Interfaces
Vol. 36, No. 1, January–February 2006, pp. 87–94
ISSN 0092-2102 | EISSN 1526-551X | 06 | 3601 | 0087

informs

DOI 10.1287/inte.1050.0180

Book Reviews

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The range of books reviewed is wide, covering theory and applications in operations research, statistics, management science, econometrics, mathematics, computers, and information systems (no software is reviewed). In addition, we include books in other fields that emphasize technical applications. Publishers who wish to have their books reviewed should send them to Professor Benjamin Lev. We list the books received; not all books received can be reviewed because space is limited. Those who would like to review books are urged to send me their names, addresses, and specific areas of expertise. We commission all reviews and do not accept unsolicited book reviews. Readers are encouraged to suggest books that might be reviewed or to ask publishers to send me copies of such books.

The authors or editors of the books reviewed in this issue are James Antonio Bucklew, Amiya K. Chakravarty, Jehoshua Eliashberg, Urmila Diwekar, Michael L. Pinedo, Reuven Y. Rubinstein, and Dirk P. Kroese.

BUCKLEW, JAMES ANTONIO. 2004. *Introduction to Rare Event Simulation*. Springer-Verlag, New York. 260 pp. $74.95.

Simulation is a powerful tool for investigating complex nonlinear systems. Models with uncertainties include generation of pseudo random numbers and samples of stochastic processes. Extensive scientific literature concerns Monte-Carlo methods for simulating stochastic phenomena. Bucklew's book undoubtedly will attract readers familiar with basic Monte-Carlo methods who want to extend their use to simulating rare events. In two books on Monte-Carlo methods, the authors (Niederreiter 1992, Fishman 1996) pay little attention to simulating rare events. In two areas, however, practitioners accept statistical simulation as an important tool, and rare events are of special interest; financial applications of Monte-Carlo methods (Glasserman 2004), and reliability of structural systems (Maes and Huyse 2004). In spite of its practical importance and theoretical interest, simulation of rare events was not well covered in monographs and textbooks. Bucklew fills the gap, presenting the theoretical aspects of simulating rare events from the point of view of the probabilistic theory of large deviations. He tries to keep the mathematical preliminaries to a minimum. Undergraduate courses in calculus and statistics would give readers enough knowledge to understand the material, but practitioners will not find the book easy reading without good backgrounds in probability theory.

Bucklew starts with two chapters on generating random numbers, autoregressive moving average sequences, and Markov chain Monte-Carlo methods. Rare events are often related to the occurrence of large deviation events. In a chapter on large deviation theory, Bucklew discusses Cramer's theorem, and the Gärtner-Ellis theorem. He considers independent identically distributed random variables in discussing Cramer's theorem and estimating the probability of large deviations of the sample average. He expresses the estimate of Cramer's theorem with the large-deviation-rate function, which is a basic concept of the theory he presents. In spite of its importance, this concept is not easy to explain without formulae. Perhaps I can provide an intuitive notion through the following examples. It is well known, that the Cauchy distribution has heavier tails than the Gaussian distribution, that is, the probability of a large deviation of the Caucy random variable is more likely than the probability of an identical deviation of the Gaussian random variable. Correspondingly, the large-deviation-rate function of the standard Gaussian random variable is quadratic, and for the Cauchy random variable it is equal to zero. The Gärtner-Ellis

theorem generalizes the classical Cramer's theorem for dependent random processes, for example, for Markov chains.

In the remaining 11 chapters, Bucklew describes importance-sampling theory and its applications to simulating rare events. Importance sampling is a simulation technique in which the original probability distribution is replaced by the importance-sampling-biasing distribution. One can reduce the variance of the corresponding estimator by choosing the appropriate importance-sampling distribution. The two methods most frequently used are the variance-scaling method, in which one multiplies the original random variables by a constant, and the mean-translation method, in which one adds a shift parameter to the original random variables. Bucklew includes several examples to illustrate variance reduction by means of the proper choice of scaling and shift parameters.

An important criterion of the quality of estimators is the rate of convergence of their variance to zero. The author analyzes an importance-sampling estimator with respect to this criterion in detail. He generalizes the results of the analysis for a conditional importance-sampling estimator for which he has some information about the random variable through another so-called informational random variable. In both cases, he proves the efficiency of the estimators. The large-deviation theory gives asymptotic rates to zero for sequences of probabilities of rare events. In practical applications, however, one needs the probabilities (at least their good estimates) of truncated sequences. Bucklew devotes Chapters 9 to 14 to the practical aspects of simulating rare events. He considers rare events in Gaussian disturbed systems, the level crossing, and queueing models. In three appendices, he presents the basic definitions and results of convex analysis, a geometric covering lemma related to the large-deviation-rate function, and three codes of congruential pseudo-random-number generators.

