



Interfaces

Publication details, including instructions for authors and subscription information:
<http://pubsonline.informs.org>

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To cite this article:

Wenjing Shen (2015) Book Reviews. Interfaces 45(4):365-368. <https://doi.org/10.1287/inte.2015.0799>

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Book Reviews

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In *Book Reviews*, we review an extensive and diverse range of books. They cover theory and applications in operations research, statistics, management science, econometrics, mathematics, computers, and information systems. In addition, we include books in other fields that emphasize technical applications. The editor will be pleased to receive an email from those willing to review a book, with an indication of specific areas of interest. If you are aware of a specific book that you would like to review, or that you think should be reviewed, please contact the editor.

The following books are reviewed in this issue of *Interfaces*, 45(4), July–August 2015: *Multicriteria Decision Aid and Artificial Intelligence: Links, Theory and Applications*, Michael Doumpos and Evangelos Grigoroudis; and *Optimized Response-Adaptive Clinical Trials: Sequential Treatment Allocation Based on Markov Decision Problems*, Thomas Ondra.

DOUMPOS, MICHAEL, GRIGOROUDIS, EVANGELOS, EDS. 2013. *Multicriteria Decision Aid and Artificial Intelligence: Links, Theory and Applications*. John Wiley & Sons. 351 pp. \$113.00.

Multicriteria Decision Aid and Artificial Intelligence: Links, Theory and Applications consists of 14 chapters that are grouped into five parts. Part I, *The Contributions of Intelligent Techniques in Multicriteria Decision Aiding*, is the introductory section and encompasses the first two chapters. The eight chapters in Parts II–IV address various methodological approaches to multicriteria decision making, including preference modeling, the decision support system (DSS) under uncertainty, decision models, and multiobjective optimization. Finally, the four chapters in Part V address the applications of multicriteria decision aids in management and engineering.

The related literature includes several edited books (Bui and Alam 2008, Coello et al. 2010, Zapounidis and Pardalos 2010) and a monograph (Deb 2001); Doumpos and Zapounidis (2002) also discuss a similar topic. In addition, international conferences on related subjects frequently publish their proceedings. Nevertheless, these publications are not redundant because of the very active research in multicriteria decision analysis and the growing interest in techniques relating to potential applications. Constructive methods, developed from the merger of decision theory and the techniques of artificial intelligence (AI) and supported

by advanced information technology, are especially attractive techniques for building applications.

This book is oriented to a broad audience of researchers and practitioners in management and engineering who seek to apply multicriteria decision techniques to solving applied problems. Novices to the field will also benefit from the book's broad introduction and comprehensive references. Hopefully, it will stimulate a new synergy between research in multicriteria decision theory and the techniques of computational intelligence.

In Chapter 1, Doumpos and Grigoroudis give an overview of the integration of computational intelligence techniques and multicriteria decision analysis. Each author has edited several books on related subjects; Zapounidis and Pardalos (2010) is an example. The real strength of Doumpos and Grigoroudis is their broad knowledge of the subject and their experience in collecting papers for the edited books. They demonstrate this in this overview in which they summarize the contents of the chapters and discuss them in the context of the state of the art. Chapter 2 (Philips-Wren) deals with the intelligent DSS and supplements the material in the first chapter. Chapters 1 and 2 are seemingly oriented to different groups of readers. The authors of Chapter 1 assume that the reader understands the main theoretical concepts and application areas of computational intelligence (e.g., artificial neural networks, fuzzy systems, and

evolutionary methods); however, in Chapter 2, the author explains some basic terms (e.g., artificial neural networks and genetic algorithms) at an elementary level.

Part II, *Intelligent Technologies for Decision Support and Preference Modeling*, reviews and discusses two such technologies: designing a multicriteria DSS (Chapter 3: Comes, Wijnngaards, and Schultmann) and preference representation with ontologies (Chapter 4: Valls, Moreno, and Borrás). In the discussion of DSS design, the uncertainty problem is emphasized. The proposed approach integrates scenario-based reasoning with decision analysis to make trade-offs. The applicability of the proposed approach highlights its key challenges. This chapter on multicriteria analysis includes little information on AI. Chapter 4, however, focuses on AI and demonstrates the usefulness of the ontology, which is a well-established branch of computer science and information technology (e.g., in the implementation of preference representation in the recommended systems).

