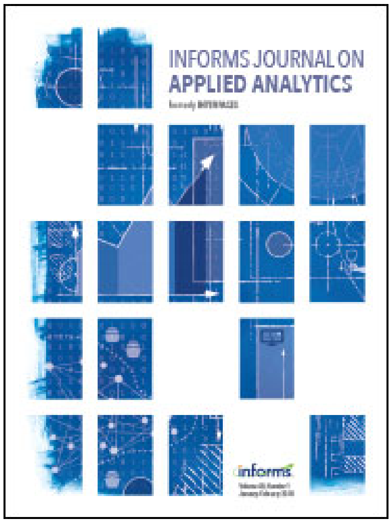

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Book Reviews

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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. However, we do not review software. To submit a book for review, please send it to me at the above address. Although we cannot review all books because of space limitations, we do list all books that we receive. We commission all book reviews and do not accept unsolicited reviews. To become a reviewer, please send me your name, address, and specific areas of expertise. We encourage readers to suggest books for review or to ask publishers to send copies of such books.

The authors or editors of books we review in this issue are Milind W. Dawande, H. Neil Geismar, Suresh P. Sethi, Chelliah Sriskandarajah, Finn R. Forsund, Yu-Chi Ho, Qian-Chuan Zhao, and Qing-Shan Jia.

Dawande, Milind W., H. Neil Geismar, Suresh P. Sethi, Chelliah Sriskandarajah. 2007. *Throughput Optimization in Robotic Cells*. Springer, New York. 417 pp. $115.00.

A robotic cell is a computer-controlled material-handling system that conveys materials through the multiple processing stages that are required to produce a finished product. Such automated environments are a staple of the modern manufacturing sector, especially in the United States. The Congressional Budget Office, in one of its Economic and Budget Issue Briefs, reports that in the past five decades, employment in the manufacturing sector (as a share of total employment) has gone from 35 percent to 12 percent. During that same period, manufacturing output (as a ratio to the GDP) has remained steady at approximately 15 percent. How were the American manufacturers able to produce more with fewer numbers of workers? Undoubtedly, the answer is automated manufacturing, and efficient design and management of such environments is of utmost importance.

As a part of a course I teach at the Johnson School of Cornell University, I take my class to visit a variety of manufacturing environments. We are always impressed with the amount of goods that a limited workforce produces. For example, the Pearl River plant of Wyeth produces seven billion Centrum tablets in a year with no more than a few hundred workers. Similarly, the Baldwinsville brewery of Anheuser-Busch produces 325,000 cases of beer per day with about 500 workers. The Geneva plant of Guardian glass produces 425 tons of float glass per day with fewer than 100 employees. The Ithaca plant of Kionix produces about 20 million micro electro-mechanical systems (MEMS)-based accelerometers each year with about 20 employees. To achieve such high levels of production volumes without employing large numbers of workers, these companies rely heavily on the automated movement of materials. This book deals with these automated material movements, and especially their optimal design. As such, its timely publication could play a role in the next stage of productivity improvements in American manufacturing.

For more than 30 years, many researchers have focused on robotic-cell design and optimization. However, there has never been a comprehensive collection of the developments in this area. This book serves that purpose well, and will be a useful resource for students, practitioners, and researchers. It accomplishes this role particularly well in Chapters 2 and 10, and in its long list of references. In Chapter 2, the authors provide a classification scheme, which is based on number of machines, number and types of robots, processing characteristics (pickup criteria, travel-time metric, and number of part types), and objective function for all the research problems studied in this area. It enables one to quickly determine which of these problems have been solved and which are yet to be addressed. Another major contribution is a collection of all the open problems in this area (Chapter 10). This chapter should be important to future researchers. The bibliography, which is a valuable resource by itself, contains about 200 references.