The book's main advantage is the presentation of a unified approach to simulating rare events based on the probabilistic-large-deviation theory. Readers with good backgrounds in probability theory will enjoy this advantage. It seems, however, that Bucklew targeted a broader audience than statisticians. Based on the book's back cover: "Until now, this area has a reputation among simulation practitioners of requiring great deal of technical and probabilistic expertise. This text keeps the mathematical preliminaries to a minimum with the only prerequisite being a single large deviation theory result that is given and proved in the text." Although his statement is true, I don't think the book will change the reputation of this area among practitioners. However, it can help practitioners to overcome theoretical and technical difficulties in understanding methods based on the probabilistic theory of large deviations and to apply these methods in simulation practice.

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Chakravarty, Amiya K., Jehoshua Eliashberg, eds. 2004. *Managing Business Interfaces: Marketing, Engineering, and Manufacturing Perspectives*. Kluwer Academic Publishers, Dordrecht, The Netherlands. 332 pp. $148.00.

During the past decade, practitioners have increased interdisciplinary work in operations management and marketing in an attempt to improve their understanding of business functionality, to improve performance, and to reflect companies' shift from traditional silo organization to cross-functional organization. This book includes assorted works that collectively provide opportunities to explore and enjoy a wide spectrum of the benefits of operations management and marketing interfaces.

The book is an important reference for the work on operations and marketing interfaces. It will unquestionably trigger additional research in the field, and it may be used to teach PhD students. It may also be attractive to practitioners who want to better understand potential integration among various

functions and departments and to consequently capture potential performance improvements. For those who deal with the topics from one side of the fence, Chakravarty and Eliashberg provide a solid bridge that will help them to comprehend the other side.

The book contains 11 invited chapters organized into four parts:

In the first part, Franza and Gaimon analyze a manufacturer's investment in flexible technology that allows rapid changeover of its short-cycle products in a competitive environment. Such rapid changeovers are crucial because they allow early entrance into the market. Chong, Ho, and Tang, alarmed by the increasing expansion rate of stock keeping units, search for an appropriate strategy for trimming the product line while incorporating product substitution.

In the second part, Yano and Gilbert discuss the coordination of pricing (which affects external demand) and production and procurement decisions. Iyer and Padmanabhan review the literature on marketing, operations, and industrial organization that deals with the role of contracts in order to better understand the implications of strategic interactions among institutions in distribution channels. Choi, Lei, and Wang explore various models that employ quantity discounts as a tool to encourage coordination among independent members of distribution channels. They also present a model that combines both marketing and operations approaches.

In the third part, Steinberg considers how Internet service should be priced, viewing pricing as a crucial factor in competition and as a way to control congestion. Bashyam and Karmarkar discuss three business-information-service offerings for searching and accessing information, and determine the conditions under which two may coexist based on their having different usage volumes and value segmentation of users. Chakravarty evaluates the preferred collaboration mode among partners in an e-business value chain, paying attention to the impact of technology and strategy.

In the fourth and final part, Bajaj, Kekre, and Srinivasan identify what factors affect the time consumed and financial performance in the design and manufacturing phases of new product development. Kumar and Hadjinicola capture the impact of platform products on an international enterprise while considering product design, marketing, and manufacturing issues. Karmarkar and Lele illustrate the need for firms to coordinate marketing and manufacturing and discuss strategies for promoting such integration and diminishing the conventional separation between the two functions.

The authors provide an excellent review of past work in the area, discuss current developments, and propose directions for future research. In light of the wide spectrum of issues they cover, the typical reader will likely be interested in only some of the chapters. Nonetheless, the value to be gained is substantial and precious.

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DIWEKAR, URMILA. 2003. *Introduction to Applied Optimization*. Kluwer Academic Publishers, Dordrecht, The Netherlands. 335 pp. $154.00.

Urmila Diwekar's book on applied optimization is one of the few books on the subject that combines impressive breadth of coverage with delightful readability. In her exposition of concepts and algorithms in the major areas of optimization, she always goes to the heart of the matter and illustrates her explanations with simple diagrams and numerical examples. Graduate and undergraduate students, who constitute part of the target audience, should find this a very useful book.

