerge as the dominant financing choice even if the immediate and higher-tier buyers are identical in their operational and financial characteristics. We identify two causes that explain this result: risk spillover and accumulation of noise in the collateral asset. We also provide conditions for the BCF to be preferred to SCF.

3 - Measuring Utility and Speculation in Blockchain Tokens

Andrew Wu, Ross School of Business, University of Michigan, Ann Arbor, MI, United States, John Silberholz

■ VWD30

Virtual Room 30

Data-Driven Healthcare Operations Management

Sponsored: MSOM/Service Operations

Sponsored Session

Chair: Jing Dong, Columbia University, New York, NY, 10027-6945, United States

Co-Chair: Carri Chan, Columbia Business School, New York, NY, 10027-6945, United States

1 - Hospitalization Versus Home Care: Balancing Mortality And Infection Risks For Hematology Patients

Mor Armony, New York University, 100 Bleecker St Apt 29d, New York, NY, 10012-2208, United States, Galit Bracha Yom-Tov

Hematology patients are susceptible to life-threatening infections post-treatment. Hence, their length of stay (LOS) optimization must balance patient infection and mortality risks. The former is reduced by minimizing hospital stay, while the latter is reduced by maximizing hospital stay, whereby infections can be identified and treated earlier. We develop a Markov decision process formulation to explore the impact of the infection and mortality risks on the optimal LOS from a single-patient perspective. We further consider the social optimization problem in which capacity constraints limit the ability of hospitals to keep patients for the entirety of their optimal LOS.

2 - Adaptive Clinical Trial Designs with Surrogates: When Should We Bother?

Arielle Elissa Anderer, The Wharton School, Wynnewood, PA, 19096-2455, United States, Hamsa Sridhar Bastani, John Silberholz

Surrogate outcomes have long been used in clinical trials when the true outcome of interest is expensive, time consuming, or otherwise difficult to measure. In this work we propose optimal adaptive clinical trial designs that integrate surrogate and true outcomes, and we analytically and empirically characterize regimes where our designs are especially beneficial.

3 - Prediction-driven Surge Planning With Application In The Emergency Department

Yue Hu, Columbia University, New York, NY, 10027-3203, United States, Carri Chan, Jing Dong

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.

4 - Optimal Staffing Levels For Emergency Departments

Gokcen Goksel, London Business School, London, United Kingdom, Nicos Savva, Tolga Tezcan

We consider the problem of determining the number of staffed beds in emergency departments (EDs) in different points in time, to minimize average waiting times of patients for a fixed budget. The system is modelled as a time-inhomogeneous multi-server queueing system (Gt/G/nt) with multiple patient classes with nonpreemptive priority. We develop a new queueing approximation which enables us to model the staffing problem as a sample-based linear program, by the means of sample average approximation and discrete approximations. We demonstrate the performance of our approach via extensive numerical experiments where parameters of the models are estimated from a real ED data, and comparing with two other simulation-based optimization techniques. Our algorithm results in consistent near-optimal solutions for reasonably small computational times in all test scenarios.

■ VWD31

Virtual Room 31

Supply Chain Management III

Contributed Session

Chair: Yungeon Kim,

1 - Profit Maximizing Showcasing Product Portfolio Optimization In Omnichannel Retail Networks

Jisoo Park, Georgia Institute of Technology, Atlanta, GA, United States, Benoit Montreuil

We focus on an onmichannel setting in which customers prefer to visit an offline showroom to experience the products in person to gain sufficient confidence in their potential purchase. We propose a quantitative approach to optimize the showcasing portfolio for a given retailer to maximize the expected profit, considering the expected sales and cost of showcasing. We conduct a case study based on data obtained from 17 dealerships of a manufacturer of recreational vehicles. The numerical results show that the expected profit for a retailer following customers' visits to a showroom can significantly increase, even in the presence of spatial and/or budget constraints.

2 - Supply Chain Viability During Pandemic

Yasamin Salmani, Bryant University, Smithfield, RI, United States, Amin Ariannezhad

Companies respond differently to the pandemic: some sink into bankruptcy, some resist the shock, and some get better. In this study, utilizing a data-driven approach, we investigate the impacts of various established supply chain partner models on the resilience and viability of the companies in the context of the COVID-19 pandemic. We use the companies' performance data before and during the pandemic to address this problem.

3 - Managing Inventory Under Disruption Risk

Canan Gunes Corlu, Boston University, Boston, MA, United States, Bahar Biller, Elliot Wolf, Enver Yucesan

We evaluate stocking decisions in the presence of operational disruptions. We combine the newsvendor model capturing demand uncertainty costs with catastrophe models capturing not only the cost of supply disruption, but also the cost of recovery, to obtain insights for managing inventory in a supply chain under disruption risk.

4 - Data-Driven Distributionally Robust Supply Chain Contracting With Stock-Out Substitution

Xuejun Zhao, Purdue University, West Lafayette, IN, United States, William Haskell

We study supply chain contracting with stock-out substitution, when the supplier only has partial information about demand distribution obtained from the past demand realizations and retailer's ordering decisions. We propose a distributionally robust contract for the supplier to hedge against the risks of extremal demand distributions. The uncertainty set combines the information from the retailer's ordering decisions and the past demand realizations, based on the Wasserstein distance. We will show both analytical and computational properties of our new uncertainty set.

5 - Data-driven Robust Optimization For Closed-loop Supply Chain Under Time-dependent Uncertain Carbon Tax Rate

Yun Geon Kim, Yonsei University, Seoul, Korea, Republic of, Byung Do Chung

Most robust optimization studies for closed-loop supply chain design (CLSC) considering uncertain carbon tax are based on the premise that uncertain carbon tax is time-independent. This study proposes a novel uncertainty set that reflects time series pattern of uncertain parameter when uncertain carbon tax follows time-dependent autoregressive process. Tractable robust counterpart is derived and the performance of the proposed method is evaluated with a multi-period CLSC design problem.

■ VWD32

Virtual Room 32

Supply Chain & Operational Risk Management

Sponsored: MSOM/Supply Chain

Sponsored Session

Chair: Youngsoo Kim, University of Alabama, Tuscaloosa, AL, 35487, United States

1 - Presenter

Vadim Glinsky, Kellogg School of Management, Evanston, IL, 60201-4428, United States, Sunil Chopra, Florian Lucker

In many industries, future demand is driven by past sales, and the inability to sell today can decrease future market size. While the dependence of demand on sales has been addressed in several streams of Operations literature, such a setting has not been studied in the disruptions literature. We find that risk mitigation strategies become quite different from those presented in the existing disruptions literature. For example, there may exist distinct values of probability of disruption, at which the order quantity from an unreliable supplier increases in probability of disruption, when the OEM either single or even dual sources from the unreliable and reliable suppliers. Our study is particularly relevant nowadays as many industries where future demand is driven by sales (i.e. consumer electronics) frequently experience supply disruptions.

2 - The Role Of Real-time Event Monitoring In Dynamic Response To Disruptions

Shailesh Divey, Rensselaer Polytechnic Institute, Troy, NY, 12180-2075, United States, Mert Hakan Hekimoglu, T. Ravichandran

This study examines the benefits of real-time monitoring of disruption events and how such monitoring capabilities influence the optimal response strategies to disruptions. Prior research sheds light on the benefits of disruption mitigation where mitigation is typically characterized in the form of either reduced likelihood of a disruption occurring or shorter time-to-recovery following a disruption. However, in practice, it may not be always possible to proactively dodge a disruption or resolve it quickly. Furthermore, it is challenging to predict from the get-go how long a disruption will last, and a firm's initial belief can become significantly off while the event unfolds. Using a two-stage stochastic program, we show the benefits of real-time monitoring capabilities coupled with dynamic response strategies.

3 - Concurrent Sourcing Under Supply And Demand Uncertainty

Bryant Cassidey, University of Alabama, Tuscaloosa, AL, United States, Nickolas K Freeman, Sharif Melouk

A central question in the supply chain strategy literature related to Supply Chain Risk Management (SCRM) asks how a firm should delineate its boundary with respect to goods composing a product or service it offers. We investigate the setting in which a firm may choose to make and buy components used to manufacture finished goods (concurrent sourcing), and determine the optimal decision strategy under uncertain supply and demand. For simplicity, we assume supply is uncertain in an all-or-nothing manner: either the supply is totally disrupted or not. We show that the optimal strategy follows a threshold structure defined by problem parameters. We also investigate the effect of concurrent sourcing on the supplier's optimal pricing strategy. Our analysis highlights the conditions under which a manufacturer and a supply chain system benefit the most from concurrent sourcing.

4 - Impact Of Ransomware Attacks On Healthcare Systems

Youngsoo Kim, University of Alabama, Tuscaloosa, AL, 35487, United States, Ming Zhao, Nickolas K Freeman

Advances in health IT systems have helped healthcare organizations to pave the way for more effective patient treatment. However, such IT developments have also made the healthcare industry more vulnerable to cyber attacks called ransomware. Utilizing a unique dataset that captures two ransomware attacks experienced by large U.S. hospitals, we employ a difference-in-differences regression design to examine the causal impact of ransomware on ambulance performance measures. Furthermore, we investigate the effectiveness of mitigation strategies that may alleviate operational disruptions in healthcare systems caused by ransomware breach. Overall, our findings can help healthcare policymakers and administrators (e.g., government health officers, EMS directors, and hospital executives) to make informed decisions about cyber security risks.

■ VWD34

Virtual Room 34

Volunteer management policies

Sponsored: MSOM/Sustainable Operations

Sponsored Session

Chair: Mariana Escallon, Chicago, IL, 60657, United States

1 - Nonprofit Operations: Managing Volunteers And Paid Workers

Lei Li, Purdue University, West Lafayette, IN, United States, Gemma Berenguer, William Haskell

Nonprofit organizations run a workforce composed of a mix of volunteers, part-time workers, and full-time workers. We study this NPO's staffing problem to determine the optimal initial staff planning and per period hiring and assignment decisions given uncertain supply of volunteers and part-time workers. Our goal is to study how to solve this problem in a way that is effective and easy to implement. 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. These policies are, in fact, optimal under staff scarcity and staff sufficiency. We further suggest two easy-to-implement heuristics and observe that both heuristics have low relative optimality gaps.

2 - Efficiently Combining Centralized Scheduling Workforce And Self-scheduling Workforce

Mariana Escallon-Barrios, Northwestern University, Evanston, IL, 60657, United States, marianaescallon2023@u.northwestern.edu, Karen Smilowitz, Reut Noham

We present a model to efficiently combine two workforces, one that self-schedule (SSW) and one that is scheduled by a centralized planner (CSW), in order to meet organizational objectives and maintain a reliable, engaged workforce. Our approach first assigns CSW to the schedule, leaving ample slots available for SSW to choose from. We incorporate behavioral components such as preferences, satisfaction, and SSW reactions to unavailable time slots (i.e. spillover effects, which were analyzed via a choice exercise). We present a case study based on five years of operation data from an emergency response organization. We analyze the importance of incorporating behavioral components and how it can change the model solution.

3 - Attraction And Compromise Effects With Environmental Information

Mirel Yavuz, University of California-Los Angeles, Los Angeles, CA, United States, Guia Bianchi, Charles J Corbett, Tayler Bergstrom, Aimee Drolet, Timothy F. Malloy, Deepak Rajagopal, Rakesh K. Sarin, Francesco Testa

Although several tools have been developed to collect environmental and social information, there is currently minimal guidance on how to make decisions based on such information and accompanying trade-offs. Decision-makers are known to be subject to a wide range of biases and heuristics in other decision contexts. This experimental study aims to explore whether a selection of well-documented biases, namely the attraction and compromise effects, occur in the context of sustainability-related decision-making.