Part III, *Decision Models*, reviews three research directions that differ substantially. The topic of neural networks is a classical branch of AI, and in Chapter 5, Hanne reviews the applications of artificial neural networks (ANNs) to the problems of multicriteria decision making. He precedes the review by introducing the basic concepts of ANNs and discusses ANNs as applied to multicriteria decision aids. A natural application of an ANN to aid multicriteria decisions is the learning of multiattribute utility functions and scalarization functions by ANNs. The classical feed-forward with back propagation methods of learning (with some modifications) are appropriate here. The author comments on numerous application papers, published mainly during the 1990s, and concludes that interest in the area has declined recently. Nevertheless, some potential for ANN applications remains in recent DSS developments.

Multicriteria ranking, the subject of Chapter 6 (Szlag, Greco, and Slowinski) is usually treated as an operations research topic; however, some ranking methods relate to AI because they use methodologies attributable to knowledge engineering and computational intelligence (e.g., fuzzy logic and rule-based reasoning). The review focuses on the rule-based

approach to ranking, a branch of multicriteria ranking developed primarily by the chapter's authors and their collaborators; their papers constitute much of the reference list. Chapter 7 (Boujelben and De Smet) considers multicriteria decisions under uncertainty. Evidence theory describes and interprets the uncertainty and imperfection of the information available to a decision maker. After introducing the basic concepts of evidence theory, the authors review applications of that theory to multicriteria decision analysis, focusing on their own work (e.g., the first-belief dominance) and ranking basic belief assignments based on belief distances. Finally, they review the other five applications of evidence theory to multicriteria methods (e.g., evidence theory-based extension of the analytic hierarchy process, called Dempster-Shaffer/AHP).

Chapters 8, 9, and 10 in Part IV, *Multiobjective Optimization*, consider the traditional topics in multiobjective optimization: interactive evolutionary algorithms (Jaimes and Coello), data envelopment analysis (Yun and Nakayama), and fuzzy optimization (Sakawa), respectively. The methods discussed in Chapter 8 are seemingly known to anybody with even a little interest in optimization. Many papers that are oriented to a broad audience discuss evolutionary optimization methods, including multiobjective optimization methods. Therefore, the authors limited this chapter to 15 pages, which include an introduction to the basic concepts of multiobjective optimization. This review of multiobjective interactive optimization focuses on the reference-point and value-function methods. Chapter 9 considers generalized data envelopment analysis (GDEA), addressing multiobjective optimization as an aid for indicating a part of Pareto optimal solutions, an area that can be most interesting to a decision maker. The method is labeled generalized because it can treat three basic models of data envelopment analysis in a unified way. Yun and Nakayama also show that GDEA is applicable in selecting favorable parameters of multiobjective optimization methods, based on the particle swarm optimization model, and that GDEA is an efficient method for approximating nonconvex parts of the Pareto frontier. Finally, they use a statistical model of objective functions to demonstrate how GDEA's efficiency can be enhanced. Some publications refer to such a method as Kriging; however, Zilinskas (1982) gave an axiomatic definition of statistical models for global optimization

much earlier than any of the papers cited in this chapter. Note that Zilinskas (2014) extends this methodology to multiobjective optimization. The chapter on the fuzzy multiobjective optimization (Chapter 10) deals with various versions of linear programming, which the authors generalize by introducing fuzzy and stochastic parameters. The style of this chapter differs from that of other chapters because it includes theorems. In this review, Sakawa devotes the most attention to his work and that of his collaborators.

The concluding part of the book, Part V, *Applications in Management and Engineering*, contains four chapters. In Chapter 11, Delias and Matsatsinis consider the resource-management problem in a cloud computing context by representing preferences of agents by a collective value function. In Chapter 12, Ucal, Öztaysi, and Kahraman describe in detail an application of the fuzzy analytic hierarchy process to warehouse locations. Two papers on the applications of multiobjective optimization methods complete the book. In Chapters 13 and 14, respectively, Diakaki and Grigoroudis adapt genetic algorithms to optimize the energy efficiency in buildings, and Vassiliadis and Dounias apply a hybrid evolutionary algorithm to the computation of the Pareto frontier in a problem of portfolio optimization.

Comparing the considered book with Bui and Alam (2008), which deals with a similar subject, is interesting. The number of pages and the content of each book are similar, and both books consist of a methodological section and papers on applications. The presentation of the material by the authors of both books has no noticeable methodological differences; and the similarity of the ideas discussed and the results obtained smoothly develop the subject; however, neither forecasts a significant breakthrough. The application sections of each book demonstrate that from the publication of the first book in 2008 until now, evolutionary algorithms remain most popular among users of the AI-related multicriteria analysis methods. Bui and Alam (2008) tackle all seven application problems using evolutionary methods; however, Doumpos and Grigoroudis apply evolutionary methods in three of four problems.

