REVIEWS AND DESCRIPTIONS OF TABLES AND BOOKS

The numbers in brackets are assigned according to the American Mathematical Society classification scheme. The 1991 Mathematics Subject Classification can be found in the annual subject index of *Mathematical Reviews* starting with the December 1990 issue.

18[65–01].—J. Stoer & R. Bulirsch, *Introduction to Numerical Analysis*, 2nd ed., Translated by R. Bartels, W. Gautschi, and C. Witzgall, Texts in Applied Mathematics, Vol 12, Springer, New York, 1993, xiv + 660 pp., 24 cm. Price $49.95.

When a textbook on any subject is being prepared, one should ask the questions: For whom is the book intended? What is the main purpose of the text and what is the appropriate level? Applied and numerical mathematics is an important subject *per se*, but possible applications are close at hand. As is well known, theoretical and experimental physics, chemistry, engineering of various kinds, statistics, astronomy, and meteorology belong here. Even if no specific indications are given explicitly, it is clear that all these areas will benefit from this exposition.

Compared with the first edition [1], several additions have been made: B-splines, differential-algebraic systems, large sparse systems, and a description of preconditioning techniques are the most important ones. A short discussion of what the B in the splines stands for (Bell-shaped, basic, B-net, Burns, Bézier seem to be the most popular guesses) would have been reasonable. With respect to presentation, the basic mathematical material as a prerequisite for the special methods can be collected in special chapters or presented together with the different special methods. The authors have chosen the second strategy, which certainly has several advantages. However, there is one striking example where this approach is a bit clumsy, namely concerning matrix theory, which is of great importance in Chapters 4 (Systems of linear equations), 6 (Eigenvalue problems), and 8 (Iterative methods for large systems of linear equations). With respect to this last chapter one could certainly ask why the authors do not use the more natural name "Numerical solution of certain partial differential equations" or perhaps just "Partial differential equations". This could have been accomplished by adding just a few pages.

There are numerous informative exercises but, unfortunately, no answers, which would have increased the value of the book considerably. Further, one gets the impression that the main part of the references are a bit old. I have certainly not tried to hunt printing errors or minor mistakes, but I did notice the name Überhuber (p. 166) which, to the best of my knowledge, actually spells *Ueberhuber*. More serious is the spelling Goldstein for Herman H. *Goldstine*

0025-5718/94 $1.00 + $.25 per page

(pages 7, 36, 652), since there are quite a few mathematicians using the first alternative.

On the whole, the judgment from the first edition prevails that the book represents an excellent modern addition to the literature in numerical mathematics. The translation is also of high quality.

CARL-ERIK FRÖBERG

Department of Computer Science
Lund University
S-22 100 Lund, Sweden

1. W. Gautschi, Review **17**, Math. Comp. **28** (1974), 664–666; B. Parlett, Review **49**, *ibid.*, 1169; C.-E. Fröberg, Review **20**, *ibid.* **37** (1981), 600.

19[65N30, 65R20, 68Q25].—A. G. WERSCHULZ, *The Computational Complexity of Differential and Integral Equations: An Information-Based Approach*, Oxford Mathematical Monographs, Oxford Univ. Press, New York, 1991, x+331 pp., 24 cm. Price $55.00.

The focus of the book is the computational complexity of numerical methods (primarily finite element methods) for solving partial differential equations (PDEs). The book develops the so-called *information-based* approach which is part of a research program developed by J. F. Traub and coworkers [4]. There is a rare (for the mathematical sciences) controversy [1, 2, 4] regarding this line of research. Parlett [2] distinguishes between *numerical analysis* and what he refers to as the more challenging subject of *complexity theory*.

It is beyond the scope of this review to comment in depth on the controversy, but it is important for potential readers to know the extent of the controversy. The first section (2.1) after the Introduction in the article [2] by Parlett has the title "This is not complexity theory," referring to the information-based approach. This is a strong statement which (if accepted) would mean that the title of the book under review is misleading.