■ VWD35

Virtual Room 35

Electrical Markets II

Contributed Session

Chair: Santiago Maiz, CIUDAD REAL, 13071, Spain

1 - Computation Of Convex Hull Prices Using Dantzig-wolfe Decomposition

Panagiotis Andrianesis, Boston University, Brookline, MA, United States, Dimitris Bertsimas, Michael C. Caramanis, William W. Hogan

Several US ISOs have recently considered Extended Locational Marginal Prices as approximation to Convex Hull (CH) prices, mainly because determining exact CH prices is computationally challenging, while providing little intuition about the price formation rationale. We describe the CH price estimation problem by relying on Dantzig-Wolfe decomposition and Column Generation as a tractable, highly parallelizable, and exact method, with finite convergence, which provides intuition on the underlying price formation rationale. We provide several stylized examples and realistic ISO-scale datasets to support scalability and validate proof-of-concept.

2 - Expansion Planning Of A Price-maker Virtual Power Plant In Energy And Reserve Markets

Santiago Maiz, Universidad de Castilla-La Mancha, Ciudad Real, Spain, santiagomaiz@gmail.com, Raquel García-Bertrand, Luis Baringo

We address the expansion planning problem of a virtual power plant (VPP) considering the possibility of building new assets such as conventional, renewable, and storage units. The VPP is modeled as a price-maker player that participates in energy and reserve markets altering the prices of these markets to its own benefit. Uncertainties in production levels of renewable units and up/down reserve deployment requests are addressed using a stochastic programming approach. Numerical results show the influence of the behavior of the VPP in the expansion decisions.

■ VWD36

Virtual Room 36

Large Scale Optimization

Contributed Session

Chair: Sai Krishna Kanth Hari,

1 - A Self-learning Hyper-heuristic Method For Strategic Mine Planning

Yassine Yaakoubi, McGill University, Montreal, QC, Canada, yassineyaakoubi@outlook.com, Roussos Dimitrakopoulos

To address the need for self-managed solution approaches that can tackle the production scheduling of large-scale industrial mining complexes without resorting to aggregation, a new self-learning hyper-heuristic is proposed. The proposed method is a multi-neighborhood simulated annealing algorithm used in conjunction with reinforcement learning (RL), where the selection of a perturbation (low-level heuristic) is made in self-adaptive learning. Several state-of-the-art agents have been implemented and incorporated into the RL framework. Results show the method's effectiveness on real-sized mining complexes reducing the number of iterations by 30-50% and computational time by 30-45%.

2 - Learn To Decompose: Enhancing Interdependent Infrastructures Resilience

Shima Mohebbi, George Mason University, Fairfax, VA, United States, smohebbi@gmu.edu, Babak Aslani

Providing timely resource allocation plans for disrupted interdependent infrastructures can expedite the recovery phase and enhance the systems resilience. This study aims to develop a hybrid approach based on the Gaussian Process (GP) and multi-objective evolutionary algorithm based on decomposition to design restoration plans for large-scale interdependent networks which are governed by several sectors. The GP module iteratively extracts valuable information from the current Pareto frontier to guide the search mechanism. We apply the framework to water-transportation networks in Tampa, FL. We also design a simulation analysis to evaluate the performance for different problems.

3 - An Odh|cplex Python Primer

Alkis Vazacopoulos, Optimization Direct, Inc., Harrington Park, NJ, United States, Robert Ashford

This short tutorial shows participants how to build a basic model using the DOCplex API in Python. This session includes setting the Python environment, reading data from a CSV or spreadsheet, creating variables, objective functions, 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|CPLEX API for Python, which improves solution times for large models.

4 - Linear Relaxations For Mixed Integer Nonlinear Programs In Natural Gas Transportation Networks

Sai Krishna Kanth Hari, Los Alamos National Laboratory, Los Alamos, NM, United States

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.

■ VWD38

Virtual Room 38

Energy Policy and Planning II

Contributed Session

Chair: Do-Hyeon Ryu, Postech, Pohang, Korea, Republic of

1 - Dynamic Adaptation Of Data-driven Uncertainty Sets For The Two-stage Robust Unit Commitment Problem Via Reinforcement Learning

Diego Jiménez, Master student, Universidad Técnica Federico Santa María, Valparaíso, Chile

Robust optimization models for the unit commitment problem are widely used on power systems scheduling since increasing penetration levels of renewable energy. Classical uncertainty sets define the robustness of the method as part of the preprocessing. This work proposes a solution scheme based on data-driven uncertainty sets, where adaptation parameters are dynamically calculated as a function of previous operation results. Reinforcement learning is used to achieve closed-loop operation. Experiments show the effectiveness of the proposed methodology against well-known non-adaptive strategies.

2 - Stochastic Unit Commitment Problem, An Analytical Approach

Carlos Olivos, Auburn University, Auburn, AL, United States, Carlos Olivos, Universidad Catolica del Norte, Antofagasta, Chile, Jorge F. Valenzuela

The stochastic unit commitment problem has been modeled using different approaches such as scenario generation, chance-constrained, and robust optimization. These methods tend to provide conservative solutions resulting in higher dispatching and commitment costs. We propose an analytical formulation of the expected dispatch and commitment costs resulting from the probability distribution function of the random load. The model is linearized through a piece-wise linear approximation and solved as a Mixed Integer Linear Program (MILP). The solution is verified by simulating and computing analytically the expected cost. Results, algorithms, and conclusions will be presented.

3 - Valuation Of An Option To Expand Generation And Transmission Capacities Under Demand Uncertainty

K. Jo Min, Iowa State University, Ames, IA, United States, Jay Ghodke, Nazia Nur, Cameron MacKenzie

Under the framework of real options, given that the demand follows a geometric Brownian process (GBM), we show how to value an option to add a generation unit in the network based on the optimal power flow and the locational marginal price. Utilizing the demand lattice discretized from the GBM process, we derive the economic consequences of costs to a bus with and without an additional power plant/transmission line. These in turn will lead to the computation of the value of an option to add a power plant/transmission line. How to utilize this value of the option for the electric power planning will be illustrated via numerical examples.

4 - A Study On The Effects Of Information Privacy Concerns And Electricity Usage Habits On The Acceptance Of Advanced Metering Infrastructure

Do-Hyeon Ryu, Postech, Pohang, Korea, Republic of, Kwang-Jae Kim

Advanced metering infrastructure (AMI) is a system to measure electricity usage in real time. Despite the benefits of AMI, its acceptance is being delayed due to some obstacles. First, the AMI could cause privacy invasion because it collects electricity usage information that may disclose the life pattern of the household. Second, consumers who regularly use a small amount of electricity would not need AMI. This study examines the effects of information privacy concerns and electricity usage habits on the acceptance of AMI using the structural equation modeling technique. The results would be useful for electric power companies to establish strategies for the AMI penetration in households.

■ VWD39

Virtual Room 39

Production & Scheduling II

Contributed Session

Chair: Guangrui Xie, PROS, United States

1 - Marginal Cost Pricing In Flow Shop Scheduling

Stanislaus Solomon, Assistant Professor of Supply Chain Management, Southern Illinois University=Edwardsville, Edwardsville, IL, United States, Kevin D. Sweeney, William A. Ellegood, Mitchell Millstein

In this research we use simulation to examine the performance of several priority scheduling rules in both total utility (value) created and make span for a flow shop where customer balking is allowed in response to shop congestion. In addition to developing two new priority scheduling rules based on marginal cost pricing, we also imbed a random choice utility model into the simulation model to more accurately mirror the customer's decision to use the flow shop or an alternative. We find that the optimal priority scheduling rule depends on the perspective of the decision maker.

2 - An Extended Supporting Hyperplane Algorithm Based On Monte Carlo Simulation For Flow-shop Scheduling Problem In Human-robot Collaboration With Joint Chance Constraints

Duo Wang, Tsinghua University, Beijing, China,

In this paper, we proposed an integrated optimization model combining resource allocation with flow-shop scheduling problem in uncertain environment of human-robot collaboration. We develops an extended supporting hyperplane (ESH) algorithm based on Monte Carlo simulation that provides an exact solution of CVaR reformulation without closed mathematical form and it is proven to be superior under various specifific parameters to well-known popular approaches: individual chance constraint programming, Bonferroni approximation and scenario-based approach. The experimental results show that our method has better effffect, stability and reliability than other mentioned methods.

3 - A Simulation Study On Optimal Production Planning With A Profit Risk Measure

Guangrui Xie, PROS, Houston, TX, United States,

In modern markets, the market prices of products are usually volatile and can pose risks of losing profit on manufacturers' production plans. We enhanced a traditional profit maximization model for production planning by considering the profit risk caused by product price uncertainty. We introduced a profit risk measure into the objective function through linearized profit variance calculation, hence the model maximizes profit at different risk aversion levels. We then simulated product prices using the Monte Carlo method based on real-world data and evaluated the enhanced profit maximization model. The enhanced model effectively reduced profit risk as compared to the traditional model.

■ VWD40

Virtual Room 40

Optimization Problems in Electricity Markets

Sponsored: ENRE/Other Energy

Sponsored Session

Chair: Maxim Bichuch, Johns Hopkins University, Baltimore, MD, United States

1 - Market Design And Multi-agent Learning In Peer-to-peer Energy Trading

Andrew Liu, Associate Professor, Purdue University, West Lafayette, IN, United States, Chen Feng, Zibo Zhao

While distributed energy resources (DERs), such as rooftop solar panels, are key to improve sustainability and resilience, they also present significant challenges to utilize them in a coordinated fashion. Peer-to-peer (P2P) energy trading within a distribution network to match supply (from DERs) and demand is one idea to better utilize DERs, and the trading can be realized via double auctions. However, we show that some distinctive features (such as zero marginal costs of renewable resources and known reservation prices) of an energy P2P market make double auctions less likely to work. Instead, we propose an alternative supply-demand ratio based matching mechanism and discuss its convergence to a mean-field equilibrium with multi-agent.

2 - Global-tep: A New Global Solver For AC Transmission Expansion Planning

Mahdi Mehrtash, University of British Columbia, Vancouver, BC, Canada, Yankai Cao

In this research, we propose a new global solver, named Global-TEP, for the transmission expansion planning problem with AC network representation (ACTEP), which is a mixed-integer nonlinear programming problem. The proposed solver is based on second-order cone relaxation, enhanced relaxation tightening constraints, and optimization-based/feasibility-based bound tightening techniques. As illustrated by numerical case studies, Global-TEP, which can solve the ACTEP efficiently with a guaranteed optimality gap, is more scalable, more flexible, and much faster than the available global solvers.

3 - Optimal Capacity Payment And Expansion Under Demand-side Risk

Xinyue Song, Johns Hopkins University, Baltimore, MD, 21210, United States, Maxim Bichuch, Benjamin Field Hobbs

The construction of capacity markets is important in maintaining grid stability and market efficiency. We propose a leader-follower game on optimal capacity and subsidy decision in a competitive market. The market faces a load consisting of heterogeneous stochastic individual demand. To promote extra capacity, the system operator grants a payment to energy suppliers for each unit of capacity added, aiming at that the suppliers voluntarily choose a utility-maximizing capacity such that the total outage probability is controlled and total market utility is maximized. We show equilibrium results of this hierarchical game and illustrative numerical examples calibrated to real-world data.

