TRIPODS+X Machine Learning & SCM Workshop

Student Poster Session

Monday, December 13, 2021 | Building C Lobby | 5:15PM

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Felix Schmidt
Logistics and Quantitative Methods
Julius-Maximilians University of Würzburg, Germany

"A Practical Application of Prescriptive Analytics for Dynamic Inventory Control"

Multi-period inventory problems have been studied extensively during the last decades. A common assumption is that the decision maker knows the distribution of uncertain demand. In practice, however, the underlying demand distribution is difficult to estimate: demand is often non-stationary, correlated across time and different products, and may depend on external factors (e.g., weather, holidays). Several studies have shown that estimating a (stationary) demand distribution and subsequently solving a stochastic optimization problem may lead to inferior results. Recently, Ban and Rudin (2019) have shown how "optimal" ordering quantities in a single-period setting can be derived using machine learning techniques that take historical demand and auxiliary data as input to directly prescribe inventory decisions. In this presentation, we show how such "data-driven" approaches can be applied to the more challenging multi-period inventory problem (fixed setup costs, ordering decisions interrelated, dependent demand). We develop an approach based on "weighted sample average approximation" as proposed by Bertsimas and Kallus (2019) and demonstrate how it can be tailored to a multi-period inventory problem with many items and demand that may depend on various external factors. We discuss the challenges that arise when applying prescriptive analytics to multi-period settings and illustrate first findings based on a real-world application in the pharmaceutical industry.

Co-Author: Richard Pibernik, Logistics and Quantitative Methods, University of Würzburg, Germany

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Kangye Li
Industrial and Systems Engineering
Lehigh University, Bethlehem, PA

"Management of OWMR System Subject to Supply Disruptions"

We study a periodic-review OWMR inventory system 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 provide an explicit cost function using a "top-down" approach and optimize

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the system by projection method. We also propose a heuristic for this problem.

Co-Author: Lawrence Snyder, Industrial & Systems Engineering, Lehigh University, Bethlehem, PA

3 **Toni Greif**
Information Systems & Business Analytics
Julius-Maximilians University of Würzburg, Germany

"Transparent Steel: Smart Silo Logistics"

Many industries boast highly efficient supply chains, but the construction industry has so far neglected this development. The reason for the less optimized supply chains is often the lack of accurate, up-to-date information. Bulk materials constitute the largest element of the construction supply chain. Thereby, bulk silos have established themselves to be particularly suitable for mobile bulk storage applications. For a leading supplier of building materials and construction systems, we create simulation-based decision support for bulk material logistics to guide the extent to which they should pursue investment in costly sensors for silo fill-level monitoring. Silos material inventory is vendor-managed since construction sites draw material from silos as they need it. The continuous availability of materials requires proactive replenishment across products and customers. The route planning problems for silo movers and tanker trucks occurring in the overall system do not correspond to standard problems served by off-the-shelf logistics optimization software. The findings on the appropriate use of information technology to improve decision-making with partial information are generally relevant for suppliers looking to stand out with service guarantees and short delivery times.

4 **Lanqing Du**
Operations and Business Analytics
Drexel University, Philadelphia, PA

"Decision Making for the Disrupted Supply Chain using Timestamped Location Graph Representation"

We propose structural analyses of the logistics network to simulate how the ripple effect of disruption influences the network and how third-party logistics services would help mitigate the disruptions. We formulate a novel optimization problem on disrupted supply chain network with suitable fulfillment constraints. With a moderate level of disruption, cooperation with third-party logistics companies could provide extra resilience. When the supply chain network is highly disrupted, direct shipping from the origin to the destination would be the optimal solution to guarantee on-time delivery with minimum cost.

Co-Author: Jinwook Lee, Decision Sciences & MIS, Drexel University, Philadelphia, PA

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5 **Simone Buttler**
Logistics and Quantitative Methods
Julius-Maximilians University of Würzburg, Germany

"Application of Generative Adversarial Networks in Inventory Management"

With machine learning methods entering the space of operations management, a growing need for training data has emerged. Historical demand data, in particular, are often highly irregular by their very nature. Furthermore, there may be confidentiality issues which limit the access to training data. One way to alleviate this shortage is the augmentation of training data by means of representative synthetic observations. However, current methods to create additional data samples such as distribution fitting suffer from the curse of dimensionality; esp. if we take into account features. We propose the use of generative adversarial networks to synthesize additional samples. In this research, we explore the suitability of this type of data generation in the context of the well-established and tractable newsvendor problem setting.

