a statement that is known to be false in general if an infinite number of inequality constraints appears. Some necessary second-order conditions taking this fact into account can be found in [1]. We note the following strange statement (after (3.2.1), p. 31): "$X = W_{1,\infty}[0, T]^n \times L_\infty[0, T]^n$ is assumed to be a Banach space, but it cannot be expected to be a Banach space unless the spaces $W_{1,\infty}[0, T^n]$ and $L_\infty[0, T]^n$ are both Banach spaces" (perhaps this must be understood as a joke).

On the other hand, Chapter 2 contains a useful review of the discussion of the smoothness of multipliers and of the "alternate optimality conditions" (involving the total derivative of state constraints). It is a merit of this book that it takes into account this "alternative theory" that explicitly handles the switching points (i.e., the times at which the set of active constraints change) and is usually associated with shooting methods. Active set strategies for the resolution of the quadratic subproblems are also discussed.

The examples are interesting. They present the numerical solution of several nontrivial real-world optimal control problems with first- and second-order state constraints.

In conclusion, this book should be considered as an introduction to the subject rather than a definitive treatise. Nevertheless, it should interest anybody willing to have an overview of some modern approaches to numerical optimal control.

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1. H. Kawasaki, *The upper and lower second order derivative for a sup-type function*, Math. Programming **41** (1988), 327–339.

**27[90C20, 90C30, 65K10].**—CHRISTODOULOS A. FLOUDAS & PANOS M. PARDALOS (Editors), *Recent Advances in Global Optimization*, Princeton Series in Computer Science, Princeton Univ. Press, Princeton, NJ, 1992, x+663 pp., $23\frac{1}{2}$ cm. Price \$69.50 hardcover, \$39.50 paperback.

This volume contains refereed versions of twenty-seven papers presented at the "Recent Advances in Global Optimization" conference held at Princeton University in May, 1991. If you have an interest in global optimization, then you will find this book fascinating. Its pages reveal the breadth of current research in global optimization, from methods tailored to the optimal reloading of a nuclear power plant, to methods designed to minimize portfolio risk.

Global optimization involves finding the minimum (or maximum) value assumed by a continuous real-valued objective function of many variables, over a constraint set which is generally assumed to be compact. Authors differ over the structure assumed of the objective function, and of the constraints. Broadly speaking, the early papers in this volume assume a lot of structure, while the later papers assume little.

The first seven papers consider variants of the situation in which the objective function is quadratic. Complexity questions are addressed, as well as applications of quadratic programming to the finding of Hamiltonian cycles in directed graphs and minimum-cost solutions to network flows. Two papers are devoted to the Linear Complementarity Problem. Interior-point methods are developed by Kamath and Karmarkar for finding upper bounds to the convex quadratic problem, when the domain is the set of vertices of a hypercube.

Papers in the next bracket of four assume a special form for the objective function, generally related to convexity. An example is the paper of Tuy and Al-Khayyal. This considers the problem of maximizing a sum of functions, each of which is a composition of a decreasing convex function with a convex function. They show that their situation is equivalent to a convex maximization problem, a classical problem in the subject.

Functions which are built from ratios of linear functions are dealt with in the next two papers. Falk and Palocsay, motivated by a shipping scheduling context, develop a new method for optimizing the sum of two such functions. Konno and Yajima optimize the product of two ratios of linear function, motivated by a bond portfolio problem.

Lipschitz-based methods are covered in three papers. Evtushenko, Potapov, and Korotkich survey nonuniform space-covering techniques. Mladineo initiates a study of an algorithm which combines her cone algorithm with Pure Random Search. Pinter describes several existing and potential areas of application of Lipschitz methods.

Standing apart is the paper of Moore, Hansen, and Leclerc. This is a pleasure to read, and provides an excellent overview of the interval-arithmetic approach to global optimization.

