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Preface

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Preface

We are delighted to bring forth this volume of TutORials highlighting selective recent exciting developments from many Informs communities to address critical challenges from various applications. We believe this compilation of contributions by experts from these topics will be a good representation of the current and emerging trends in OR/MS. We provide brief summaries of the chapters under sub-themes of the compilation.

OR/MS Frontiers: Mixed-integer programming (MIP) and stochastic programming (SP) represent two of the most challenging classes of optimization models. The discrete and non-convex aspects of MIP, and the need to capture uncertainty via SP, raise serious conceptual and computational challenges. The chapter by Küçükyavuz and Sen provides an introduction to two-stage stochastic mixed integer programs (SMIP), the integrated model of both MIP and SP. The chapter describes methods which decompose the problem by scenarios representing randomness in the problem data, and discuss the theoretical properties and numerical performance of these methods. The chapter by Ning introduces a class of decomposable affine Markov decision processes (MDPs) that have continuous multi-dimensional endogenous states and actions, and an exogenous state that follows an exogenous Markov chain. Unlike most MDPs with continuous state and actions, decomposable affine MDPs are free of the curse of dimensionality and can be solved easily and exactly. The applicability of decomposable affine MDPs is illustrated by several application examples. Demand information is an input for a great deal of OR models. In many problem instances in the literature, demand data are difficult to generate. The chapter by Bierlaire and Lurkin provides an introduction to disaggregate demand models that are designed to capture in detail the underlying behavioral mechanisms at the foundation of the demand.

Optimization and Deep Learning: In 2016, a computer Go-playing program called AlphaGo stunned the world by winning a match against the reigning human world champion. The main engine behind AlphaGo combines deep learning approaches with a technique called Monte Carlo tree search, whose roots can be traced back to an adaptive multistage sampling simulation-based algorithm for Markov decision processes (MDPs). The chapter by Fu describes AlphaGo and the simulation-based MDP algorithm, as well as provides contextual and historical background material for both, and uses simple examples to illustrate the main ideas behind Monte Carlo tree search. The chapter by Curtis and Scheinberg reviews key models, algorithms, and open questions related to the use of optimization methods for solving various machine-learning problems from the classical support vector machines to deep neural networks. The chapter will also describe numerous effective optimization algorithms, which include the first-order methods, the stochastic gradient method, variance reducing stochastic methods, and second-order methods, and discuss how these methods can be employed to address complex machine learning issues.

OR Approaches for Biology, Energy and Health Care Systems: The adroit OR repertoire has flourished through interactions with many other disciplines. The chapter by Brooks and Holder considers the metabolic network, represented by a system of differential equations, a model widely used in the study of biochemical reactions that sustain life. A basic linear optimization model called Flux Balance Analysis (FBA) is introduced to identify the optimal metabolic conditions for growth. Several open research avenues on integration of various modern optimization models and FBA analysis are discussed. The chapter by Anjos and Gomez describes how to ensure that production and demand of electricity are continuously in balance, given fundamental changes in the power grids caused by recent

developments in energy technology and policy. Existing OR models and open opportunities are discussed as well. The chapter by Wu et al. focuses on research investigating the roles of medical imaging in cancer diagnosis and treatment planning, and offers a comprehensive review and discussion on four important components in medical image process: imaging pre-processing, imaging feature extraction, feature dimensionality reduction and classification. Two clinical case studies are presented to illustrate the clinical relevance of the imaging Multi-Texture Disease Diagnosis System (iMT-DDS).

New Developments from Traditional OR/MS Fields: The INFORMS communities had played and still playing an instrumental role in shaping numerous fields of OR/MS. In their chapter, Federgruen and Hu review recent development in the study of price competition models, focusing on latest models for multi-echelon supply chains with an arbitrary number of competing firms and products at each echelon. Recent technological developments such as GPS and mobile services have greatly enhanced the communication capabilities of travelers, facilitating ridesharing in real-time. This opportunity has created a new ridesharing industry built on making use of the unused vehicle capacity moving about on the roads. The chapter by Ordóñez and Dessouky reviews recent research on new vehicle routing models, cost sharing mechanisms, and planning models that incorporate ridesharing. Emergence services can be found in both public and private sectors. The chapter by Marianov describes some of the successive location model innovations that have addressed the main issues and added increasing degrees of reality to the modeling, with a focus on applications to the design of medical and firefighting systems. The chapter by Kara and Savaser provides an introduction to humanitarian logistics by defining its characteristics, application areas and challenges. Relief logistics and development logistics literature are analyzed and synthesized based on OR models appeared in recent disaster management cycle. Several case studies in disaster management and health care delivery are presented.

RAJAN BATTA
University at Buffalo,
The State University of New York
Buffalo, New York

and
JIMING PENG
University of Houston
Houston, Texas