The author has devoted a chapter to each of the following topics: linear programming, nonlinear programming, discrete optimization, stochastic optimization, multiobjective optimization, and optimal control. Every chapter includes a summary of the key points of the chapter, a set of references, and a number of numerical exercises set in a practical environment. There are several references in the book to an "enclosed CD" (for example, on p. 42), but the copy of the book I received had no CD enclosed.

Very commendably, Diwekar has used a single application to illustrate all the different optimization techniques: the hazardous waste blending problem encountered at the US Department of Energy's Hanford nuclear plant in southeastern Washington. This facility produces a lot of hazardous radioactive waste (as by-products), and the problem is how to

process the waste optimally. Diwekar introduces the problem in the chapter on linear programming, formulating it as a linear programming problem; then she continues it in the chapter on nonlinear programming, where she adds a little more complexity and formulates it as a nonlinear programming problem, and so on right through the chapter on multiobjective optimization.

To describe the problem briefly, the Hanford facility has 177 huge tanks of anywhere from 50,000 to 1,000,000 gallons containing radioactive waste coming from a number of processes in the plant. The waste is separated into high-level and low-level waste, both of which must be processed further for disposal. The high-level waste has to be converted into a glass form. To do this, the plant first blends waste from the different tanks into different blends according to various operating constraints and then vitrifies these blends in a melter with the addition of *frit*, which contains a number of different components needed to form the glass. The objective is to minimize the masses of these components subject to a number of constraints on the components themselves, and on the glass crystallinity, and solubility.

In the chapter on linear programming, the author ignores certain constraints related to durability, viscosity, and electrical conductivity and can therefore combine various wastes into a single blend. She formulates the problem as a linear programming problem. In the chapter on nonlinear programming, she introduces those durability, viscosity, and electrical-conductivity constraints, which are nonlinear, making the problem a nonlinear programming problem. In the chapter on discrete optimization, she changes the objective to one of selecting the combination of blends that minimizes the total amount of frit used. In the chapter on stochastic optimization, she considers the same problem with uncertainties in the waste compositions (which hitherto had been considered as known and constant), and so on.

In this way, Diwekar provides a very good learning experience for students in the realities of modeling as a skill in its own right, apart from learning the use of the optimization techniques themselves.

I am impressed with the large number of topics and techniques she covers; yet she explains each topic so well that readers can get a good understanding of the basic concepts. For example, she begins the chapter on discrete optimization by explaining the tree and network representations of discrete optimization problems, and the strengths and shortcomings of each. She illustrates the ideas by solving a small mixture-component-separation problem through both approaches. In the process, she explains the main ideas of the branch-and-bound technique and the depth-first and breadth-first methods of pruning the tree. Through this initial graphical representation, she leads the reader to the algebraic representation, which is required for larger, practical problems, and how each node in a tree representation is represented by binary variables in the algebraic representation. From there, she goes on to explain the concept behind cutting planes and LP relaxations.

Under mixed-integer nonlinear programming, she explains the generalized-bender's-decomposition, and the outer-approximation algorithms, illustrating both with an example worked out in detail.

She explains how these methods encounter difficulties when functions do not satisfy convexity conditions or when the number of combinatorial possibilities is very large or when the solution space is discontinuous. This leads her naturally into the concepts of simulated annealing and genetic algorithms. She explains both of these thoroughly, first in the context of their original, physical settings and then in the context of discrete optimization.

She covers the subjects of two other chapters, optimization under uncertainty and multiobjective optimization, in similar fashion.

Some readers may also appreciate, as I did, the few historical notes and remarks scattered throughout the book. In bulk, they are as miniscule as spices in a meal. But like spices, they add a delightful flavor that makes the whole book that much more enjoyable. I particularly liked the "Announcement" of Bernoulli dated 1 January 1697, that Diwekar quotes on p. 257. The announcement is a mathematical challenge thrown by Bernoulli to "...the finest mathematicians of our time...." I made a couple of feeble attempts to find out the source from which Dr. Diwekar reproduced this ancient challenge, but I could not find it.

All in all, the book is an extremely commendable exposition of a large number of tough topics, and

it will be a valuable addition to any collection of books on applied optimization.

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PINEDO, MICHAEL L. 2005. *Planning and Scheduling in Manufacturing and Services*. Springer, New York. 506 pp. $69.95.

