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Topic: Co-, Cross- and Transfer Learning In Manufacturing and Service Operations Management

ABSTRACT

Decision making with limited data is challenging. In this talk, we discuss the ideas of co- cross- and transfer learning in areas such as predictive maintenance, queueing and inventory control. We will relate the ideas here to the data pooling idea that originated with Charles Stein. In particular we introduce the framework of operational data analytics (ODA) that integrates data to predictive or prescriptive solutions. This framework strikes a delicate balance between the (likely imprecise) statistical structural knowledge and the data. The two pillars of the ODA framework are (i) a data-integration model that identifies the class of operational statistics based on the desired structural properties of the models within the domain of validation, and (ii) a validating model that appropriately utilize the data to validate the choice of the operational statistics. Using the classical newsvendor model as an example, we show that the ODA framework generalizes the existing approaches including predict-then-optimize, regularized empirical optimization, robust optimization, robust satisfying, order statistics and smart-predict-and-optimize. We further demonstrate that the data-integration model and the validating model in ODA must be formulated in a coordinated way based on the preciseness of the knowledge and the availability of the data. We present co-, cross- and transfer learning with ODA for a newsvendor system in two specific scenarios:

(1) When ample data form a related system can be used to supplement the limited data from the focal system, we demonstrate that the ODA solution exhibits apparent advantages over the popular transfer-learning solutions. In particular, we propose cross learning by adapting the parametric ODA solution for non-parametric decision making. Under this approach, we utilize the ample data from the related system to mimic the stochastic environment of the focal system, which allows for effective validating. The resulting ODA solution significantly improves the performance of the focal system over the transfer-learning solution and is shown to be asymptotically optimal.

(2) When there are multiple related systems each with limited data, we transform the data from different systems to create a generic stochastic environment for the decision-making problem, which facilitates the implementation of the ODA solution. We show that the derived co-learning solution is asymptotically optimal for each involved system, as well as the aggregate system, and outperforms the existing data-pooling strategies, which focus only on aggregated performance.

These results underscore the importance of domain knowledge and the structural relationships (between the data and the decision) in designing efficient decisions with limited data and co-, cross- and transfer learning.

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BIOGRAPHY

J. George Shanthikumar is the Richard E. Dauch Chair Professor of Manufacturing and Operations Management and a University Distinguished Professor of Management at the Krannert School of Management, Purdue University, West Lafayette, IN and a Professor Emeritus of Industrial Engineering and Operations Research at the University of California, Berkeley, CA. Before joining Purdue, he was a Chancellor's Professor of Industrial Engineering and Operations Research at the University of California, Berkeley, CA. He received the B. Sc. degree in Mechanical Engineering from the University of Sri Lanka, Peradeniya, and the M. A. Sc. and Ph. D. degrees in Industrial Engineering from the University of Toronto, Toronto, Canada.

He was the president of POMS for the year 2018, is a Fellow of the Institute for Operations Research and Management Science (INFORMS) and Production and Operations Management (POM) Societies. He is a departmental editor of Management Science, and Production and Operations Management Society Journal, an associate editor of Naval Research Logistics.

His research interests are in model uncertainty, learning, data-integrated operations management, production systems modeling and analysis, queueing theory, reliability, scheduling, semiconductor yield management, simulation, stochastic processes, and supply chain management. He has written or written jointly over 300 papers on these topics. He is a coauthor (with John A. Buzacott) of the book Stochastic Models of Manufacturing Systems and a coauthor (with Moshe Shaked) of the book Stochastic Orders and Their Applications and the book Stochastic Orders.

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Dr. Shanthikumar has extensively consulted for various companies like Applied Materials (AMAT), Bellcore, IBM, KLA-Tencor, NTT (Japan), Intel, Intermolecular, Reel Solar, Safeway, and Southern Pacific Railways and through KLA-Tencor worked on Joint Development Projects for AMD, IBM, Intel, LSI, Motorola, TI, Toshiba, Fujitsu, TSMC and UMC. He is an advisory consultant for Sensor Analytics and was member of the technical advisory board of Inter Molecular Inc. and Reel Solar, Inc.