To conclude this review, I recommend that departmental libraries buy this book for its presentation of state-of-the-art methodologies in multicriteria decision analysis as it relates to AI.

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ONDRA, THOMAS. 2015. *Optimized Response-Adaptive Clinical Trials: Sequential Treatment Allocation Based on Markov Decision Problems*. Springer-Verlag, Springer Spektrum. 102 pp. \$89.99.

This book—a monograph concerning the use of Markov decision processes (MDPs) to the application of response-adaptive clinical trials in a pharmaceutical setting—is a translation of a master's thesis from the mathematics department of the University of Vienna.

It is a remarkably concise exposition of the use of MDPs in a pharmaceutical setting; as such, the book's audience is the intersection of researchers and students with a sophisticated mathematical background and professionals in the pharmaceutical industry.

This book seeks to balance the design of the clinical trial process to ensure that the most efficient treatment is identified, while minimizing the assignment of patients to the inferior treatment—a most worthy objective considering the ethical dilemma inherent in this scientific process. The author's background of mathematics and statistics gives him the foundation to discuss the MDP theory and methodology and his research experience with the Medical University of the University of Vienna underscores his practical experience.

The only other book I have found at the intersection of MDP and the pharmaceutical industry that seems

to come close to this book is by Chang (2011), which uses simulation to argue for MDPs in clinical trial research. Many other journal articles, however, discuss the important issues in this book under review.

The main points of the book are that MDPs are very useful in planning a response-adaptive clinical trial program. The author constructs his arguments from a mathematician's viewpoint wishing to explain Bellman's equations and demonstrating algorithms for their implementation.

He carries out this quest through the structure of four chapters and an appendix:

- I. *Introduction to Markov Decision Problems* (17 pages)
- II. *Finite Horizon Markov Decision Problems* (18 pages)
- III. *Infinite Horizon Markov Decision Problems* (26 pages)
- IV. *Markov Decision Problems and Clinical Trials* (27 pages)
- V. *Appendix* (five figures)

Chapter I is a nice summary of the MDP problem and Onda's definitions and notation parallel those of Puterman (1994). He concludes with three examples.

Chapter II deals with finite horizon MDPs. He explains the optimal policies through Bellman's equations, develops algorithms for their solutions, and demonstrates the algorithms using the examples presented in Chapter I.

Chapter III parallels Chapter II in its structure and style presenting the infinite horizon case, the Bellman equations, and a value and policy iteration algorithm for their solutions.

Chapter IV is the main event in which the author investigates the applicability of the MDP models for the clinical trial problem. He compares two medical treatments, T1 and T2, with success probabilities p_1 and p_2 , respectively, and the allocation of M patients to the two treatments. He explains in detail the finite and infinite horizon cases with examples that indicate the randomization model. The number of wrong decisions in which better treatments were not detected is comparable with that of the equal randomization strategy, whereas the number of study participants receiving the inferior treatment with the MDP strategy is much smaller than in the equal randomization case. When p_1 and p_2 are close, the strategies do not

differ much. Overall, the implementation of the MDP is very successful.

My overall evaluation is that the presentation is basically theorem proof. This is fine from a mathematician's viewpoint, but it could be intimidating for the nonmathematician. Examples are sprinkled throughout the book; however, explanations of the importance and significance of the theorems remain hidden.

In addition, the book does not include an index, which seems to be a major oversight. Although it is a master's thesis, such an index would be most helpful. For a monograph to be brief and to the point is positive; however, for most readers, the lack of an index makes connecting the concepts or going back and revisiting them difficult.

The author does an excellent job of explaining the computational complexity of the algorithms, which is certainly important given the size of the state space of the models; however, he never really explains how he implemented the algorithms in a computer language, an important consideration of the practical implementation of his ideas.

The bibliography lists only 17 references—a minimal number. Although the author has cogently chosen these references, he should have included more. I am not an expert in the adaptive clinical trial research; however, a quick perusal of the literature in this area revealed that the author does not seem to have compiled a thorough review of the available technical literature of MDP models in this area and possible variations on the author's own MDP models.

Overall, I think that the book is a very sophisticated treatise on MDP models for managing response-adaptive clinical trials and both mathematicians and pharmaceutical professionals would appreciate it.

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