Planning and scheduling activities are pervasive but complex. People dealing with them have many different views and perspectives. In many cases, planners and schedulers see their jobs as vainly trying to satisfy requirements in an environment that constantly changes. Managers want to keep resources busy and customers happy, while foremen view these demands as impossible. Mathematicians see opportunities to develop new algorithms. Pinedo sees problems to be solved and software to be developed.

This substantial and comprehensive text is a revision of Pinedo and Chao (1999). Like the previous version, the revised book is intended for a senior-level or master's-level course on planning and scheduling, and its focus is formulating and solving scheduling problems.

Pinedo covers planning and scheduling in a wide range of industries, including manufacturing, transportation, and sports and entertainment. He discusses in detail topics related to problem formulation, solution approaches, and scheduling software. The variety of models and methods are useful for answering such questions as, "If I find myself with a scheduling problem, how can I formulate it? How should I solve it? How can I build software that will collect the necessary data, solve the problem, and present the solution?" Although Pinedo deliberately omits the traditional material on the basic single-machine, parallel-machine, and shop-scheduling problems, he proceeds from the perspective that formulating and solving the correct sequencing problem is the key to improving performance.

In this revision, he has added new chapters and includes a CD-ROM. He has added sections describing specific applications to each chapter. For example, the chapter on scheduling in sports and entertainment includes a section on creating a schedule for the men's basketball teams from the schools in the Atlantic Coast Conference. The new chapters cover models for service settings, scheduling in supply chains, scheduling in sports and entertainment, scheduling in transportation, and a look at the newest ideas in planning and scheduling. The book's appendices cover the fundamentals of optimization and provide some information about LEKIN, the scheduling system included on the book's CD-ROM.

The CD-ROM includes multiple sets of slides contributed by faculty members of five different universities who used the first version of the text. Each set covers most of the material in the new book, and it is interesting to see how different instructors organized and presented the same material. All follow a familiar style (most in PowerPoint), with more or less use of color and graphics. I thought that the most attractive slides were those created by Cees Duin and Erik van der Sluis at the University of Amsterdam. The CD-ROM also contains supplemental materials that are well organized but vary in significance, from examples that directly address material in the book to brief descriptions of scheduling applications done by consulting firms. The most effective, by far, is a 15-minute movie about a scheduling system the Paris airports use.

The LEKIN scheduling system software is a very useful tool for learning about the basic machine-scheduling problems. Andrew Feldman was responsible for system development. The software was easy to install, and the software help screens made it easy to learn the fundamentals: create a scheduling problem, use a heuristic to generate a schedule, and modify the schedule. After some practice, generating and comparing multiple schedules was a straightforward task. The educational version can handle deterministic, static scheduling problems for the following environments: single machine, parallel machine, flow shop, job shop, flexible flow shop, and flexible job shop. The software includes the ability to use external scheduling algorithms for generating schedules. Because it is the educational version, the software is limited to problems with at most 20 work centers and 50 jobs.

The book has a companion Web site, http://www.stern.nyu.edu/om/faculty/pinedo/book3/, with additional supplementary information, including suggestions for cases, readings, and videotapes that

should be useful to anyone teaching production and operations management, not just those adopting this book.

The educational emphasis distinguishes Pinedo's book from a number of other new and interesting scheduling books available today: McKay and Wiers (2004) describe the real world of production scheduling and describe tools to help the planners and schedulers who are trying to coordinate activities and resolve problems. Leung (2004), on the other hand, is a comprehensive summary that covers many results from academic research on scheduling theory. Brucker (2004) is the fourth edition of his book covering the computational complexity of algorithms used to solve machine scheduling problems. In his *Scheduling: Theory, Algorithms, and Systems*, Pinedo (2002) also describes specific machine-scheduling environments (single machine, parallel machine, flow shops, and job shops), and he presents theorems and proofs for both deterministic and stochastic models, material that is mostly absent from *Planning and Scheduling in Manufacturing and Services*. Both of Pinedo's books contain some of the same background material, including an introduction to scheduling, a discussion of general purpose heuristics, the design of scheduling systems, and mathematical programming.

Pinedo's discussion of practical issues related to planning and scheduling is incomplete, unfortunately, especially on the day-to-day challenges that affect planning and scheduling, including uncertainty and the dynamic nature of factories, transportation systems, and other real-world organizations. Instructors should consider supplementing this text with material on the critical role of human decision makers in the messy world of planning and scheduling. On the more theoretical side, Pinedo covers very little of the classic scheduling theory in this book.