Chapters 3 to 7, which provide a comprehensive description of the existing results in the design and analysis of robotic cells, contain the main content of the book. Much of their emphasis is on identifying the optimal sequence of robot moves in a given cell; they include an incredibly large number of results related to these problems. Chapter 3 deals with the cells that produce one type of part using a single-gripper robot, Chapter 4 focuses on the cells that contain dual-gripper robots, and Chapter 5 addresses settings that contain multiple machines at each stage. Chapters 6 and 7 focus on settings in which multiple types of products are manufactured with a single-gripper robot (Chapter 6) or a dual-gripper robot (Chapter 7). The authors have done an excellent job of documenting all these results in a consistent notation and have written easy-to-follow proofs for each. Therefore, this book and its contents are easily understandable to graduate students and researchers who are new to this area. Chapters 8 and 9 deal with relatively unexplored topics associated with multiple robots (Chapter 8) and no-wait and interval-pickup criteria (Chapter 9).

This book would be an excellent reference source for any reader who is broadly interested in the optimization of automated manufacturing environments. It could also be used as a textbook for an advanced two-semester graduate-level course. The problem-classification scheme, list of open problems, bibliography, and easy-to-read proofs of existing results are highlights of the book. However, it lacks a few "nice-to-have" features. The first is an easy-to-use index table that connects the classification scheme to the bibliography. Using such a table, a reader can quickly determine which papers deal with the specific problem in which he or she has an interest. The second is another table that clearly indicates the specific sections of the book that address each of the problems in the classification. The addition of these two features would have significantly enhanced the value of this book as a reference. I hope the authors add them in a second edition of the book.

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Forsund, Finn R. 2007. *Hydropower Economics*. Springer, New York. 261 pp. $99.00.

This book claims that if one is to correctly comprehend deregulation in electricity markets, then one must first develop an appreciation for the optimal use of hydro and thermal power. A key question that arises in the study of the production of hydroelectric power concerns the utilization of the water in the reservoir(s). This question is nontrivial because water that is used to produce electricity today can also be used tomorrow. That is, the analysis of the production of hydroelectric power is fundamentally an intertemporal problem. Given this background, the primary purpose of this book's 10 chapters is to "provide qualitative economic analyses of how to utilize stored water in a hydropower system…" (p. 4) and to "provide a social planning perspective on [the] optimal use of water…" (p. 5). Methodologically, the book conducts its analyses using the tools of modern nonlinear programming. It employs the Kuhn-Tucker conditions extensively to provide qualitative interpretations of the various models that the author constructs.

Chapter 2 begins by presenting a basic hydroelectric power model in which there is neither discounting nor a reservoir constraint. This model evaluates the consumption of electricity using utility functions; it treats water as a natural resource that is in finite supply. It derives a pricing rule a la Harold Hotelling; this rule tells us that the price of electricity must be the same in every period under consideration. This chapter also considers the consumption of water by several user groups. The analysis first assumes that each user group consumes water in each pertinent time period; it then shows that if this assumption is valid, the "discounted socially weighted marginal utilities of water consumption should all be equal between different user groups and equal over time …" (p. 29).

Chapter 5 addresses how the presence of thermal generators affects the generation of hydroelectric power. The author begins his discussion by pointing out that unlike the operation of hydroelectric power plants, the running of thermal plants is basically a static problem. The theoretical analysis that the author undertakes in this chapter leads to the following salient conclusion: When reservoir constraints do not bind, "thermal capacity may be regarded as base load because it will be used at constant capacity … for all periods when hydro is also used, while the use of hydro will follow any shift of the demand over the periods" (p. 106). An implication of this conclusion is that in periods in which hydroelectric power is not used, the social price level is lower than the so-called "water value." Hence, less thermal power is used during these periods.

In reality, countries often trade in electricity. Therefore, it is interesting to study the impact of such trade at fixed foreign prices on the price of electricity in the home country. Chapter 6 focuses on this question and makes two noteworthy points. First, it provides a useful discussion of the circumstances under which the trading home country will find it desirable to adopt the foreign price as its own price. Second, it includes comments on the importance of whether or not the transmission constraint binds; it notes that at home there will be "import and no use of hydro when the transmission constraint is not binding and use of hydro in addition when the transmission constraint is binding with positive shadow price" (p. 133).