Three papers involve a random flavor. Zabinsky and co-authors present an algorithm, based on the hit-and-run technique, which aims to realize Pure Adaptive Search. Törn and Viitanen introduce a new clustering algorithm. Shalloway presents a deterministic annealing algorithm which aims to converge to the global minimum with few function evaluations.

A paper of appeal to the functional analyst is that due to Zheng and Zhuang. They approximate an infinite-dimensional constrained optimization problem with a sequence of finite-dimensional problems.

Discrete-valued constraint variables are discussed. Grossmann, Voudouris, and Ghattas address engineering problems involving components which come in standard sizes only. Nielsen and Zenios, motivated by the problem of designing a computer board so as to minimize the total length of connecting wiring, develop a method to solve a mixed-integer nonlinear work program with generalized network constraints.

Least structure of all is assumed in the paper of Li, Pardalos, and Levine. They consider the problem of optimal nuclear reactor design, where the aim is to reach an optimal state at the end of a fuel cycle, subject to constraints, such as maintaining a certain level of energy production.

Trust region methods of Powell come under scrutiny, while a new path-following method is presented to find all the stationary points of a nonlinear program with inequality constraints.

The final paper is intriguing. Barbagallo, Recchioni and Zirilli tackle the question "Does your software do what it is supposed to do?" They set up the language of a Warnier's flow chart and investigate the problem of finding the $n$ test cases which will maximize the reliability of the software.

In summary, this set of papers is compulsory reading for the researcher in global optimization, and highly recommended for those interested in gathering a flavor of the methods and applications of the subject.

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**28[49-01, 49-04, 65K10, 90C35].**—DIMITRI P. BERTSEKAS, *Linear Network Optimization: Algorithms and Codes*, The MIT Press, Cambridge, MA, 1991, xi+359 pp., $23\frac{1}{2}$ cm. Price $39.95.

This book provides an introduction to the field of network optimization. The most general problem treated in the book is the *minimum-cost flow problem*, which is the problem of finding a minimum-cost flow in a network that satisfies supplies and demands at the nodes, and upper and lower bounds on the arcs. The book also treats the standard special cases of this problem, namely the assignment problem, the maximum-flow problem and the shortest-path problem. The book consists of five chapters and an appendix. Chapter 1 serves as an introduction, both to problem types and algorithmic strategies. Each of Chapters 2–4 describes an algorithmic strategy in detail; Chapter 2 focuses on the simplex methods, Chapter 3 on dual ascent methods, and Chapter 4 on auction methods. Chapter 5 provides a brief overview of the empirical performance of these methods. Finally, the appendix consists of FORTRAN listings of many of the algorithms discussed in the text.

The book is interesting for what it does, as well as for what it does not do. The book is not comprehensive, nor does it pretend to be. As the author indicates in the preface, the coverage is focused and selective. The primary algorithmic treatment of the maximum-flow and shortest-path problems is done in the introduction. The treatment of the maximum-flow problem is cursory, at best. Little mention is made of the recent preflow-push algorithms. The shortest-path problem receives a more detailed treatment, concentrating on the single-source multiple-destination version of the problem. The treatment is standard. Chapter 2, entitled *Simplex Methods*, is devoted almost entirely to a description of the primal simplex method for the minimum-cost flow problem. Again, the description is standard. Chapter 3, entitled *Dual Ascent Methods*, first describes the primal-dual method for the minimum-cost flow problem and then the relaxation method of the author. The primal-dual method is given both in its basic form and as a sequential shortest-path method. What sets this book apart from others is Chapter 4, entitled *Auction Algorithms*. This chapter is roughly twice as long as the previous two and provides an in-depth presentation of auction algorithms, which were first proposed by the author. The chapter begins by describing an auction algorithm for the assignment problem, which seems to be its most natural domain. The chapter then winds its way through variations of the basic auction algorithm applied to variations of the assignment problem. In the end, an auction algorithm for the minimum-cost flow problem is given.

The book is well written. The algorithms are motivated both through examples and intuitive reasoning. Proofs of correctness are included throughout.