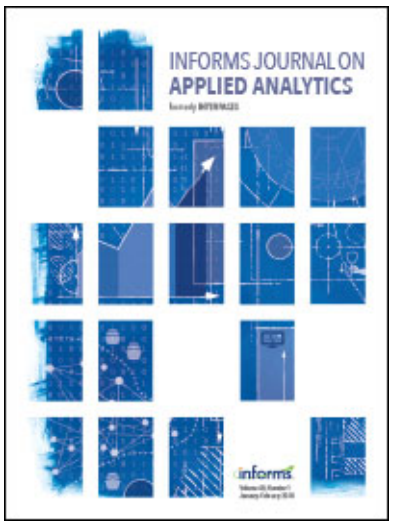

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Book Reviews

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Book Reviews

Benjamin Lev
School of Management, The University of Michigan–Dearborn, 4901 Evergreen Road,
Dearborn, Michigan 48128-1491, blev@umich.edu

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 Yann Collette and Patrick Siarry; Paul Glasserman; Fred W. Glover and Gary A. Kochenberger.

COLLETTE, YANN, PATRICK SIARRY. 2003. *Multiobjective Optimization: Principles and Case Studies.* Springer-Verlag, New York. 317 pp. $89.95.

Multiobjective optimization is a popular topic among the authors Deb (2001), Hooker (1996), Lootsma (1999), Miettinen (1999), Sakawa (2002), and Shi (2001). All of these authors aim for a broad audience and therefore include a large amount of material. For example, they all introduce the concept of Pareto optimality and discuss various reductions of multiobjective problems to one criterial problem. They vary in rigor of presentation, but all write for readers at the undergraduate level. Similarly, in the first part of their book, Collette and Siarry cover the principles of multiobjective optimization methods. They discuss the standard topics: dominance relations, Pareto optimality, reduction of multiple criteria to one criterion, and interactive methods. They also include the popular modern topics, fuzzy sets and metaheuristics. They introduce the decision-support techniques ELECTRE and PROMETHEE. Their presentation is intended for readers with only an introductory knowledge of calculus. They formulate some results as theorems but omit their proofs.

In Part 2, "Evaluation of methods and choice criterion," Collette and Siarry present material that, to the best of my knowledge, has not been covered in other monographs. The assessment and comparison of the efficiency of the multiobjective optimization methods is more complicated than the assessment and comparison of mathematical programming techniques. The criteria for evaluating performance, the collections of test functions for different subclasses of problems, and the requirements for publishing testing results of mathematical programming techniques and software are widely accepted and used by the mathematical programming community. Nevertheless, active research in heuristic techniques requires the development of new approaches (Hooker 1996). The experience accumulated in testing mathematical programming techniques is helpful for multiobjective optimization; however, it presents some new problems. The authors introduce several criteria for measuring the quality of solutions obtained with multiobjective optimization methods, for example, "error ratio" (p. 190), "generational distance" (p. 191), and "maximal error to the tradeoff surface" (p. 194). Generally speaking, these criteria characterize either the cardinality of the intersection of the Pareto set with the found approximation to the Pareto set or some distance between these sets. An approximation of the Pareto set normally consists of a finite number of points. A good approximation is supposed to cover the Pareto set uniformly. Therefore an important characteristic of the representativeness of the found approximation is the discrepancy of the set of points representing the found solution. Collette and Siarry propose to measure the discrepancy in the "Hole relative size metric" (p. 201), which is expressed as the ratio of maximal and average distances between the points of approximation of the Pareto set. Further, they apply the measures of approximation quality to assess the progress of optimization, which is to assess the improvement in approximation quality in subsequent iterations. To test and compare multiobjective methods, one needs a set of test functions representing typical practical problems and possessing some difficulties. The authors include a set of test functions (Deb and Hanne test problems) {and present} the formulae and graphical illustrations.

The second part of the book ends with a short chapter (15 pages), "Attempt to classify multiobjective optimization methods."