4 - Bidding Mechanisms And Incentive Analysis For Temporally-coupled Electricity Markets

Pengcheng You, Johns Hopkins University, Baltimore, MD, United States, Rajni K Bansal, Dennice Gayme, Enrique Mallada

This work studies competition among heterogeneous participants in temporally coupled markets. We first characterize the cross-time coupled incentives that each group of participants experience and develop bidding mechanisms that accurately convey preference, without revealing private information. We then characterize the strategic behavior of individual participants and investigate their joint impact on market conditions. Our analysis unveils the opportunities for participants to manipulate prices and exercise market power. Further, we evaluate the inter-group market power shift and identify cases where a particular group of participants has an edge over others in competition. This study highlights the importance of accounting for the interplay among heterogeneous participants and their extra flexibility endowed by market participation across time.

■ VWD41

Virtual Room 41

Machine Learning meets Discrete Optimization

Sponsored: Computing Society

Sponsored Session

Chair: Thiago Serra, Bucknell University, Lewisburg, PA, 17837-2005, United States

1 - Efficient Active Search For Combinatorial Optimization Problems

Kevin Tierney, Bielefeld University, Bielefeld, 33615, Germany, André Hottung, Yeong-Dae Kwon

Deep learning-based machine learning approaches have recently seen increasing success at solving difficult combinatorial optimization problems. Combining deep networks with effective search procedures has proven critical to finding good solutions. We propose three generic search strategies that can be combined with many neural network models extending the active search approach proposed in Bello et al. (2016). Our search strategies involve updating network weights or output probabilities while searching for a solution, thus allowing deep learning approaches to better generalize to problems they have not been trained on. Our approach offers significant performance improvements on two routing problems and the job shop scheduling problem.

2 - A Hierarchy Of Relaxations Between Big-m And Convex Hull Formulations

Jan Kronqvist, Imperial College London, Kensington, London, SW7 2RH, United Kingdom, Ruth Misener, Calvin Tsay

We present a new class of formulations in between the convex hull and big-M formulations for disjunctions, resulting in relaxations stronger than big-M and computationally cheaper than the convex hull. The proposed "P-split" formulations split convex separable constraints into P partitions and form the convex hull of the partitioned disjuncts. Under certain assumptions, the relaxations form a hierarchy starting from a big-M equivalent and converging to the convex hull. Several applications in machine learning have a disjunctive structure suitable for the P-split formulations, and computational results show that the new formulations can give significant computational advantages.

3 - Scaling Up Exact Neural Network Compression By ReLU Stability

Thiago Serra, Bucknell University, Lewisburg, PA, 17837-2005, United States, Abhinav Kumar, Srikumar Ramalingam, Srikumar Ramalingam

We can compress a neural network while exactly preserving its underlying functionality with respect to a given input domain if some of its neurons are stable. However, current approaches to determine the stability of neurons in networks with Rectified Linear Unit (ReLU) activations require solving or finding a good approximation to multiple discrete optimization problems. In this work, we introduce an algorithm based on solving a single optimization problem to identify all stable neurons. Our approach is on median 21 times faster than the state-of-art method, which allows us to explore exact compression on deeper (5 x 100) and wider (2 x 800) networks within minutes. For classifiers trained under an amount of L1 regularization that does not worsen accuracy, we can remove up to 40% of the connections.

4 - Discrete Black-box Optimization Using Mixed Integer Programming

Christian Tjandraatmadja, Google, Cambridge, MA, United States, j98
Theodore P. Papalexopoulos, Ross Anderson, Juan Pablo Vielma, David Belanger

Model-based Black-box Optimization (MBO) maximizes an expensive black-box function by iteratively refining a surrogate regression model, where the next point to query is selected by optimizing an acquisition function based on the surrogate model. This inner acquisition problem may itself be a challenging optimization problem, particularly when the domain is discrete and combinatorially constrained. In practice, Mixed-Integer Linear Programming (MILP) solvers are not only able to efficiently search over such domains, but can also globally optimize piecewise-linear acquisition functions. We propose a general framework for discrete MBO that combines MILP with neural networks as surrogate models. We test our approach on a range of unconstrained and constrained discrete problems, including DNA binding and the NAS-Bench-101 neural architecture search benchmark.

■ VWD42

Virtual Room 42

New Product Development

Contributed Session

Chair: Weihan Jia,

1 - Ai-assisted Multimodal Evaluation System For Design Assessment

Chenxi Yuan, Northeastern University, Boston, MA, United States,

Design concept evaluation is a key process in new product development with a significant impact on the product's success. In view of limited and biased concept evaluation caused by subjective judgment of designers, we propose a deep multimodal regression model as a potentially disruptive way to bridge this gap. Specifically, we develop a deep neural network enabling accurate and scalable prediction of overall and the attribute-level performance ratings of design concepts from product images and descriptions. We test and validate the model through experiments on a large footwear dataset with low MSE loss and high accuracy.

2 - Optimal Product Introduction Strategies Under Price Signals Of Quality

Yalan Zhu, Northwestern Polytechnical University, Xi'an, China, Gongqian Liang, Yufei Huang

Product introduction strategies plays an important role when a firm introduces successive generation of product. When the firm introduces a product with unobservable quality, price can act as an effective tool to signal product quality. This paper studies the firm’s decision on product introduction strategy in the presence of strategic consumers considering price signaling product quality. We consider four product introduction strategies: single rollover strategy, skipping, shelving and trade-in program. We find that, in the presence of price signal, single rollover strategy is optimal even though no consumer purchases the old version.

3 - Impact Of Consumer Complaints On Time To Recall: Empirical Investigation Of The Automobile Industry

Weihan Jia, Trinity College Dublin, Dublin, Ireland, Yufei Huang, Xingjie Wei

We obtain a car recall dataset with almost 80 variables and 26 million observations by merging three data files from National Highway Traffic Safety Administration in the USA. This paper uses dictionary-based analysis to identify 10 defect signals from description of component and measures consumer complaints as the similarity of the occurrences of defect signals between consumer complaints and recall with cosine similarity and Euclidean distance, and then perceives time to recall as both categorical and continuous variable. After that, we investigate the effect of consumer complaints on the manufacturer's recall timing decision via pooled regression and multinomial logistic regression.

■ VWD43

Virtual Room 43

Advances in Auction Design

Sponsored: Auctions and Market Design

Sponsored Session

Chair: Benjamin Lubin, Boston University, Boston, MA, 2215, United States

Co-Chair: Sven Seuken, University of Zurich, Switzerland

1 - Revenue-incentive Tradeoffs In Dynamic Reserve Pricing

Sebastien Lahaie, Google Research, New York, NY, 06830-5228, United States

Online advertisements are primarily sold via repeated auctions with reserve prices. We study how to set reserves to boost revenue based on the historical bids of strategic buyers, while controlling the impact of such a policy on the incentive compatibility of the repeated auctions. Adopting an incentive compatibility metric which quantifies the incentives to shade bids, we propose a novel class of dynamic reserve pricing policies and provide analytical tradeoffs between their revenue performance and bid-shading incentives. The policies are inspired by the exponential mechanism from the literature on differential privacy, but our study uncovers mechanisms with significantly better revenue-incentive tradeoffs than this mechanism in practice. We empirically evaluate the tradeoffs on synthetic data as well as real ad auction data from a major ad exchange.

2 - VCG, The Core, And Assignment Stages In Auctions

Oleg V. Baranov, University of Colorado-Boulder, Boulder, CO, 80309-5002, United States, Lawrence M. Ausubel

The VCG mechanism is one of the most compelling constructs in mechanism design, but complementarities create the possibility of non-core outcomes. In this article, we develop a theory of complementarities in assignment stages of spectrum auctions. The contiguity restriction—the standard rule guarantying contiguous spectrum to each bidder—is shown to enable a new type of bidder complementarity, creating a setting with endemic bidder complementarities. When the VCG mechanism is used, non-core outcomes, together with all of the known anomalies, must be expected. We provide an empirical case study of these issues by examining a conspicuous spectrum auction. For the FCC’s Incentive Auction, we find many non-core outcomes, establish a potential for non-core outcomes in the majority of the sample, and provide the first empirical documentation of zero-revenue outcomes.

3 - Fourier Analysis-based Iterative Combinatorial Auctions

Jakob Weissteiner, University of Zurich, Zurich, 8045, Switzerland,

Recent advances in Fourier analysis have brought new tools to efficiently learn set functions. We bring the power of Fourier analysis to the design of CAs. The key idea is to approximate bidders' values using Fourier-sparse set functions, which can be computed via value queries. Since the number of queries is too large for real-world CAs, we propose a new hybrid design: we first use NNs to learn bidders’ values and then Fourier transform these learned representations. We formulate a Fourier transform-based WDP and derive its MIP formulation. We then devise an iterative CA that asks Fourier-based queries. We experimentally show that our hybrid ICA achieves higher efficiency than prior work, leads to a fairer distribution of social welfare, and reduces runtime. With this paper, we are the first to leverage Fourier analysis in CA and lay the foundation for future work in this area.

4 - Electricity Markets In Transition

Peter Cramton, Professor of Economics, University of Cologne, University of Maryland, Cologne, 20816, Germany, Emmanuele Bobbio, David Malec, Pacharasut Sujarittanonta

Electricity markets are changing the way electricity is generated and consumed. The transition depends critically on climate policy and market design. We model the markets to evaluate the impact of alternative policies on electricity market outcomes over decades, including costs, profits, social welfare, risks, and reliability. Each year, investors decide which resources enter and exit given forward-looking consistent expectations about energy profits. We model decisions at the unit level based on precisely calculated profits from energy, reserves, and capacity markets. Profits depend critically on the resource structure, which changes each year. New elements of electricity markets, such as battery storage and demand response are fully integrated. The model provides insights into how policies such as carbon pricing impact the transition to renewable energy.

■ VWD45

Virtual Room 45

Analytics IV

Contributed Session

Chair: Edward Tuorinsky, DTS

1 - Determining Diagnostic Priorities For Machines In Serial-parallel Multistage Manufacturing Process

Young-Gwan Kim, Pohang University of Science and Technology, Pohang, Korea, Republic of, Seung-Hyun Choi, Ju-Yeong Kim, Dong-Hee Lee, Young-Mok Bae, Young-Chan Oh, Jong-Bum Park, Kwang-Jae Kim

In a serial-parallel multistage manufacturing process (SP-MMP), each stage has several alternative machines among which one machine is assigned to an individual product. In SP-MMPs where products are produced in batch units, the products in the same batch tend to move collectively through the same process path (i.e., the same set of machines in several stages). This property makes it difficult to diagnose faulty machines that result in a high defective rate. This study develops a method to derive diagnostic priorities for a set of machines considering the collective movement of products. The proposed method is applied to the semiconductor manufacturing process to demonstrate its effectiveness.

2 - Crisis Of Plastic: Business Implications From Data Analytics

Nesreen El-Rayes, New Jersey Institute of Technology, Newark, NJ, United States, Junmin Shi

The crisis of plastic is an intriguing problem. A global move toward the urgency of taking actions as plastic pollution has imposed a detrimental impact on biodiversity loss, climate change, among other forms. The main contributions of our work are about providing an extensive data-based analysis on the status and implications of plastic pollution using machine learning and visualizations through three lenses of different levels: (1) global-level view, (2) industry-level view in the United States, and (3) consumer-level view based on social media platform data (i.e., Twitter). This study sheds light on the prevailing crisis of plastic with rich insights derived from real-world data for each level.