In justifying the proposition "This is not complexity theory," Parlett refers to complexity theory as a subject devoted to the *intrinsic difficulty* of a problem and criticizes the proponents of the information-based approach for restricting to a limited class of algorithms, rather than considering the intrinsic difficulty of the problem at hand. It is therefore worthwhile to consider these notions in some detail.

Complexity theory is always restricted to an explicit class of algorithms defined in a mathematical way. An excellent and accessible introduction to the complexity of basic arithmetic operations is [5]. Thus the comments of Parlett refer to the scope of the algorithms mentioned in §2.1 of [2], not the fundamental approach of limiting to a mathematically defined class of objects.

The term *intrinsic difficulty* should also be viewed in this context. For example, the prediction of whether a drop of honey will form and fall on your breakfast table before you get the spoon back to the honey jar requires the solution of an extremely complex free-boundary problem for a system of PDEs [3]. However, the intrinsic difficulty of the required experiment is minimal. Thus complexity theory typically works within a framework that would rule out a physical experiment being done to evaluate a function.

The book under review attempts to establish complexity theory for the solution of boundary value problems for PDEs, at least in the context of Galerkin methods. Some sort of restriction is required, as simple physical experiments can produce solutions of certain equations to remarkable accuracy. A major feature of complexity theory for PDEs is that the data and unknowns of a boundary value problem are infinite-dimensional in character, involving functions of continuum variables. The notion of *information*, a finite set of linear functionals of the data and unknowns, is introduced to circumvent this difficulty. For example, the value of the solution to Poisson's equation is sought at only N points, to an accuracy $\varepsilon > 0$, given the right-hand-side values only at a similar number of points.

The detailed results of the book require not only the full power of Sobolev spaces, but the definition of probability measures on them as well. It would be quite lengthy to describe a typical result, but the conclusions of one line of investigation shed light on a long-standing question of practical importance. In solving a problem with singular solutions, it has long been debated whether to use high-order or low-order methods. This book concludes that high-order methods are preferable, as the low-order methods would be potentially nonoptimal in complexity. Roughly speaking, the book points out that the order of the method should *exceed* the order of smoothness of the solution, otherwise all of the potential rate of convergence will not be realized. A lower-than-possible rate of convergence leads to a suboptimal algorithm, and there is no penalty (in terms of asymptotic complexity) for having an order of approximation greater than the level of smoothness of the solution.

The conclusion of another line of research is anticipated by Werschulz to be controversial, namely that adaptive methods are frequently no more efficient (in an asymptotic sense) than nonadaptive ones. Here the results are somewhat limited, and the results are predicated on various assumptions that may need further refinement. In particular, the results so far are restricted to linear problems. In any case, this intriguing opinion alone makes the book worth investigating in more detail.

Whether this book is, or is not, a part of complexity theory, it adds an interesting new dimension to the study of numerical methods for the solution of PDEs. Now that the numerical analysis of PDEs is well developed, it is certainly time to consider questions regarding the related complexity theory.

L. R. S.

1. M. W. Hirsch and R. S. Palais, *Editor's remarks*, Bull. Amer. Math. Soc. (N.S.) **26** (1992), 1–2.

2. B. N. Parlett, *Some basic information on information-based complexity theory*, Bull. Amer. Math. Soc. (N.S.) **26** (1992), 3–27.

3. W. G. Pritchard, L. R. Scott, and S. J. Tavener, *Numerical and asymptotic methods for certain viscous free-surface flows*, Philos. Trans. Roy. Soc. London Ser. A **340** (1992), 1–45.

4. J. F. Traub and W. Woźniakowski, *Perspectives in information-based complexity*, Bull. Amer. Math. Soc. (N.S.) **26** (1992), 29–52.

5. S. Winograd, *Arithmetic complexity of computations*, SIAM, Philadelphia, PA, 1980.

20(a)[68N15, 68N20, 65Y05].—PHILIP J. HATCHER & MICHAEL J. QUINN *Data-Parallel Programming on MIMD Computers*, The MIT Press, Cambridge, MA, 1991, xiv + 231 pp., $23\frac{1}{2}$ cm. Price $31.50.