Co-Authors: Richard Pibernik, Nikolai Stein, Christoph M. Flath, Logistics & Quantitative Methods, Juilus-Maximilians University of Würzburg, Germany

6 **Sagnik Das**
Operations Research
Carnegie Mellon University, Pittsburgh, PA, USA

"Order Fulfillment Under Pick Failure in Omnichannel Ship from Store Programs"

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.

Co-Authors: R. Ravi, Operations Research & Computer Science, CMU; Srinath Sridhar, Onera

7 **Kai Michael Günder**
Logistics and Quantitative Methods
Julius-Maximilians University of Würzburg, Germany

"A Two-Step Machine Learning Approach to Improve Decision in The Face of Intermittent Demand"

In many operations management settings demand frequently contains zeros, which leads to so called intermittent demand patterns. Accurately predicting these demand patterns usually is a very difficult task,

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which leads to subsequent insufficient planning quality like unnecessary overstocking. For that reason J. D. Croston (1972) proposed the idea to split the prediction of intermittent demand time series into two parts: First estimating the probability that any demand will occur and then predicting the level of the demand size provided that there is positive demand. In my research I leverage this concept by applying it to modern machine learning approaches like LightGBM and combining it with the weighted sample average approximation (wSAA) approach by Bertsimas and Kallus (2018). This leads to a new approach that inherits valuable theoretical properties like asymptotic optimality from wSAA and in many settings generates superior decisions for intermittent demand data.

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Andreas Philippi
Logistics and Quantitative Methods
Julius-Maximilians University of Würzburg, Germany

"ddop: A Python Package for Data-Driven Operations Management"

In recent years, several data-driven approaches have been developed, that combine machine leaning and traditional optimization techniques to improve and automate decision making in operations management. However, what is missing is efficient access to open-source code and datasets. With ddop, we have developed a Python package that integrates well-established algorithms form the field of data-driven operations management, as well as standard benchmark datasets. The application programming interface (API) of ddop is designed to be consistent, easy-to-use, and accessible even for non-experts. With only a few lines of code, one can build and compare the various models implemented in the package.

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Mohammadhossein Mohammadisiahroudi
Industrial & Systems Engineering
Lehigh University, PA, USA

"Application of Quantum Linear System Algorithms for Machine Learning"

Due to its potential to revolutionize computing, Quantum Computing has attracted significant interest in many fields, including Artificial Intelligence and Machine Learning (ML). One major direction is using Quantum Linear System Algorithms (QLSA) since they can solve large linear systems arising from ML problems much faster than classical computers. Using QLSAs on contemporary NISQ devices comes with challenges such as considerable error, noise, and their dependence on condition number. We will address these challenges by proposing an Iterative Quantum Algorithm (IQA) for solving linear systems using QLSAs efficiently. The proposed IQA speed up solving Least Squares problem for linear regression problems compared to classical and previous quantum solvers. Numerical experiments show how adaptive regularization helps to reduce solution time for ill-conditioned systems.

Co-Authors: Brandon Augustino, Michael O'Neill, Tamás Terlaky, Industrial & Systems Engineering, Lehigh University, PA

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Nikolai Stein
Logistics & Quantitative Methods
Julius-Maximilians University of Würzburg, Germany

"Data-driven Maintenance Job Assignment in Manufacturing"

In the manufacturing and service industry, companies face the challenge of assigning employees to jobs in a cost-minimizing way. A case in point are manufacturing companies that have to assign service workers to stochastically occurring disruption events. In these and many other instances, there are two types of workers that can be assigned: generalist and specialist. Specialists usually process a subset of possible jobs more quickly, whereas generalists require more time but can solve several job types. While generalists can therefore be deployed on a broad basis, it is possible to reduce costs by assigning a specialist. However, assigning a specialist to a wrong problem results in delays and higher costs. Additionally, workers assigned to an occurring disruption now might not be available to handle disruptions appearing later. Ultimately, this results in a problem with two types of uncertainties: One regarding the type of the current disruption and one regarding the occurrence and type of upcoming jobs.

Motivated by a real-world maintenance assignment problem of a manufacturing company, we propose and study a new data-driven approximate dynamic stochastic programming approach, which addresses both types of uncertainty. To this end, we leverage local machine learning methods to approximate the conditional distribution of the uncertainties, with respect to a set of features. Based on these distributions, we solve the dynamic stochastic optimization problem and benchmark it with a set of existing state-of-the-art approaches that do not account for both uncertainties.

Co-Authors: Felix Oberdorf, Business Management & Economics; Christoph Flath, Information Systems and Business Analytics; Richard Pibernik, Logistics and Quantitative Methods, Julius-Maximilians University of Würzburg, Germany

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