3 - The Analytics Of A Hybrid Workforce

Edward Tuorinsky, Managing Principal, DTS, Arlington, VA, United States

Missions haven't changed, but day-to-day operations have. The pandemic is driving a modernization of the government workforce, introducing a truly hybrid model. Though the situation seems new, existing organizational data can reveal how agencies meet their mission today and provide direction for the future. This session will draw on our experience with the U.S. Fish and Wildlife Service to illustrate how human data analytics can be used to understand the impact of a hybrid workforce and better position government agencies for change. We will cover tools and techniques to capture and organize relevant data, using data visualization to make data actionable, and leveraging human data analytics.

■ VWD46

Virtual Room 46

Artificial Intelligence I

Contributed Session

1 - Aggregating In-Distribution Data into Positive Examples for Safe Semi-Supervised Contrastive Learning

Mingu Kwak, Korea University, Seoul, Korea, Republic of, Seoung Bum Kim

Semi-supervised learning methods have been suffered from performance degradation when the class distributions of labeled and unlabeled data are diferrent. Even if previous studies have tackled the problem by removing the unncessary mismatch data. they might lose the basic information that all data share regardless of class. To this end, we propose to apply self-supervised learning to leverage the whole unlabeled data. We also propose a loss function to use in-distribution data as positive examples. We evaluate our method on image classification datasets under various mismatch ratios. The results show that our method produces good representation and improves classification accuracy.

2 - Optimization Of Missing Value Imputation For Neural Networks

Jongmin Han, Sungkyunkwan University, Suwon, Korea, Republic of, Seokho Kang

For predictive modeling of a neural network with missing values, several imputation methods that have different competences are available. Existing studies have selected a single method or manually combined them. In this study, we propose a method to optimize missing value imputation for a neural network. Using various imputation methods, we obtain different imputations for each instance. The convex combination of the imputations is used as an input of a neural network. The neural network and the weights of the combination are simultaneously trained toward improving the performance. We verified the effectiveness of the proposed method on benchmark datasets with various missing rates.

■ VWD47

Virtual Room 47

Financial Engineering

Contributed Session

Chair: Yan Wang, Hong Kong, 999077, China

1 - Forecasting Market Price'S Rise And Fall Using Visiontransformer Based On Chart Images

Toshinari Tanaka, Tokyo University of Science, Tokyo, Japan, Ryo Hatano, Hiroyuki Nishiyama

In this paper, we propose a method for predicting the market price's rise and fall based on a deep learning model called VisionTransformer based on chart images that are commonly used in the stock market. Since we focused on the fact that stock price behaviors in chart images affect a trader's decision in the stock market, we employ a binary classification model that can forecast the rising or falling of the next day's stock price from chart images. VisionTransformer is superior to CNN models in terms of computational speed and accuracy for image classification tasks. Therefore, as an evaluation, we compare the computational speed and accuracy of the obtained model with the CNN model.

2 - Identifying Broad And Narrow Financial Risk Factors With Convex Optimization

Chang Yuan Li, UC Santa Barbara, Santa Barbara, CA, United States, Alexander Shkolnik, Lisa R. Goldberg, Jeffrey R. Bohn

Factor analysis of security returns aims to decompose a return covariance matrix into systematic and specific risk components. Traditional statistical approaches like PCA and MLE suffer from drawbacks, including a lack of robustness, strict assumptions on the underlying model, and insensitivity to narrow factors such as industries and currencies. We propose a 2-step convex optimization procedure to decompose a security return covariance into its low rank and sparse parts. The low-rank component includes the broad factors that affect most securities. The sparse component includes narrow factors and security-specific effects. We illustrate with simulated and empirical data examples.

3 - A Bayesian Methodology For Portfolio Optimization

Yan Wang, Graduate student, The University of Hong Kong, Hong Kong, Hong Kong, Peng-Chu Chen

We developed a Bayesian method to optimize the portfolio in the stock market. We use the enhanced data set of stock historical return and Markov chain Monte Carlo method to obtain the posterior distribution of the stock average return. We show that if the extended data set size is infinite, the posterior distribution is consistent. We provide the credible interval for the out-of-sample return realized by the portfolio constructed from the posterior average return. In addition, we compared it with the out-of-sample return realized by the portfolio based on the maximum likelihood average return. In most cases, the Bayesian posterior average return outperforms the maximum likelihood average return.

■ VWD48

Virtual Room 48

Decision Support Systems

Contributed Session

Chair: Thomas De Munck, Etterbeek, 1040, Belgium

1 - Effect Of Decision Support Systems On Complex Decision-making Processes

Onur Altintas, Boston University-Questrom School of Business, Boston, MA, United States

With the help of digitization, the sophisticated decision support systems have become more and more popular in many industries. Even though, the stand-alone effectiveness of these systems is well proven, how they are used in a business setting is still a conundrum. With this study, we aim to investigate how individuals make decisions with the presence of these systems in a complex business setting. The results of the study will be presented.

2 - The Data Acquisition Scheduling Problem For A Constellation Of Satellites

Mônica Maria De Marchi, IEAv/DCTA, Sao Jose dos Campos, Brazil, Maria Jose Pinto, Ana Claudia Hayashi

This work addresses the scheduling problem of imagery collection for a constellation of satellites to monitor targets with different priorities for a planning horizon. The mathematical model ensures that target observations would take place within the available observation time-windows as well as the satellites processing time capacities. It also explicitly models the revisit time (the time between successive observations of the same target), the due time and the setup time to adjust the sensor between two consecutive acquisitions with different acquisition modes. The methodology will be demonstrated in a deforestation context wherein targets need to be regularly monitored.

3 - Vancomycin Dosing In Critically Ill Patients: A Machine Learning Approach

Mohammad Samie Tootooni, Assistant Professor, Loyola University Chicago, United States, Erin Barreto, Kianoush Kashani, Kalyan Pasupathy

As a nephrotoxic medication, both sub- and supra-therapeutic vancomycin trough concentrations have consequences. We aimed to identify the key predictive factors for the vancomycin steady-state trough level and their relative contribution and estimate the risk of a steady-state trough outside the goal range. Our models were tested via the left-out set in predicting sub-therapeutic (ROC: 0.85, Specificity: 0.53, and Sensitivity: 0.94) and supra-therapeutic (ROC: 0.83, Specificity: 0.47, and Sensitivity: 0.94) categories, respectively. We also developed an on-demand recommendation engine which offers the optimal dosing regimen for each individual.

4 - Developing a Novel Exact Model of Zoning Optimization for Marine Spatial Planning

Mohadese Basirati, IMT Atlantique, Lab-STICC, Brest F-29238, France, Brest, France, Patrick Meyer, Romain Billot

Marine spatial planning (MSP) as an efficient planning tool simplifies decisions on the sustainable use of marine resources. Determining an optimal zone for one marine user, considering the other users' activities, represents one challenge in MSP. We propose modeling the problem as an Exact Multi-Objective Integer Linear Program. We developed the raster data model to maximize the interest of the zone dedicated to a single actor and to maximize its spatial compactness. We are studying two approaches for resolution: first, a weighted sum and second, an improved augmented version of the -constraint method, AUGMECON2. We validate the model by performing experiments on artificially generated data.

5 - Priority Queueing On Ride-hailing Platforms

Thomas De Munck, PhD Researcher, UCLouvain, Louvain-la-Neuve, Belgium,Philippe Chevalier, Jean-Sebastien Tancrez

Several ride-hailing platforms have started experiencing priority mechanisms for riders during peak hours. Given their limited capacity, how to allocate drivers between high-priority and regular riders is not a trivial question. To investigate it, we design a continuous-time Markov decision process. In this model, riders may be rejected or may abandon the queue with respective penalty costs associated. In this setting, we find the optimal admission policy for riders. We also evaluate the implications of this policy for the classes of riders through several performance measures such as the expected waiting time, service level, or the probability of abandonment before getting service.

■ VWD49

Virtual Room 49

Health Care, Public Health II

Contributed Session

Chair: Surya Bhaskar Ayyalasomayajula, Oklahoma State University, Stillwater, OK, 74074, United States

1 - Responses To Readmissions Penalties: What Can We Learn About Hospital Behavior?

Kevin N. Griffith, Assistant Professor, Vanderbilt University, Nashville, TN, United States, Steven D. Pizer, Melissa M. Garrido, Vijaya Kolachalama, Jacob H. Bor

The Hospital Readmission Reduction Program (HRRP) penalizes hospitals with higher than expected 30-day readmissions for Medicare patients with certain conditions. Approximately $550 million in penalties are levied against hospitals each year. However, the program's effects on readmissions and mortality remain uncertain. We employed a regression-discontinuity/regression-kink approach to analyze how hospitals with varying readmission rates responded to the HRRP's financial incentives. Overall, we find HRRP implementation led to a 1.4 percentage-point reduction in readmission rates and 28,838 avoided readmissions. We find no evidence of increased mortality at penalized hospitals.

2 - Optimal Distribution Of Mass Doxycycline Prophylaxis For Plague Control In A Resource-constrained Setting

Giovanni S.P. Malloy, Stanford University, Stanford, CA, United States, Margaret L Brandeau

Plague has caused some of humanity's worst pandemics. Recent outbreaks have in some cases caused substantial numbers of illness and deaths. Plague control measures include insecticide to control flea populations, treatment of infected individuals with doxycycline, and doxycycline prophylaxis for uninfected individuals. We develop an analytical decision rule to determine when mass prophylaxis is cost-effective. We evaluate the decision rule performance using Monte Carlo simulations of a stochastic SEIR model and compare the performance to popular machine learning classification algorithms.

3 - Enabling Mental Healthcare Delivery To Underserved Populations: An Empirical Analysis Of The Equity Advancing Effect Of Mobile Apps

Yi Tang, Carlson School of Management, Minneapolis, MN, United States, Adam Moen, Kingshuk K Sinha

The gap between the supply and demand for mental health care is raising alarms in the U.S. and around the world. Certain populations are suffering more by having significantly less-than-average treatment rates and treatment efficacy. Mobile health technologies such as mobile apps are believed to have the potential to reduce the disparities by breaking the geographical and temporal barriers and by reducing stigma through a psychologically safe environment for people in need. In this study, we document empirical evidences that mobile apps can create capacity in a mental healthcare supply chain so as to reduce the disparities associated with gender, sexual orientation, and race-ethnicity.

4 - Continually Improving Diabetes Education Based On Patients Social Media Interactions Using Text Analytics

Surya Bhaskar Ayyalasomayajula, Oklahoma State University, Stillwater, OK, United States, sDursun Delen

The pressing need for diabetes patient's education is addressing their concerns about medicines, insulin injection, and usage of glucose monitoring devices. In this paper, we employ text mining on a popular diabetes support group used by diabetes patients in UK. We find that the expert advice and education based on research and clinical trials, is not sufficient for addressing the diabetes patient concerns. We describe and evaluate a new process and decision support system for diabetes patient concerns identification and prioritization. Our findings provide insights into how text analytics can improve diabetes education for patients and healthcare providers.

■ VWD50

Virtual Room 50

Simulation II

Contributed Session

Chair: Eunji Lim, United States

1 - Simulation Modelling Of Primary And Secondary Healthcarefacility Networksusing Stochastic Metamodels
Mohd Shoaib, Indian Institute of Technology Delhi, New Delhi, India, Varun Ramamohan

We present a discrete event simulation model of a network of primary and secondary healthcare facilities developed using stochastic metamodels of full-featured parent simulation models of the individual facilities in the network. The metamodels include full-featured representations of only the parent simulation components relevant to the analysis, whereas other components are either abstracted out or scaled-down. The metamodel-based network simulation yields statistically similar outcomes in comparison to the parent model in significantly lesser runtime.