Chapter 8 studies the behavior of a monopoly producer of hydroelectric power. The author demonstrates that the monopolist will tend to shift water away from periods in which demand is relatively inelastic to those periods in which it is elastic. He then continues his analysis by focusing on a model that has a dominant firm and a competitive fringe. This analysis tells us that the "existence of a fringe leads the dominant firm to use more thermal capacity in the high price period than in the low price period, in contrast to the monopoly case" (p. 208).

The inflows of water into reservoirs are typically probabilistic variables. Therefore, it is important to determine the impact that the presence of uncertainty about inflows has on the pricing of electricity. The author addresses this and other related issues in the penultimate chapter of this book. He shows that deviations between the expectations and the realizations of water inflows may generate differences in the price of electricity over time. That is, uncertainty "contributes independently to price variation" (p. 225). This occurs because the above-mentioned deviations make the continuous adjustment of prices toward the planning horizon the optimal policy.

In conclusion, I make the following five observations. First, this book would have profited from a thorough review of the extant literature. Second, in some cases, the assumptions that the author makes raise questions about the robustness of his conclusions. Third, one gets the impression that the author has occasionally chosen to focus on optimization problems that he knows he can solve rather than on the most pertinent optimization problems. Fourth, on multiple occasions, the author says virtually nothing about germane topics in the context of the production and management of hydroelectric power. Finally, the above caveats notwithstanding, it is important to note that the author deals well with his selected topics. Therefore, I recommend this book to all readers who wish to learn more about the economics of hydroelectric power.

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Ho, Yu-Chi, Qian-Chuan Zhao, Qing-Shan Jia. 2007. *Ordinal Optimization: Soft Optimization for Hard Problems*. Springer, New York. 317 pp. $89.95.

Ordinal optimization (OO), as the authors state in the book's preface (p. xiii), was created in the early 1990s to optimize discrete-event systems, such as automated manufacturing plants, large communication networks, and traffic systems. There are no analytical descriptions of such systems; therefore, we cannot apply classical optimization methods to them. In addition, because these systems have large computational requirements, it is difficult to optimize them using simulation models and modern heuristic optimization methods. This monograph discusses how the OO methodology addresses these problems and covers the main aspects of its applications to practical problems. Discussions on practical applications focus on optimization of discrete-event dynamic systems (DEDS). The book consists of seven chapters and four appendices; the main text comprises 250 pages, and the appendices comprise 50 pages.

In Chapter I, the Introduction, the authors explain the meaning of the term *ordinal optimization.* The methodology searches for acceptable, feasible solutions of a stochastic, discrete system using simulation. The authors claim: "…ordinal optimization as presented in this book does offer a quantified rather than just heuristic account of reducing the intensive computational burden associated with performance evaluation and optimization of complex human made systems" (p. 5). In Chapter II, "Ordinal Optimization Fundamentals," the authors quantify two basic concepts of the OO approach, which they formulate as "order is easier than value," and "nothing but the best is very costly." The main theoretical question addresses the convergence of alignment probability (AP) to one in which AP represents the probability that the selected items belong to the "good-enough" set. The simplest version of OO, which is called "blind pick," is the independent random draw of a sample from the discrete search space and selection of the best item from the drawn sample. From elementary probability calculus, it follows that AP converges exponentially fast as the sizes of the sample and the good-enough set increase. The authors present similar results for the case in which items are noisy; they average observed values to increase the probability of a correct outcome, which they define as the "horse race" selection rule. To assist a reader in understanding the material in this chapter, the authors provide 12 exercises and 16 figures.

Chapter III, "Comparison of Selection Rules," describes sophisticated methods for formulating a sample of potential solutions. It describes selection rules to obtain samples covering large subsets of acceptable sets while using less computer memory. To achieve this objective, a large random sample from an initial design space (i.e., noisy and crude model) is filtered by rejecting bad items. The smaller sample is reevaluated using more precise models or other noise-reduction methods. This reduces the computing resources needed because the more costly evaluation procedures are applied only to the smaller number of candidate solutions. This chapter introduces a set of selection rules; these include sequential pair-wise elimination, optimal computing-budget allocation, and breadth versus depth. For example, by using sequential pair-wise elimination, a large number of candidates are chosen at random and grouped into pairs. The winners of the pair-wise comparisons are then grouped into pairs for the next comparison round. This chapter also includes a discussion of selection-rule efficiency and presents some recommendations with respect to their application. Depending on the computer power available, the authors would normally recommend one of several selection rules; examples include horse race, optimal computing-budget allocation, or breadth versus depth.