Pinedo's *Planning and Scheduling in Manufacturing and Services* is a good choice for a course introducing planning and scheduling, especially for students interested in solution techniques. Though its presentation is more scholarly than a typical operations management textbook, it includes homework problems, valuable information on a variety of planning and scheduling topics, and interesting extras that should be helpful for teaching and learning.

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Rubinstein, Reuven Y., Dirk P. Kroese. 2004. *The Cross-Entropy Method: A Unified Approach to Combinatorial Optimization, Monte-Carlo Simulation, and Machine Learning*. Springer, New York. 295 pp. $84.95.

In *The Cross-Entropy Method*, Rubinstein and Kroese present a novel new method for accomplishing combinatorial optimization, Monte-Carlo simulation, and machine learning. The authors' intent in this straight-to-the-point book is to provide a comprehensive and accessible introduction to the cross-entropy (CE) method. They aim the book for the audience of engineers, computer scientists, mathematicians, statisticians, theorists, and practitioners who are interested in combinatorial optimization, simulation, and related areas.

The original intent of the CE method was to improve rare-event simulation. Once it had been implemented, the authors realized that the CE method was adaptable to a very wide range of combinatorial optimization problems, including the traveling salesman problem; the quadratic assignment problem; the max-cut problem; the alignment of deoxyribonucleic acid (DNA) sequences, and noisy estimation problems, such as the buffer-allocation problem; noisy optimization; continuous multi-external optimization; machine learning; and clustering and vector quantization problems.

The CE method takes its name from cross entropy, sometimes called relative entropy, or the Kullback-Leibler distance, which is a well-known measure of information that has been employed in the fields of engineering and science, and in particular in neural computation, for about half a century.

The CE method is an iterative method, which consists of the following two phases:

(1) Generating a sample of random data (trajectories, vectors, and so forth) according to a specified random mechanism;

(2) Updating the parameters of the random mechanism, on the basis of the data, to produce a "better" sample in the next iteration.

The significance of the cross-entropy concept is that it defines a precise mathematical framework for deriving fast and in some sense optimal updating or learning rules.

The book contains exercises, wide-ranging numerical examples, an extensive introduction into each subject (supported by a literature survey), and example programs. An associated Web site, http://www.cemethod.org, contains additional material, namely, programs, tutorials, papers, and links. Rubinstein and Kroese have taken most of the combinatorial and continuous multi-extremal optimization problems they present as case studies in the book from the World Wide Web and have compared the CE method solution with the best known solutions. In all cases tested, the CE method produced solutions that were within two percent of the best known solution.

Chapter 1 contains introductory material, such as mathematical definitions and concepts relevant to the CE method from such areas as probability, statistics, information theory, and simulation. In Chapter 2, the authors lay out the CE method, applied to both combinatorial optimization and simulation. They suggest that Chapter 2 is a good entry point to the book. Each chapter includes exercises.

In Chapter 3, the authors consider efficiency improvements the CE method can achieve in rare-event simulation and present an adaptive CE algorithm for estimating optimal parameters for importance sampling. Chapter 4 concerns the application of CE methods to solve a wide variety of optimization problems. The authors make the point that the CE method is a versatile randomized algorithm. They explicitly do not compare the CE method to other randomized methods, such as simulated annealing, ant algorithms, and genetic algorithms, preferring to focus on the reliability, simplicity, and high speed of the CE method. The approach taken is to transform the combinatorial optimization problem into an associated rare-event estimation problem and then solve that problem with the methods covered in the chapter. Chapter 4 finishes with numerical results for several well-known problems.

The focus for Chapter 5 is continuous optimizations and modifications to the basic CE method. The authors discuss a very interesting, fully adaptive CE method, called FACE. In Chapter 6, the authors cover the application of the CE method to noisy optimization, such as the analysis of data networks, stochastic scheduling, stochastic shortest- and longest-path problems, and the buffer-allocation problem. In Chapter 7 they apply the CE method to combinatorial optimization problems and present numerical results. Machine-learning applications of the CE methods are the topic of Chapter 8, with examples from games, Markov processes, and clustering. The authors provide example programs in an appendix.

In summary, the CE method is a simple, efficient, and general method for solving a wide range of optimization problems. The CE method, like good heuristics in general, produces very good, if not necessarily optimal, solutions. In addition, the CE method is useful for stochastic, or noisy, problems and improves the performance of Monte-Carlo simulation of rare events. Scientists, engineers, and other practitioners, students of the physical and engineering sciences, and any practitioner using stochastic optimization and simulation should read this book. They will learn the essence of a modern and extremely powerful computational tool.

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Books Received for Review

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