In the third part of the book, the authors discuss several practical problems. Most likely, this material has not been published in scientific journals since they give no references. The first problem is related to tuning a mathematical model to experimental data by the number of criteria selecting the values of two parameters. The authors do not explicitly define the criteria, but they discuss three criteria. They use an artificial neural network to approximate the objective functions (criteria) of the problem. The second problem concerns multicriterial decision making in an extension of a telecommunications network. Collette and Siarry consider two criteria, total cost and flexibility of the network. They apply a genetic algorithm to solve the problem. In a third example, they consider a multicriteria decision tool to deal with bids and discuss applications of multicriteria decision methods to real-world problems by the European Aeronautic Defence and Space Company. To decide whether to respond to a call for bids, the company continuously uses a method based on a multicriteria decision model ELECTRE TRI. The authors discuss simulated examples, because the real data is confidential.

Collette and Siarry have done well in selecting material to introduce the theory and methods of multiobjective optimization. However, the presentation contains many inaccuracies. Even important definitions of main concepts are not always clear. For example, in formulating a multiobjective optimization problem (p. 20), the authors define the number of parameters as equal to n and the number of criteria as defined equal to k. Two pages later, they define a set called a cone (in fact, not necessarily a cone) as a set in the n dimensional space of parameters, although they mean a cone in the k dimensional space of criteria (Definition 9, p. 22). They don't define the term *solutions*; therefore, it is not clear whether they mean the points in parameter space or the points in criteria space. In the very important definition of Pareto points, they consider the points in n dimensional space (Definition 7, p. 22), but the illustration (Fig. 1.4) shows the point in the criteria space. Afterwards they use the term *Pareto solutions* for both the Pareto set in criterial space and the set of efficient points in parameter space. They define the global minimum of a scalar function incorrectly; according to Definition 3 (p. 19), a global minimum does not exist if the global minimum value of the objective function is indeed attained at several points. Some of the terms the authors introduce do not seem very successful, for example, *extremal optimality* and *maximal optimality* (p. 36). They do not explain the meaning of the terms *optimal tradeoff surface* (p. 190) and *best non dominated solutions* (p. 201). They use the term *tradeoff surface* incorrectly: "Be given F' and F'' two tradeoff surfaces." According to their definition (p. 42), the tradeoff surface is unique. I would not discuss such inaccuracies if the book were not intended for students in applied mathematics and computer science among others (back cover). In my opinion, people in mathematics and computer science want an accurate presentation of material. The book has too many mistakes in English, so many that it is difficult to understand the meaning. Here are a few examples: "A test function is a function which goals is to be hard to solve for mutliobjective optimization method, when trying to find a uniform spreading of solutions along the tradeoff surface" (p. 211); "The parameter which characterise the disponibility of the network" (p. 259); "Cases study" (p. 245). However, in my opinion, the book conforms to the aims of the Wiley series on decision engineering: "The series provides an aid to practising professionals and applied researchers in the development of tools for informed operational and business decision making, within industry, by utilising distributed organisational knowledge" (back cover).

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A. Zilinskas
Department of Informatics, Vytautas Magnus University, Kaunas, Lithuania

GLASSERMAN, PAUL. 2004. *Monte Carlo Methods in Financial Engineering: Applications of Mathematics, Stochastic Modelling and Applied Probability*. Springer-Verlag, New York. 596 pp. $69.95.

In recent years, researchers have published many papers on financial mathematics. Many of these papers concern specific questions about stochastic processes and are directed towards theoreticians in probability theory rather than the finance audience. Several monographs summarize the results in the field for experts and students in stochastic processes. Springer-Verlag has published three books (Karatzas and Shreve 1998, Musiela and Rutkowski 1997, Niederreiter 1992) in the same series as Glasserman's book that are intended for narrower audiences.