Chapters II and III describe the fundamentals of OO and of its main techniques. The authors devote other chapters to extensions of the proposed techniques and practical applications. Chapter IV discusses vector ordinal optimization (VOO). Its objective is to find a set of designs that is not too distant from the Pareto frontier. In a manner similar to scalar optimization, VOO defines the good-enough and selected sets. The main theoretical result is about the exponential rate of the probabilistic convergence of current potential solutions to the Pareto frontier where probability exists by randomness in evaluations of objective function values (noise) and in the search procedure (randomized search).

Chapter V presents constrained ordinal optimization (COO). The chapter begins with a discussion of duality between constrained and vector optimization; however, this discussion does not result in the development of algorithms. The authors formulate the problem as one of stochastic programming, and they interpret probabilistic constraints as an "imperfect feasibility model." Again, their intention is to implement algorithmically the concept of finding a feasible, good solution with a high probability. Because they do not present implementation details, the types of constraints that COO can address efficiently are not clear. The authors state: "The testing results also show that the method is very robust, even when the feasibility model is not very accurate" (p. 124).

Chapter VI, "Memory Limited Strategy Optimization," discusses the challenges to be addressed as the dimensions of the problem increase. This implies an exponential growth in the computing time and memory space that traditional algorithms require. To address this problem, the authors suggest the use of theoretical tools, such as Kolmogorov Complexity, Universal Turing Machine, and NP-completeness. They conclude that for difficult problems, OO is promising as a replacement for the standard optimization approach.

The two final chapters, "Additional Extensions of the OO Methodology" and "Real World Application Examples," provide further arguments to support this conclusion that applying OO to difficult problems shows promise. The authors show that OO is prone to parallelization; even the simplest parallelization method, *single instruction multiple data* (SIMD), can ensure parallelization efficiency that is close to one. In many combinatorial problems, the decision space is very large; thus, using nested partitions to narrow the search space is logical. The combination of nested partition and OO provides an efficient solution of large-scale problems by applying OO procedures iteratively. Finally, many combinations of OO with other optimization methods also show promise. Examples include a combination of a genetic algorithm with OO and a combination of the simulated annealing method with OO. The real-world applications that using OO has solved are indeed impressive. As Ho et al. (1992) describe in one of the first publications on OO applications, optimal design of DEDS is a major OO application field. The Center for Intelligent and Networked Systems (2007) collected a set of references. These references include discussions of the following application examples: the apparel-manufacturing scheduling problem, the control of the manufacturing process of integrally bladed rotors for aircraft engine turbines (where the balance of the blades around the rotor is a critical quality criterion, and many technological restrictions in the manufacturing process must be addressed), and performance optimization for remanufacturing systems. OO has been tested also using a special, difficult test problem of optimal stochastic control proposed by Witsenhausen (1968). In all cases, the use of OO has enabled researchers to find solutions that are good enough in acceptable time.

Appendices A and B are intended for readers who are not familiar with DEDS simulation and modeling, or with the simulation of stochastic processes; they include definitions of essential terms of the DEDS theories and of stochastic processes, and present formulas that are important for understanding the material in the main text. Appendix C contains data and parameters used in the experiments that the main text describes, and Appendix D provides additional exercises.

I believe that *Ordinal Optimization: Soft Optimization for Hard Problems* is the first monograph on OO. The authors were among the founders of OO, and they continue to actively develop the methodology. Because it differs from the methodology that is based on traditional optimization theory, its content is not what readers of this book would normally expect in a book on optimization: there are no analytical specifications of problems, no theorems about convergence of a current candidate solution to the true minimum point, and no massive comparison with competing methods of test functions. However, the reader will find philosophical and probabilistic arguments that justify the OO methodology and experimental results that show its practical potential.

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