2 - Optimal Control Models Of A Biological Invader Using Gaussian Kernels
Sevilay Onal, University of Illinois Springfield, Springfiled, IL, United States, Sabah Bushaj, Esra Buyuktahtakin Toy, Jennifer Smith, Gregory Houseman

Weeds have been detrimental to the crop acreage and yield. Sericea lespedeza is recognized as a biological invader in the Federal Noxious Weed Act in 2000. Control programs to such infestation have been designed to reduce the harmful impacts on biodiversity and bioeconomy in the Great Plains of the U.S. An integrated simulation-optimization model estimates the seed dispersal using Gaussian cell-to-cell transition probabilities, and the treatment locations are prescribed over a predetermined time period depending on the infestation level.

3 - Designing An Emergency-vehicle Fleet Through Simulation
Juan Carlos Espinoza Garcia, Assistant Professor, Tecnologico de Monterrey, Querétaro, Mexico

We study the pattern of traffic accidents from historical data and define locations for emergency-vehicles to meet international and local service objectives. We propose a combination of stationary and mobile vehicles and study, through scenario-based simulation, the impact of mobility to increase efficiency.

4 - A Cost Reduction Model In A Fuel Distribution Terminal
André R. Cruz, Universidade de Brasília, Brasília, Brazil, Reinaldo Crispiniano Garcia

This work implements a model for the operations of a fuel distribution terminal. The study comprises the loading of tanker trucks, in order to test the impact of different scenarios in the terminal's performance indicators and costs. The used input data set includes about 11,600 trucks arriving in the terminal in a four month period. The preliminary results show to be possible to obtain about 11.5% of savings when comparing with actual costs.

5 - Simulation-based Optimization For Convex Functions Over Discrete Sets
Eunji Lim, Adelphi University, Garden City, NY, United States,

We propose a new iterative algorithm for finding a minimum point of a real-valued function f* with the domain X, when f* is known to be convex, but only noisy observations of f*(x) are available at each point x in X. The proposed algorithm not only estimates the minimum point of f*, but also provides the probability of each point in X being a minimum point of f*, using the fact that f* is convex. Numerical results indicate that the proposed algorithm converges to a minimum point of f* as the number of iterations increases and shows fast convergence especially in the early stage of the iterations.

■ VWD52

Virtual Room 52

Text Mining and Social Media Analytics for Business Value

Sponsored: Social Media Analytics

Sponsored Session

Chair: Nohel Zaman, Loyola Marymount University, Rancho Palos Verdes, CA, 90275, United States

1 - Is Sharing Really Caring? The Negative Impact Of Promoting Online Donation Campaigns On Social Media
Yashar Dehdashti, Texas Wesleyan University, Fort Worth, TX, 76102, United States, Aidin Namin, Brian T. Ratchford, Larry Chonko

Online donation through crowdfunding has become increasing popular in recent years These campaigns need to raise awareness about their existence. Social media are the perfect vehicle to inform people about the need for help and raise awareness as they can reach a large audience in a short time. However, users might merely like and/or share these campaigns without making a meaningful contribution (e.g., giving money to a donation seeking campaign); known as slacktivism. We investigate the underlying mechanism through which liking and sharing these campaigns on the social media affect their success. Our data come from a major crowdfunding website over a significant period of time. We show that the overall effect of using social media for online donations is negative. Our research has important managerial implications in that using social media should be done more creatively.

2 - Opinion Leader Identification Associated With Covid-19 In Online Social Networks
Behnam Malmir, Virginia Tech, VA, United States

Safety culture is a collection of beliefs, attitudes, and practices that is focused on improving individual and organizational health and safety. Providing interactions between citizens and governments could elevate this improvement. Social media has been known as one of the most valuable tools to this aim and government agencies eagerly have applied social media applications to enhance citizen engagement in managing crises. However, employing opinion leaders (OLs) to improve the effects of social media on people's safety culture has been neglected in the literature. This paper provides a framework for OLs identification in the era of pandemic situations called 'Pandemic OL Finder'. The proposed framework comprises three steps of finding potential OLs on the Twitter platform, determining the characteristics of those OLs, and discovering real OLs.

3 - Extracting ESG Indications From 10-K Documents
Varada Krishnaswamy, Virginia Tech, Blacksburg, VA, United States

Extraction of indications from financial statements, such as 10-K documents, is critical in investment decisions. Manually processing these files is time-consuming and labor-intensive. We present text-mining-based methodologies for retrieving knowledge about Environment, Social, and Corporate Governance (ESG) indicators from 10-K documents in this paper. Since these reports include unstructured formats and a large amount of text, it is a struggle to interpret the text accurately. Until searching for text blocks that reflect ESG indications, we present methods for detecting text blocks in unstructured text. We expect to list the retrieved texts according to their logical similarities to the indicators and their quantitative content.

■ VWD53

Virtual Room 53

Auctions/Mechanism Design

Contributed Session

Chair: Sebastien Mitraille, Toulouse Business School, Toulouse, 31000, France

1 - Selling Multiple Complements With Packaging Costs
Simon Finster, University of Oxford, Oxford, United Kingdom

I consider a package assignment problem where multiple units of indivisible objects are allocated to individuals. The seller can specify additional cost (savings) on packages of objects: e.g. a manufacturer may incur cost savings if they obtain several products from a single supplier. I propose a sealed-bid, social welfare maximising auction with a novel cost function graph to express the seller's preferences. The graph structure facilitates the use of linear programming to find anonymous, competitive, and package-linear prices. If agents are price takers, these prices support a Walrasian equilibrium, and I provide necessary and sufficient conditions for its existence.

2 - Single Sourcing From A Supplier With Unknown Efficiency And Capacity
Sebastien Mitraille, Toulouse Business School, Toulouse, France, Christophe Bernard

We characterize the optimal order of a retailer when its supplier is either efficient but faces a steep marginal cost, or is inefficient but faces constant returns-to-scale, or any combination of the two. When demand is large enough, the retailer under-purchases compared to an informed monopolist, resulting in additional social losses. When demand is low enough, the retailer over-purchases compared to an informed monopolist. In the interim situation, the retailer over-purchases from efficient but capacity constrained sellers, and under-purchases from inefficient but capacity unconstrained sellers. Bunching occurs, and the quantity purchased is not always continuous in the supplier's type.

■ VWD54

Virtual Room 54

Nick's PSOR session

Sponsored: Public Sector OR

Sponsored Session

Chair: Nicholas A. Arnosti, Columbia Business School, New York, NY United States

1 - Fair Allocation Of Vaccines, Ventilators And Antiviral Treatments: Leaving No Ethical Value Behind In Healthcare Rationing

Tayfun Sonmez, Boston College, Department of Economics, Chestnut Hill, MA, 02467, United States, Parag Pathak, Utku Unver, Bumin Yenmez

COVID-19 has revealed limitations of existing mechanisms for rationing medical resources under emergency scenarios. Many argue that these mechanisms abandon various ethical values such as equity by discriminating against disadvantaged communities. Illustrating that these limitations are aggravated by a restrictive choice of mechanism, we formulate pandemic rationing of medical resources as a new application of market design and propose a reserve system as a resolution. We develop a general theory of reserve design, introduce new concepts such as cutoff equilibria and smart reserves, extend analysis of previously-known ones such as sequential reserve matching, relate these concepts to current debates, and present policy impact.

2 - Application Mistakes And Information Frictions In College Admissions

Tomas Larroucau, Arizona State University, Tempe, AZ, United States, Ignacio Rios, Christopher Neilson

We analyze application mistakes in a centralized college admissions system. We use data from Chile and exploit institutional features to identify a common type of mistake: applying to programs without meeting all requirements (admissibility mistakes). We find that changes in admission requirements increase admissibility mistakes. However, this effect fades out over time, suggesting that students adapt to changes in requirements but not immediately. In addition, we find that between 2% - 4% of students do not list their top-true preference of program, even though they face a positive admission probability. We use these insights to design a large-scale information policy. We find that showing personalized information about admission probabilities has a causal effect on improving students' outcomes even in seemingly strategy-proof college admissions systems.

3 - Designing School Choice For Diversity In The San Francisco Unified School District

Katherine L Mentzer, Stanford University, Stanford, CA, 94305, United States, Irene Yuan Lo, Itai Ashlagi, Maxwell Allman

Prompted by a redesign of the San Francisco Unified School District (SFUSD) school choice system, we explore how choice mechanisms affect tradeoffs between choice, diversity, and other school district goals. We used simulations combining zone optimization with choice to propose new assignment policies. We found that zones must be designed with choice, as choice can lead to resegregation of diverse zones. However, well-designed zones combined with minority reserves could attain SFUSD diversity goals, as well as other district objectives such as predictability and proximity. In SFUSD, traditional school choice tools such as priorities can also attain diversity goals and provide choice, at the expense of predictability and proximity. Based on our findings, we recommended a policy of medium zones and reserves that was approved by the SFUSD Board of Education.

■ VWD55

Virtual Room 55

Disaster and Disruption Management III

Contributed Session

Chair: Maria Jose Pinto, IEAv/DCTA, Sao Jose dos Campos, 12228-001, Brazil

1 - Optimizing Evacuation Traffic During Natural Disasters

Hai Yu, Northeastern University, Boston, MA, United States, Peter Kubat, Emanuel Melachrinoudis

A linear optimization model for evacuation of population in an area affected by a hurricane storm is developed. The model determines the best traffic flow rates from population centers to safe zones so that a maximum evacuation time is minimized.

2 - Large-scale Zone-based Evacuation Planning: Generating Convergent And Non-preemptive Evacuation Plans Via Column Generation

Jorge A. Huertas, Georgia Institute of Technology, Atlanta, GA, United States, Pascal Van Hentenryck

In zone-based evacuations, the evacuated region is divided into zones, and vehicles follow the single evacuation path assigned to their corresponding zone. Ideally, these evacuation paths converge at intersections to reduce driver hesitation; and non-preemptive schedules ensure that the evacuation of a zone, once it starts, proceeds without interruptions. We present a macroscopic optimization model to produce convergent and non-preemptive evacuation plans. Furthermore, we decompose our model and use a column-generation algorithm to solve it in real large-scale evacuation scenarios. Finally, we use a microscopic traffic simulator to evaluate the quality of the generated plans.

3 - Nurturing Empirical Research in Operations Management: Key Challenges and Future Directions

Nitin Jain, Indian Institute of Management Udaipur, Udaipur, India,

The operations management (OM) discipline is influenced by diverse fields like economics, engineering, operations research, and organizational theory. Despite this interdisciplinary nature and quantitative rigor's advancement, OM research is still unable to address practitioners' issue well. The concerns raised in the extant literature emphasize on the need for more empirical advancement in OM area. Hence, this paper investigates how empirical research can complement the traditional analytical techniques. It also identifies critical themes in OM ranging from sustainability to humanitarian operations wherein empirical investigation can add immense value to make OM research holistic.

4 - Air Route Planning To Minimize The Radiation Dose In Aircraft Operating Under Radioactive Plume Scenarios

Maria Jose Pinto, Dr, IEAv/DCTA, Sao Jose dos Campos, Brazil, Claudio Antonio Federico, Breno Dabela Luna, Monica De Marchi

This work aims to provide an optimized safe route for an aerial vehicle on situations of exposure to ionizing radiation by overflight within radioactive or nuclear plumes in the scope of Chemical, Biological, Radiological and Nuclear defense (CBRN defense) missions. The purpose of the developed methodology to solve the problem is to minimize the radiation accumulated dose along the route, aiming at preserving the health of the crews and minimizing vehicle contamination. The methodology is applied through different random instances and to a simulation of the prognosis of the temporal evolution of the radioactive plume, produced using the ARGOS code for a hypothetical nuclear scenario.