20(b)[65-06, 65Y05, 68N99].—PIYUSH MEHROTRA, JOEL SALTZ & ROBERT VOIGT (Editors), *Unstructured Scientific Computation on Scalable Multiprocessors*, Scientific and Engineering Computation Series, The MIT Press, Cambridge, MA, 1992, xviii + 407 pp., $23\frac{1}{2}$ cm. Price $39.95.

20(c)[65-06, 65P05, 76-06].—HORST D. SIMON (Editor), *Parallel Computational Fluid Dynamics: Implementations and Results*, Scientific and Engineering Computation Series, The MIT Press, Cambridge, MA, 1992, xii + 347 pp., $23\frac{1}{2}$ cm. Price $45.00.

These are volumes one, two, and three of the *Scientific and Engineering Computation Series*, edited by Janusz S. Kowalik. Libraries may not have made their acquisition decisions regarding this series, so we will comment on the series objectives and format to some extent. The second two books are the proceedings of conferences held in 1990. The "unstructured" conference was held at Nags Head in October, 1990, and the "CFD" (computational fluid dynamics) conference was held at Indianapolis in May, 1990.

The subject of all three books is parallel computing. Thus one might conclude that the Series will be devoted to parallel computing. However, the Series Foreword by Kowalik indicates broader objectives: "It will include books on theories, methods, and original applications in such areas as parallelism, large-scale simulations, time-critical computing, computer-aided design and engineering, use of computers in manufacturing, visualization of scientific data, and human-machine interface technology." The first three volumes are devoted to the first two topics on this list (parallelism and large-scale simulations). The last five are also topics of much current interest. If done well, it could be a valuable series.

Volume one of the series is devoted to programming languages for parallel computing, and it focuses in particular on *data-parallel* languages (which it defines rigorously). These languages are naturally associated with SIMD parallel computers, so the book emphasizes their effectiveness as well on MIMD Computers. The book is designed for three different uses. First, it is intended as an introduction to high-level parallel computing languages. Secondly, the book is intended to be used by people developing compilers for either distributed- or shared-memory parallel computers. Finally, it is intended to be a reference book for the programming language Dataparallel C.

The book outlines the various choices that are made in designing a parallel programming language, such as whether parallelism should be explicit or implicit, synchronous or asynchronous, etc. There are five different choices to be made, with more than two options in some cases. Dataparallel C represents one particular choice from the more than seventy possible designs. After describing the language in detail, extensive applications are presented, and the efficiency of the compiler is measured. This book sets a high standard for the presentation and evaluation of a parallel programming language. Given the variety of possible parallel languages, such an exposition is essential for the general technical community to be able to form an opinion on the best type of parallel programming model to use for particular applications. At the moment, sequential application codes are written variously in C, Fortran, Ada, Lisp, and probably many more sequential languages. It is reasonable to expect that there will be equal or greater variety in the ways that parallelism is expressed, and this book makes a clear case for the data-parallel approach.

The "CFD" proceedings consists of 16 papers, averaging 22 pages in length, and the "unstructured" proceedings consists of 20 papers, averaging 20 pages in length. However, the variation in page length is what one would expect in a journal, indicating that no artificial limits were placed on these papers. This is a refreshing alternative to the practice of limiting proceedings papers to a length appropriate only for an extended abstract, or prescribing any arbitrary (target) length.

Although not an important technical issue, the cover design of this series is quite attractive. However, quality control over the typography is varied. The "CFD" proceedings is quite uniform, with each chapter being individually numbered and the section (and subsection) numbers within each article adhering to this numbering. Moreover, the typography appears to be quite uniform as well in the "CFD" proceedings. The typography of the "unstructured" proceedings is less well structured, with some articles using densely spaced, small fonts and others having quite large print. This variation is unnecessary today, as authors can easily conform to typography requirements with minimal effort.