Glasserman's book consists of nine chapters and three appendices. In the first chapter, Glasserman introduces the principles of Monte Carlo techniques and of derivative pricing. The main idea is to formulate a problem of derivative pricing as an integration problem. Integration problems can be solved using Monte Carlo techniques. Two subsequent chapters concern methods of generating random numbers, random variables, and sample paths of stochastic processes. The chapter on generating random numbers and random variables contains the standard material normally covered in a textbook on Monte Carlo methods. In the chapter on generating sample paths, the author considers stochastic processes suitable as models for financial engineering, for example, Brownian and geometric Brownian motions, square-root diffusion, and processes with jumps. He discusses the mathematical properties of the models and their economic sense, enabling readers with limited knowledge of mathematical finance to understand the context.

Although Monte Carlo techniques are widely used, they sometimes lack precision. Methods of improving their precision constitute about one third of the book. The author begins the chapter on variance reduction techniques with material on control variables. He assumes that two correlated random variables are observable and that the mean value of the second random variable is known. The idea is to improve the standard estimate of the mean value of the first random variable using the observed values of both random variables and the known mean value of the second random variable. He discusses the large-sample and the small-sample versions of the method of control variables and includes examples of different pricing models. He also describes stratified sampling, Latin hypercube sampling, and importance sampling in detail. He does not make strict recommendations about where to apply these methods; justifying such recommendations would be difficult. Instead, he includes general assessments of the methods with respect to the criteria of complexity and effectiveness, and lists references to publications about typical examples. Glasserman continues his consideration of efficiency enhancement in the next chapter, "Quasi-Monte Carlo." He considers deterministic low discrepancy sequences instead of random uniformly distributed sequences. It is well known that quasi-Monte Carlo techniques outperform Monte Carlo techniques in numerical integration: The error converges to zero much faster for integration based on deterministic low discrepancy sequences than for integration based on random uniform sequences. He covers the main ideas covered thoroughly by Steele (2000). The author was right to include such a chapter, explaining the reason for reformulating a problem of security pricing as a problem of numerical integration. By doing so, he also shows that probabilistic techniques are not the only techniques used in financial engineering. Quasi-Monte Carlo is based on number theory and algebra. The methods mentioned above are supposed to be appropriate for general problems of calculating integrals and estimating means. In pricing models, we are interested in specific averages, for example, in an average of a functional of a stochastic process. Computing such averages normally involves discretizing the underlying stochastic processes, thus also dealing with discretization errors. The chapter "Discretization methods" is devoted to the analysis of errors in the solution of stochastic differential equations and such methods as extrapolated Euler approximation and order expansions. As would be expected, the techniques using information about the problem context are often more effective than general-purpose techniques.

The third part of the book, consisting of three chapters, concerns the state of the art of Monte Carlo simulation in estimating risk, prices, and price sensitivities. The last problem is of special importance since price sensitivities cannot be observed in the market, and their estimation presents both theoretical and simulation difficulties. The author discusses finite difference, pathwise derivative estimation, and likelihood ratio methods and gives examples of sensitivity estimation. Glasserman also devotes a chapter to pricing American options. Every general method of pricing American options requires a computing-intensive simulation. The author shows that the methods described earlier in the book are especially applicable to pricing American options. The book ends with a chapter titled "Applications in risk management," covering the problem of measuring risk for a portfolio of assets. The author pays particular attention to estimating the probabilities of large losses by simulating rare but significant events. He covers techniques for estimating loss probabilities, value at risk, and credit risk. He applies various variance reduction techniques to enhance the modeling efficiency. He also discusses heavy tailed models.

Glasserman's book is suitable for graduate studies in financial engineering. It is self-contained in its coverage of Monte Carlo methods, but potential readers require good backgrounds in stochastic calculus. The book contains appendices concerning the main ideas of probabilistic convergence: Ito integral, stochastic differential equations, and change of measures. They would be helpful in refreshing the memories of readers who have studied these subjects previously. However, reading only these appendices would not allow readers to understand the theoretical material of the book. Some familiarity with stochastic processes or with mathematical finance is necessary. For researchers and practitioners, however, the book

will be a valuable reference on advanced Monte Carlo techniques adapted to financial modeling.