■ VWD56

Virtual Room 56

Revenue/ Yield Management I

Contributed Session

Chair: Haobo Yu, Hong Kong

1 - Counterfactual Self-Training

Ruijiang Gao, University of Texas at Austin, Austin, TX, United States, Max R. Biggs, Wei Sun

Unlike traditional supervised learning, in many settings only partial feedback is available. Such settings encompass a wide variety of applications including pricing, online marketing and precision medicine. We approach this task as a domain adaptation problem and propose a self-training algorithm which imputes outcomes with finite discretevalues for finite unseen actions in the observational data to simulate a randomized trial. We offer a theoretical motivation for this approach by providing an upper bound on the generalization error defined on a randomized trial under the self-training objective. We empirically demonstrate the effectiveness of the proposed algorithms.

2 - Lift Estimates And Schedule Optimization For Trade Promotion Planning

Sophia Huang, Senior Data Scientist, Vistex, Inc., Chicago, IL, United States, Maarten Oosten

Trade promotions consist of the multi-level promotional activities of a manufacturer. The manufacturer tries to promote their products to the consumers but since the retailers are the intermediate parties that sell and promote the products they must be incentivized to execute the promotions. After all, if the promotion is not attractive for the retailer, there won't be a promotion. Therefore, the manufacturer should model the behavior of the consumers as well as that of the retailers. In this presentation we discuss the challenges this poses in both the estimation of the promotion effects as well as the optimization of the promotion schedule and propose models that address these challenges.

3 - Waiving Commissions for Food Delivery Services
Haobo Yu, University of Hong Kong, Hong Kong, China, Wei Zhang

Online food channel increases the restaurant's profit, but worsens offline diners' experience. Given a fixed commission rate, a restaurant prefers small online orders to large ones due to limited cooking capacity and shorter wait time. However, platform's preference is opposite due to the fixed delivery cost. In practice, restaurants set a minimum consumption and platform better designs the contract to mitigate the conflict. We consider three components of the contract: commission fee, service fee, and membership fee. We find that membership fee and service fee are important to channel coordination while commission rate's efficiency varies a lot and depends on the offline diners' heterogeneity.

■ VWD57

Virtual Room 57

Operations/ Marketing Interface I

Contributed Session

Chair: Ming Jin,

1 - The Effect Of The U.S.-China Trade War And The Covid-19 Pandemic On The Effectiveness Of The Promotion Of U.S. Agricultural Exports.
Misty Blessley, Associate Professor, Temple University, Philadelphia, PA, United States

U.S. agricultural exports have long been vulnerable to changes in weather, politics and the global economy. Recently, agricultural exports have been hurt by the U.S.-China trade war and the COVID-19 pandemic. The objective of our project is to improve understanding of the factors that lead to U.S. government's export promotion of specific agricultural product categories, and the effectiveness of the export promotions. Insights are developed through the analysis of multiple years of agricultural export promotions. The findings are expected to provide important contributions to theory, policy and practice.

2 - Overage Disutility, User Trading And Tariff Design
Yanzhi Li, City University of Hong Kong, Kowloontong, Hong Kong, Weixiang Huang, Youhua Chen

Popular tariffs in the telecommunications market, such as three-part tariffs and flat-rate plans, specify an allowance below which customers enjoy a free and high-quality service. Some network service providers have recently begun to allow data trading among their subscribers, who can now sell their allowances or buy up to meet their needs. We find that allowing trading among users improves system-wide consumption efficiency and reduces overage disutility at the expense of losing overage revenue. Overall, trading can be beneficial to the firm. Moreover, allowing trading always improves social welfare and can also improve consumer surplus.

3 - Game-theoretic Analysis Of Alliance Between Platforms And Competing Manufacturers In Sharing Consumer Data For Product Developments
Hiroshi Matsuhisa, Keio University, Yokohama, Japan, Nobuo Matsubayashi

This study investigates strategic interaction between a monopolistic platform and competing manufacturers, where each manufacturer has three options as its product strategy; joining the platform and developing its product by utilizing consumer data shared among the alliance members, employing a direct-to-consumer model and developing its product by utilizing only its own consumer data, and simply selling its existing product. We show that the platform becomes the most beneficial in equilibrium when the manufacturers are moderately differentiated.

4 - Direct-to-consumer Firm'S Competitive Strategy Against A Dominant Retailer: Opening An Experiential Physical Store Vs. Specializing In An Online Store
Masanobu Takeda, Keio University, Yokohama, Japan, Nobuo Matsubayashi

This study provides a game-theoretic analysis to investigate whether a firm employing a direct-to-consumer (DTC) business model should open an ``experiential" physical store, or specialize in and enhance its online store, in competition with a dominant retailer that owns both physical and online channels. We show that opening its experiential physical store is likely to be more effective for the DTC firm as its competitive strategy.

5 - Live Commerce Retailing With Online Influencers: Two Business Models
Baolong Liu, Assistant Professor, ShanghaiTech University, Shanghai, China, Weilong Wang

Selling during online influencers livestreaming has become prevalent in the retailing sector. For firms, to keep the business sustainably profitable, key decisions to make include whether it is worth collaborating with influencers and how, as well as the corresponding pricing and inventory decisions. Based on industrial practice, we investigate two business models: the Influencer-oriented Short-window (IOSW) model and the Market-oriented Long-window (MOLW) model, to understand how the models benefit a firm and how decision making affects profit sustainability. To this end, we build stochastic optimization models and derive regarding managerial insights.

6 - Trade Promotions And Their Consequences
Ming Jin, University of Oregon, Eugene, OR, United States,

Using data from a multi-echelon pharmaceutical supply chain, we study the dynamics between pricing, orders, and inventory at each tier. For example, we study how distributors respond to trade promotions (price discounts by the manufacturer). We quantify the financial impact of trade deals and evaluate their effectiveness.

■ VWD58

Virtual Room 58

Transportation-Planning II

Contributed Session

Chair: Saumya Bhatnagar, Indian Institute of Science, Bangalore, India, Bengaluru, 560013, India

1 - Optimal Autonomous Fleet Sizing During The Transition From Human-driven Vehicles To Autonomous Vehicles For Ride-sourcing Systems
Gulam Kibria, Georgia Institute of Technology, Atlanta, GA, United States, Srinivas Peeta

During the transition from human-driven vehicles (HDVs) to autonomous vehicles (AVs), both HDVs and AVs will be on the road network in a mixed traffic environment. Actions of the AV manufacturers and related industrial partners point towards the initial deployment of AVs in ride-sourcing systems. A critical challenge for ride-sourcing system operators will be to determine how many AVs to deploy alongside the existing fleet of HDVs in mixed traffic. To address this problem, we propose a mathematical model for optimal AV fleet sizing that simultaneously addresses multiple objectives: maximization of operator's and drivers' utilities and minimization of riders' disutilities.

2 - Applying Net Present Value Curves For Investiment In High Speed Rail (HSR) Lines Project.
Reinaldo Crispiniano Garcia, Director - Operat. Res. Lab. Universidade de Brasilia (UnB) -Brasilia, Brazil, , Nathalia C. Soeira, Carolina S. de O. Pereira

This Project deals with Net Present Value (NPV) curves for the feasibility of High Speed Rail (HSR) lines, in Brazil. In particular, the evaluated HSR connects large urbanized areas including the Metropolitan areas of Rio de Janeiro, São Paulo and Campinas having about five midway stations. The considered costs include the installation, structure maintenance and trains acquisition ones. The revenues are obtained through the passenger demand and ticket prices. Acquired social benefits are also evaluated (time savings and, the reduction of accidentes and, environmental and noise pollution). The applied NPV methodology aims to determine the best time to invest in the Project.

3 - Traffic Equilibrium With Shared Mobility Services In A Coupled Morning-evening Commute Framework
Wei Gu, University of Southern California, Los Angeles, CA, United States, Maged Dessouky, Jong-Shi Pang, Michael Zhang

In this study, we develop a general equilibrium model to capture the complex interactions between solo-driving, rideshare and e-hailing that allows travelers to switch between different transportation modes in a coupled morning-evening commute. The model is formulated as a mixed complementarity problem. Then the existence of an equilibrium solution and the properties of the solution are investigated, and we provide conditions on the model parameters under which the equilibrium will be unique. The proposed model is validated with the renowned Sioux-Falls network.

4 - Quantifying Resilience Of Multi-modal Public Transportation System: Implications From Hong Kong
Zizhen Xu, PhD Candidate, City University of Hong Kong, Hong Kong, Hong Kong, Shauhrat S. Chopra

While studying the resilience of city-wide public transportation, evaluation of individual systems in isolation provides unclear insights on resilience, without considering the increasing interconnectedness of the systems. To address this, we evaluate the resilience of the multi-modal public transportation network (MPTN) in Hong Kong by simulating disruption scenarios and assessing topological factors on the graph model, which integrates the layers of the metro, franchised bus, minibus, tram, and ferry systems by modeling the transfer behavior. We find that quantifying resilience from MPTN provides better solutions in identifying critical structures and improving overall resilience.

5 - Optimizing Vehicle Allocation For First- And Last-mile Connectivity Using An Agent-based Framework
Saumya Bhatnagar, Senior Project Associate, Indian Institute of Science, Bengaluru, India, Tarun Rambha, Gitakrishnan Ramadurai

The first and last mile of a trip are often inconvenient to transit users. This has led to a decline in the ridership of public transit systems in many cities because of competing ride-hailing services or personal travel modes. To address this problem, we propose an agent-based simulation and optimization approach for resource allocation of first- and last-mile vehicles at different stations of a metro network. Performance measures such as fleet utilization and unserved trip requests are analysed under different policy frameworks such as zonal restrictions and operational strategies involving matching and routing. A case study involving metro and land-use data from Bangalore, India, is presented.

■ VWD60

Virtual Room 60

Game Theory II

Contributed Session

Chair: Tal Alon,

1 - Tripartite Evolutionary Game Research On Government-enterprise Collaborative Innovation In Intelligent Manufacturing
Mengshan Zhu, Tongji University, Shanghai, China, Wenyong Zhou, Chunyan Duan

Intelligent manufacturing has become the main trend in the transformation and upgrading of manufacturing industries among countries in the world. This paper constructs a tripartite evolutionary game model of collaborative innovation between the government, manufacturing companies, and Internet companies, analyzes the three parties' strategic choices in the process of collaborative innovation, and reveals the influencing factors through numerical simulation. Results indicate that evolutionary stability strategies are affected by costs, government support, incentives, penalties, and the initial willingness of all parties to participate.

2 - Consumer-to-consumer Fashion Product Exchange In The Sharing Economy: Good Or Bad For Copycats?
Yingjia Wabg, Hong Kong Polytechnic University, Hong Kong Hong Kong, 19044791r@connect.polyu.hk, Yi-Ning Fung, Suyuan Luo

With the development of digital platforms and mediating technologies, consumer-to-consumer product exchange (C2C-PE) has become very popular in the sharing economy for fashion products. Another noticeable challenge in the fashion industry is copycat trading. In this paper, we construct analytical models to explore how C2C-PE affects copycat products. We theoretically find that the presence of C2C-PE benefits the original brand and their consumers, while harms the copycat brand. To check the robustness of the results, we further consider the cases of strategic quality decision and price dependent C2C-PE utility.