The two proceedings represent two different types of conferences. The "unstructured" conference was an *ad hoc* workshop, whereas the "CFD" conference was the second in a series that held its nth meeting in June, 1993, in Paris. Although the intersection of contributors could have been much larger (over one-third of the papers in the "unstructured" proceedings are CFD-related), the intersection consists of only two authors, both associated with RIACS (the Research Institute for Advanced Computer Science) at NASA Ames Research Center, a major center in these research areas. Although both proceedings are quite general and interdisciplinary, the "CFD" proceedings has a flavor more towards aeronautical engineering, whereas the "unstructured" proceedings tilts more toward computer science.

The "unstructured" proceedings, according to its Preface, addresses "unstructured and dynamically varying computations on scalable multiprocessors." Organized into categories, the problems addressed include:

- methods to effectively map fluids and structural mechanics codes that employ unstructured and/or adaptive meshes,
- scalable algorithms for problems in sparse linear algebra,
- scalable tools and compilers designed to handle irregular scientific computations,
- mapping methods for adaptive fast multipole methods, and
- parallelized grid generation and problem partitioning.

The number of papers devoted to sparse linear algebra, adaptive fast multipole methods and parallelized grid generation is quite small, roughly two or less each. Thus the book is less than definitive in these areas; rather it forms a snapshot of some of the research going on at the time.

The "CFD" book is more than a proceedings; according to its Preface "this book has been nurtured by the conference, but includes a number of additional chapters, dedicated to recent research work of relevance to the emerging field of parallel computational fluid dynamics." Most of the major discretization techniques are addressed (finite-difference, finite-element, spectral and particle methods). It also includes studies of parallel algorithms of relevance beyond fluid dynamics, such as parallel versions of

- iterative methods for solving discretizations of elliptic boundary value problems,
- integer sorting, and
- discrete Fourier transforms.

It also begins with an overview chapter (by the editor and two colleagues), and ends with a chapter (by the editor and a different colleague) discussing hardware and software issues related to projected teraflops computers and their use for parallel CFD.

The audience for these books is large and interdisciplinary. The publication of the proceedings makes them available to a much broader audience than would normally be the case with a proceedings published by an engineering or science disciplinary organization or just by the conference itself. This series is off to a good start, and it is easy to recommend it for library acquisition. The individual books reviewed here will be valuable to researchers specializing in the particular area covered by each book. People interested in programming unstructured fluids codes will want all three.

L. R. S.

21[65–06, 65P05, 35R35].—P. Neittaanmäki (Editor), *Numerical Methods for Free Boundary Problems*, Internat. Ser. Numer. Math., Vol. 99, Birkhäuser, Basel, 1991, xvi + 439 pp., 24 cm. Price $98.00.

This book is the proceedings of a conference held at the University of Jyväskylä, Finland, in July, 1990. The subject is free-boundary problems for partial differential equations. Although this may sound like a unified theme, it is not, owing to the diversity of types of free-boundary problems. Even in the area of fluid dynamics, there are three distinct research areas represented here, having essentially no relationship between them. No synthesis of these different areas has been attempted in this book.

The decision to publish a proceedings such as this can be justified on various grounds. The proceedings [1] intended to stimulate the combination of numerical and analytical techniques for studying singularly perturbed differential equations. One can argue this is a need that is not being met by regular journals. The justification for the proceedings under review seems less strong and rests primarily in the extra visibility provided to the important subject(s) of free-boundary problems for partial differential equations.

The proceedings consists of 39 papers, averaging 11 pages in length. In fact 29 of them are between 8 and 12 pages (with 10 pages being the mode). It would appear that authors were instructed to provide manuscripts ten pages in length, as is typical in many conferences today. This length leads to rather long extended abstracts (or in some cases advertisements) of work to be found elsewhere. Indeed, any restriction is somewhat unnatural; one finds far more variability in length of paper (and longer papers) in a typical journal, such as this one. This criticism is meant for the genre of conference proceedings as a whole, not just this book in particular. In fact, many of the papers are informative at a survey level, even if important details are often missing.