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A. Zilinskas
Department of Informatics, Vytautas Magnus University, Kaunas, Lithuania

GLOVER, FRED W., GARY A. KOCHENBERGER, EDS. 2003. *Handbook of Metaheuristics*. Kluwer Academic Publishers, Dordrecht, The Netherlands. 570 pp. $174.00.

Handbooks have a strong attraction for me, perhaps because they remind me of my life as a student. The first time I browsed through Glover and Kochenberger's book, I thought it would be a source of inspiration for new procedures and algorithms, and it is. It is similar in structure and purposes to Osman and Kelly's (1996) work titled *Metaheuristics: Theory and Applications*. As is to be expected, however, it covers in depth new methods, such as scatter search, path relinking, memetic algorithms, hyperheuristics, and computational parallel strategies.

Glover and Kochenberger's book is closely related to other works about algorithms (Berman and Paul 1997, Cormen et al. 2003). The use of metaheuristics has taken off in the last few years with impressive implementations. Nowadays, there is a long list of specific methods (genetic algorithms, evolutionary methods, and so forth) for solving difficult problems (Miettinen et al. 1999). Various ideas about heuristics have served as preambles and inducements for metaheuristics (Michalewiczm and Fogel 2000).

The major virtue of the *Handbook of Metaheuristics* is Glover and Kochenberger's selection of papers covering the most popular topics in the development of metaheuristics (genetic algorithms, tabu search, and simulated annealing, to name a few). Thus, the book can serve its readers as an algorithm finder for developing new procedures for resolving problems.

The book should interest a wide range of readers: professors, developers of computer packages, researchers in practical issues, and theoretical researchers. They should find it a valuable reference work.

The authors devote the first chapter to reviewing scatter search and path relinking, describing applications and scenarios appropriate to those techniques and listing useful references. The applications include the graph-coloring problem, assigning proctors to exams, and periodic vehicle loading.

In Chapter 2, the authors describe tabu search, highlighting its application in routing and location problems. The chapter is short but clear and helpful. It includes good recommendations for using tabu search algorithms and outstanding references.

Chapter 3 is devoted to genetic algorithms and is divided into two parts: background and guidelines. The authors give a painstaking description of genetic procedures during the last 20 years and a good summary of the main characteristics of these algorithms. This chapter has a natural sequel in the fourth chapter, which concerns genetic programming and its applications in electrical engineering and in networks. In the fifth chapter, Pablo Moscato and Carlos Cotta explain the characteristics of mimetic algorithms simply and meticulously and describe appropriate cases.

Many chapters concern local search techniques, for example, Chapter 6 on the variable neighbourhood search technique, Chapter 7 on the guided local search procedure, Chapter 11 on iterated local search and local search, and Chapter 13 on constraint programming. Other metaheuristics analyzed are GRASP techniques (Chapter 8), ant-colony optimization algorithms (Chapter 9), simulated annealing (Chapter 10), and artificial neural networks (Chapter 15). The authors explain some new aspects of metaheuristics, such as the constraint satisfaction procedure (Chapter 14), the implementation of parallel strategies for metaheuristics (Chapter 17), and asynchronous teams (Chapter 19).

Chapters 16 and 18 concern hyper-heuristics and metaheuristic class libraries, respectively. Their authors offer excellent ideas for understanding the open questions related to metaheuristics. A one-page glossary concludes the text.

The book is a wonderful reference for the algorithm builder or the operations researcher. It contains new ideas for developing new algorithms and procedures and it covers all the latest methods in metaheuristics. The meaningful references in all the chapters form a treasure trove. I highly recommend this book to researchers and consider its contents exceptional.

Some organizational changes would improve the book: The editors could have grouped chapters in parts. Each chapter should have had an abstract (some, but not all, do). The glossary should have contained many more terms.

In conclusion, I think this is a brilliant book about metaheuristics and related topics, and many researchers will find it a source of inspiration. Some professors already use it for specialized courses on algorithm design. It contains many intuitive ideas about metaheuristic algorithms and their resolution.

I think it will become one of the most popular books in its field.

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Javier Faulin
Department of Statistics and Operations Research, Public University of Navarra, 31006 Pamplona, Spain

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