3 - Algorithm For Computing Approximate Nash Equilibrium In Continuous Games With Application To Continuous Blotto
Sam Ganzfried, Ganzfried Research, Miami Beach, FL, United States

Successful algorithms have been developed for computing Nash equilibrium in a variety of finite game classes. However, solving continuous games -- in which the pure strategy space is (potentially uncountably) infinite -- is far more challenging. We present a new algorithm for computing Nash equilibrium strategies in continuous games. We experiment with our algorithm on a continuous imperfect-information Blotto game, in which two players distribute resources over multiple battlefields. Blotto games have frequently been used to model national security scenarios. Experiments show that our algorithm is able to quickly compute close approximations of Nash equilibrium strategies for this game.

4 - Optimization And Game Theory For Coordination In Humanitarian Operations: A Systematic Review
Ayesha Farooq, Kansas State University, Manhattan, KS, United States, Jessica Heier Stamm

Optimally utilizing limited resources while activating coordinated response from multiple participants can lead to more effective and efficient humanitarian operations. Although OR/MS applications in humanitarian logistics have grown rapidly, their contribution to facilitating coordination among stakeholders is unclear. We present results from a systematic literature review that explores the potential for game theory and optimization to facilitate vertical or horizontal coordination between multiple actors engaged in humanitarian operations, highlighting trends and opportunities.

5 - Contracts With Private Cost Per Unit-of-effort
Tal Alon, Technion - Israel Institute of Technology, Haifa, Israel, aInbal Talgam-Cohen, Paul D. Duetting

Economic theory distinguishes between principal-agent settings in which the agent has a private type (e.g. private cost per unit-of-effort) and settings in which the agent takes a hidden action. Many practical problems, however, involve aspects of both. A natural goal is to design an IC contract, which consist of an allocation rule that maps types to actions, and a payment rule that maps types to payments. Our main contribution is an LP-duality based characterization of implementable allocation rules, which applies to both discrete and continuous types. We present several applications, including a polynomial-time algorithm for finding the optimal contract with a constant number of actions.

■ VWD61

Virtual Room 61

Towards the Future of Air Traffic Flow Management

Sponsored: Aviation Applications

Sponsored Session

Chair: Lu Dai, University of California, Berkeley, University of California, Berkeley

1 - Evaluation Of Wind And Convective Weather Impacts On Trajectory-based Operations (TBO)
Gabriele Enea, Technical Staff, MIT Lincoln Laboratory, Lexington, MA, 02421, United States, Michael McPartland

The FAA is evolving the air traffic control system from a tactical, position-based approach, to a more strategic, trajectory-based operations (TBO) approach. Currently, TBO systems do not have appropriate information about convective weather and extreme wind conditions to continue to operate effectively under these demanding conditions. This presentation will discuss MIT Lincoln Laboratory work in building the TBO Weather Testbed to develop a roadmap of studies and enhancements necessary to support TBO under all wind and weather conditions and the vision to create weather-aware TBO automation.

2 - Requirements Consideration for Commercial Aircraft formation flight
Safa Saber, King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, Eric Feron

Aircraft have been flying in formation for mutual benefit for about a century. The possibility of commercial aircraft formations are only now becoming a viable option due to modern flight control systems and more capable computation. At the same time, commercial aircraft formations are also becoming a valuable construct due to congested airspace and the desire for greater fuel efficiency. The realization of commercial formations requires serious consideration of aircraft deconfliction and safety during closer-in maneuvering of large aircraft. This paper introduces formation deconfliction of transport category aircraft and presents possible solutions and questions for further research.

3 - Predicting Future Delay In The National Airspace System
Mark M. Hansen, University of California-Berkeley, Berkeley, CA, 94720, United States

Air traffic flow management (ATFM) is the regulation of air traffic in order to minimize overall delays in the NAS, while ensuring capacity is not exceeded. To shed some light on the future TFM concepts and strategies, we employ machine learning techniques to model the system-wide delay for the 2010s, with a wide range of location-specific, time-varying features. In this presentation, we will discuss to what degree the NAS delay is changing over time, and how different factors affect the NAS performance spatially and temporally. Moreover, the model estimates are transferable to a counterfactual context for enhancing our understanding of how the system and its environment have changed and affected the system delay over time.

4 - Applying Artificial Intelligence To Air Traffic Flow Management
Craig Wanke, MITRE Corporation, McLean, VA, 22102, United States

Recent successes in applying machine learning (ML) to decision making suggest that such techniques could help solve the complex task of air traffic flow management (ATFM), a discipline marked by large design spaces and high uncertainty. We have been exploring the use of ML to generate new ATFM strategies and to study the performance of traditional ATFM approaches. This talk will cover some successes and some newfound challenges in using ML for ATFM.

■ VWD63

Virtual Room 63

Practical Optimization: what it takes to make optimization succeed in real life

Sponsored: OPT/Computational Optimization and Software

Sponsored Session

Chair: Richard Oberdieck, Gurobi Optimization, Gurobi Optimization, Hvidovre, 2650, Denmark

1 - Challenges and Rewards in Practical Optimization

Jakob Blaavand, Head of Business Insight and Analytics at the Danish Crown, Oxford, United Kingdom, ja

In real life, data is messy, decisions are made based on multiple opposing metrics, deadlines are tight, users are reluctant to change and managers wanted results yesterday. Tackling all of these challenges, and more, are essential for optimisation solutions to succeed in real life, and when you do the impact can be large. This talk will discuss the key ideas, tasks and activities required for successful optimisation solutions. The talk will be driven by examples from solutions developed and deployed in the energy, pharmaceuticals and telecommunications sectors.

2 - Catching Fraud And Money Laundering With Machine Learning And Optimisation.

Ruben Menke, Banking Circle, Copenhagen, Denmark, rum@bankingcircle.com

Anti money laundering and fraud detection is a significant challenge for the financial industry. To improve the effectiveness of transaction monitoring machine learning models are deployed to augment the established rule based models. Selecting which payments to forward for manual analysis is a reinforcement learning problem. Methods to optimally select transactions for screening are investigated and compared. It is demonstrated that careful selection is essential to maintain the performance of the machine learning model. Quantifying and optimising the performance of machine learning models in anti money laundering is necessary for approval by regulators.

3 - Deploying A Hybrid MILP Solution For Highly Complex Semiconductor Scheduling Problems

Semya Elaoud, Flexciton Limited, London, United Kingdom, Dionysios Xenos, Ioannis Konstantelos

Job scheduling in semiconductor factories is an NP-hard problem. It is a non-identical parallel machines job shop problem with secondary resources. Practical applications typically resort to the use of approximate techniques. Many factors render the use of MILP optimisation challenging: problem complexity, high uncertainty, multiple objectives. We present a novel solution strategy that combines MILP optimisation with heuristic techniques to schedule thousands of wafers. Flexciton has been deployed in semiconductor fabs and shown to outperform existing approaches. Using case studies we showcase how we can accommodate complex problem features and provide high quality schedules

4 - Practical Optimization: What It Takes To Make Optimization Succeed In Real Life

Thomas Fliedner, Kearney, Munich, Germany, Sven Flake

A core property of bringing operations research methods into industrial-size projects is a heterogeneous context of business requirements and technical questions, of very abstract and very detailed topics. In this talk, we showcase a customer project and we use this showcase to highlight core steps of applying OR: (1) How to keep track of the customer's vision during the project; (2) How to identify, isolate, and tackle mathematical questions that customers cannot be aware of; (3) How to bring a project to life step by step while keeping mathematical complexity at bay.

5 - Tools And Processes For Rapid Prototyping Of Optimization Applications

Richard Oberdieck, Gurobi Optimization, Nordlundsvej 27, Hvidovre, 2650, Denmark

Ideally, projects involving optimization start out with the business problem for which a decision strategy is needed. Based on this, a mathematical model is designed, implemented and validated against a set of test data, before it is encoded in an optimization application which solves the business problem. Unfortunately, most projects do not follow this path, for example due to complicated business logic, stakeholder management and data quality issues. Therefore, it is crucial to be able to iterate through each step quickly in order to quickly identify and resolve any blocking issues. In this talk, we will share some of the tools and processes used inside Gurobi that we have found to work well in these situations. In addition, we will provide recommendations to OR experts, developers and project managers on common pitfalls we see and several strategies on how to mitigate them.

6 - Optimization in Renewables: Focus on Hydrogen

Jens Jakob Sørensen, Ørsted, Skærbæk, Denmark

Ørsted is an energy company concentrating on renewables that uses optimization for decision support in several problems. This talk discusses some of the challenges in developing optimization tools and what steps we have taken to overcome them. As an example, a rolling horizon dispatch model is used to assess how to operate green hydrogen plants and estimate their profitability.

■ VWD65

Virtual Room 65

Discrete Optimization

Contributed Session

Chair: Qian Xie, Ithaca, NY, 14850, United States

1 - A Polyhedral Approach To Some Max-min Problems

Thomas Lidbetter, Assistant Professor, Rutgers Business School, Newark, NJ, United States, Lisa Hellerstein

We consider a max-min variation of the classical problem of maximizing a linear function over the base of a polymatroid. In our problem we assume that the vector of coefficients of the linear function is some unknown vertex of a simplex, and we maximize the linear function in the worst case. Equivalently, we formulate the problem as a zero-sum game. We show how to efficiently obtain optimal strategies for both players and an expression for the value of the game. Furthermore, we give a characterization of the set of optimal strategies for the minimizing player. We consider four versions of the game and discuss the implications of our results for problems in search, sequential testing and queueing.

2 - The Lot-sizing And Scheduling Problem Coupled With Cutting Stock And Featured With Temporal-spatial Constraints

Xinye Hao, Tsinghua University, Beijing, China, Li Zheng, Na Li, Canrong Zhang

This paper deals with a practical production problem arising from an aviation manufacturing factory, which focuses on the production of different types of composite aeronautic products, where splicing and assembling are the two major operations conducted in the production process. We extract a new mixed integer programming model which integrates the multi-level lot-sizing problem with cutting stock problem, with its machines both temporally and spatially constrained. A Dantzig-Wolfe decomposition-based heuristic is proposed. Extensive experiments are conducted and its performance is compared with the CPLEX.

3 - Multiple Objectives And History Dependent Solutions In A Capital Accumulation Problem

Andrea Seidl, University of Vienna, Vienna, Austria, Richard F. Hartl, Peter M. Kort

We consider the optimal control problem of a firm which decides about investing into a capital stock needed for production. On the one hand the firm wants to maximize revenues, on the other hand it wants to minimize emissions which are caused by production. To handle the conflicting objectives, we apply the epsilon-constraint method. A boundary value and continuation approach is used to numerically calculate the Pareto front for different initial state values. We are able to determine a threshold curve which separates areas on the Pareto front on which long-run steady states are approached. We analyze the impact of key parameters on the solution paths and on the Pareto front.

4 - Decomposition-coordination Methods For Finite Horizon Bandit Problems

Benjamin Heymann, Criteo, Paris, France, Michel De Lara, Jean-Philippe Chancelier

The complexity of the multi-armed bandit problem grows exponentially in the number of arms in Bayesian setting with finite horizon. We present a Decomposition-Coordination (DeCo) algorithm, whose complexity is essentially linear in the number of arms, and we apply it to the multi-armed binary bandit problem. On numerical experiments, DeCo obtains performances that match the (optimal) full dynamic programing resolution, and outperforms Thomson Sampling, while keeping the computing time polynomial in the number of rounds.

5 - Strategic Defense Of Feedback-controlled Parallel Servers Against Reliability And Security Failures

Qian Xie, New York University, Brooklyn, NY, United States, Zhengyuan Zhou, Li Jin

In this research, we analyze the reliability/security risk of feedback-controlled queuing systems and propose advice for strategic defense. We consider a system of parallel servers and queues with dynamic routing subject to reliability and/or security failures. For the reliability setting, we formulate it as a Markov decision process. We prove that the system operator's optimal protecting policy is threshold-based and use dynamic programming to compute it. For the security setting, we formulate it as an attacker-defender game. We characterize the equilibria regimes and apply Shapley's algorithm to compute the equilibria. We also present examples to illustrate our proposed models and methods.

■ VWD66

Virtual Room 66

Network Optimization: Theory and Applications

Sponsored: OPT/Network Optimization

Sponsored Session

Chair: Demetrios Vasilios Papazaharias, Buffalo, NY, 14214-2399, United States

1 - Optimal Task Planning Of Adversarial Games: An Integer Programming Approach

Demetrios Vasilios Papazaharias, University at Buffalo, Buffalo, NY, 14214-2399, United States, dv Jose L Walteros, Moises Sudit

In this study we will focus on determining an optimal schedule of tasks in an adversarial setting. We model this problem within the guise of network interdiction, where the defender seeks to complete a schedule of tasks in the minimum amount of time. The attacker can expend some resources in order to delay the processing time of the defender's tasks. The attacker seeks a minimum cost interdiction plan to ensure that the minimum completion time of the defender's schedule is bounded by a given parameter. We first model this problem as a bilevel mixed integer program. We then propose a reformulation with respect to the extreme points of the defender's polyhedron. Finally, we develop a decomposition algorithm to handle its exponential size.

2 - Conditional Value-at-Risk Shortest-Path Interdiction

Di Nguyen, Clemson University, Clemson, SC, United States, Cole Smith

We investigate an interdictor-evader shortest-path problem in which the interdictor attacks the network in advance and therefore only knows that the arc costs are uniformly distributed in given finite non-negative intervals. The impact of interdiction, i.e., the exact increase in an arc cost if interdicted, is known to both players. The evader, however, observes the arc costs in real time and chooses a shortest path when traversing the network. The interdictor seeks a solution that protects against the worst cases by maximizing the Conditional Value-at-Risk of the evader's shortest-path cost.

3 - Resilient Network Flow Models

Masoud Eshghali, University of Arizona, Tucson, AZ, United States, Pavlo Krokhmal

In this talk we propose metrics of network resilience with respect to exogenous stochastic disruptions in the context of network flow models, such as the classical maximum network flow and minimum-cost network flow models. The proposed approach is based on stochastic programming and is inspired by concepts of modern risk theory. The properties of the resulting problems are discussed, and numerical studies are presented, including Benders decomposition based solution algorithms.

■ VWD67

Virtual Room 67

Recent Methods for Nonlinear Optimization, Saddle Point Problems, and Games

Sponsored: OPT/Nonlinear Optimization

Sponsored Session

Chair: Mert Gurbuzbalaban, Rutgers University, Piscataway, 8854, United States

Co-Chair: Necdet Serhat Aybat, Penn State University, State College, PA, 16802-6817, United States

1 - Robust Primal-dual Methods For Computing Saddlepoints

Xuan Zhang, Penn State, PA, United States

We propose a stochastic accelerated primal-dual algorithm(SAPD) for the robust saddle point problem. Suppose the gradient estimator has a zero mean and finite variance, then the variance term in iteration complexity bound is optimal up to a log factor, which can be removed employing restarting strategy; the biased term concerning the initial error also obtains a linear decay rate, and we are not aware of other better single-loop algorithms. We also study the trade-off between robustness-to-gradient noise and the convergence rate depending on the choice of SAPD parameters. Either deterministic or merely convex-merely-concave results can be deferred from our analysis immediately.

2 - Synchronous and Asynchronous Randomized Douglas-Rachford Splitting Algorithms for Composite Finite-Sum Nonconvex Optimization

Quoc Tran Dinh, UNC, Chapel Hill, NC, United States

In this talk, we will present two randomized Douglas-Rachford (DR) splitting algorithms for a class of composite finite-sum nonconvex optimization problems widely used in machine learning and federated learning. The first algorithm is a randomized coordinate DR splitting scheme, while the second one is its asynchronous variant. We show that both algorithms achieve state-of-the-art iteration-complexity bounds and allow one to inexactly evaluate the underlying proximal operations. We apply our methods to a well-known federated learning model and numerically compare them with other methods on several numerical experiments of both synthetic and real datasets. Our results show some promising performance. This is a joint work with Nhan H. Pham (UNC), Lam M. Nguyen (IBM), and Dzung T. Phan (IBM).

3 - New Tools for Adversarial learning in Games

Jacob Abernethy, Ann Arbor, MI, 48104, United States

The fields of Machine Learning, Game Theory, and Optimization were originally thought to be quite distinct, but in recent years researchers have found a number of surprising and puzzling connections among the algorithmic tools used in each. In this talk we'll explore a number of emerging results on the unusually strong relationships between no-regret learning, nash equilibrium computation, multi-player game dynamics, and convex and non-convex optimization; we will also lay out a number of open problems that have remained a challenge in these areas.

■ VWD69

Virtual Room 69

Two-stage and Multistage Robust Optimization: Theory and Applications

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Maryam Daryalal, University of Toronto, Toronto, ON, Canada

1 - Practical Adjustable Robust Optimization Strategies For Online Production Scheduling Under Uncertainty

Qi Zhang, University of Minnesota, Minneapolis, MN, 55419, United States, Wei Feng, Yiping Feng

Operational schedules are commonly re-optimized at a given frequency or in response to certain events such as changes in demand or equipment failure. The goal of online scheduling is to design an appropriate "open-loop" scheduling problem that is solved such that the quality of the implemented "closed-loop" schedule is optimized. In this work, we apply an adjustable robust optimization approach to online production scheduling with uncertain product demands and processing times. To improve the computational performance, we explore practical strategies including a tailored discrete-time formulation, a mixed-integer decision rule approach, and a tailored online cutting-plane algorithm.

2 - Multi-sstage Robust Convex Optimization Problems: çA Sampling -based Approach

Francesca Maggioni, Associate Professor, University of Bergamo, Bergamo, Italy,Fabrizio Dabbene, Georg Pflug

In this talk, we consider multi-stage robust convex optimization problems of the minimax type. We assume that the total uncertainty set is the cartesian product of stagewise compact uncertainty sets and approximate the problem by a sampled subproblem. Instead of looking for the worst case among the infinite set of uncertain parameters, we consider only the worst case among a randomly selected subset of parameters. By adopting such a strategy, two main questions arise: (1) Can we quantify the error committed by the random approximation, as a function of the sample size? (2) If the sample size tends to infinity, does the optimal value converge to the true optimal value? Both questions will be answered. An explicit bound on the probability of violation is given and chain of lower bounds on the original problem provided. Numerical results show the efficiency of the proposed approach.

3 - Rsome In Python: An Open-source Package For Robust Stochastic Optimization Made Easy

Peng Xiong, National University of Singapore Business School, Singapore, Singapore, Zhi Chen

We develop a Python package called RSOME for modeling a wide spectrum of robust and distributionally robust optimization problems. RSOME could be used as a platform for formulating various optimization problems subject to distributional ambiguity in a highly readable and mathematically intuitive manner. Compared with the MATLAB version, RSOME in Python is more versatile and well fits in the open-source software community. We highlight its features through several practical application examples in the literature. RSOME is freely distributed for academic use on GitHub and one can find detailed user guides and more application examples from our official website.

■ VWD70

Virtual Room 70

Optimal Decision Making via Large Deviations Principles

Sponsored: OPT/Optimization Under Uncertainty

Sponsored Session

Chair: Daniel Kuhn, Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland, 1015, Switzerland

Co-Chair: Tobias Sutter, École Polytechnique Fédérale de Lausanne (EPFL)

1 - A General Framework For Optimal Data-driven Optimization

Tobias Sutter, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, Bart Paul Gerard Van Parys, Daniel Kuhn

We advance a novel framework which allows us to study how to transform data into optimal decisions. We characterize the optimal decision as the least conservative decision that guarantees an exponential decay of its corresponding out-of-sample disappointment, where the out-of-sample disappointment quantifies the probability that the actual expected cost of the proposed decision exceeds its predicted cost. By invoking a large deviation principle, we show that the optimal decision can be constructed via a separation into an estimation and a subsequent robust optimization phase. The corresponding robust optimization scheme relies on an ambiguity set that is induced by the large deviation rate function of the estimator used. The presented framework is the first to attempt rating the zoo of ambiguity sets derived in the recent literature in terms of statistical power.

2 - Distributionally Robust Optimization with Markovian Data

Mengmeng Li, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, Tobias Sutter, Daniel Kuhn

We study a stochastic program where the probability distribution of the uncertain problem parameters is unknown and only indirectly observed via finitely many correlated samples generated by an unknown Markov chain with d states. We propose a data-driven distributionally robust optimization model to estimate the problem's objective function and the corresponding optimal decision. By leveraging results from large deviations theory, we derive statistical guarantees on the quality of this estimator. The distributionally robust optimization problem is a nonconvex program of size (d2). By exploiting the underlying problem structure we propose a customized Frank-Wolfe algorithm to solve it with simple convex oracle subproblems of size (d). Numerical experiments show that our approach statistically outperforms existing methods from the literature.

3 - On Large Deviation Principles In Dynamic Decision Problems

Wouter Jongeneel, PhD student, EPFL Lausanne, Switzerland, Lausanne, Switzerland

Just recently, an optimal formulation of data-driven static optimization has been proposed by appealing to the theory of Large Deviations. The approach displays great flexibility and in this talk we will start the discussion regarding to what extent these ideas can be carried over to the dynamic setting.

4 - Optimal Data-driven Decision-making With Any Desired Out-of-sample Guarantees

Mohammed Amine Bennouna, PhD student, Operations Research Center, MIT, Cambridge, MA, United States, Bart Paul Gerard Van Parys

We study the problem of designing optimal approaches for stochastic optimization problems when only data is available. Most prior works construct estimators of the true unknown expectation using data and derive out-of-sample bounds to guarantee the quality of the estimator. We follow a different route. We formalize what are the desirable properties of estimators used for stochastic optimization problems and seek to find the "optimal" estimator verifying these properties. For any desired out-of-sample guarantee, we construct explicitly a Distributionally Robust (DR) estimator that is uniformly closer to the true cost than any other estimator verifying such guarantee, making it optimal. We exhibit three different regimes depending on the strength of the guarantee for which the optimal DR estimator has uncertainty set all probability simplex, KL ball and ellipsoid.

5 - Optimal Transport In The Face Of Noisy Data

Bart Paul Gerard Van Parys, MIT Sloan School of Management, Cambridge, MA, 02139, United States

Optimal transport distances are popular and theoretically well understood in the context of data-driven prediction. A flurry of recent work has popularized these distances for data-driven decision-making as well although their merits in this context are far less well understood. This in contrast to the more classical entropic distances which are known to enjoy optimal statistical properties.This begs the question when, if ever, optimal transport distances enjoy similar statistical guarantees. Optimal transport methods are shown here to enjoy optimal statistical guarantees for decision problems faced with noisy data.