To provide coherence to the book, Neittaanmäki has written an extended Preface, which describes the various topics covered. The papers are not grouped accordingly, but rather are presented in alphabetical order based on the last name of the first-named author. Using the Preface, one can scan for a particular topic area, then easily look up the corresponding paper based on the author names which are provided in the Preface.

The areas described in the Preface are organized in three groups. The first is "Stefan-like problems" devoted to models for phase transition in materials. This group is further subdivided into 'modeling, existence and uniqueness' and 'modeling and numerical methods.' The first of these subgroups has papers with basic information relevant to numerical modeling but which contain nothing about numerics themselves. The second subgroup contains papers more in line with the title of the book. The second group in the Preface is devoted to "optimal control, optimal shape design and identification." The final group is on fluid flow with free boundaries.

There are three distinct areas of fluid flow with free boundaries that are covered in this book. One concerns flow of a fluid in a porous medium, with flow of water through a dam being a typical example. Another example is a two-fluid interface, such as the air-water interface. Two regimes are covered. In the case of an inviscid fluid having a free boundary, waves in the free surface are an area of research covered in the book. For viscous fluids having a free boundary, such as honey pouring from a jar, different phenomena are important, and this is also covered by papers in the book. It would be interesting to explore the relationships (if any) between the various types of free-boundary problems outlined in the Preface, but none exists so far to my knowledge.

Libraries have likely made their acquisition decisions regarding this book, through standing orders, as it appears in a well-known series. It is certainly a valuable library holding, and it will be important for researchers in any area of free-boundary problems to consult it. Whether an individual would want to buy a copy is more debatable. It provides a snapshot of the state of research in an important group of areas. However, some of these areas (for example, fluid-dynamical free-boundary problems) are not covered in sufficient depth to justify buying the book by an individual working only in that area.

L. R. S.

1. Hans G. Kaper et al., eds., *Asymptotic analysis and the numerical solution of partial differential equations*, Lecture Notes in Pure and Appl. Math., vol. 130, Dekker, New York, 1991; Reviewed in Math. Comp. **59** (1992), 303–304.

22[41A15, 65-04, 65D10, 65D17].—Paul Dierckx, *Curve and Surface Fitting with Splines*, Clarendon Press, Oxford, 1993, xviii + 285 pp., 24 cm. Price $53.00.

Over the past fifteen years, the author of this book has developed an extensive collection of algorithms for fitting curves and surfaces using spline functions. This book was written to explain the mathematics involved, to discuss the intricacies of the associated algorithms, to present examples to show how they work in practice, and to serve as a manual for his package (which consists of 83 FORTRAN routines, and is available to the public under the name FITPACK).

The book is divided into four parts. In the first part the author reviews (without proofs) the basic theory of univariate and bivariate splines, with special emphasis on computational aspects. Part 2 is devoted to curve fitting. This includes methods for least squares fitting with both fixed and free knots, smoothing splines with and without end-point constraints, periodic smoothing, and shape-preserving approximation (with emphasis on convexity).

The fitting of surfaces using tensor-product splines is the subject of Part 3. This part includes methods for fitting both gridded and scattered data using least squares and smoothing criteria. The questions of how to choose knots, and how to deal with large data sets and with incomplete data are also addressed. In addition, the author discusses methods for data on a unit disk, for data on the surface of a sphere, and for reconstructing surfaces from planar contours.

Part 4 of the book explains the organization of FITPACK and the main parameters in the various routines. Numerical results are presented to illustrate the performance of the methods, often on real-life problems. The book contains around 50 figures, and about 150 references. The reader should be aware that it is not intended to cover all applications of splines, and that many aspects of curve and surface fitting are not treated here.

I found the book to be well written in a clear and understandable fashion. It should be useful to a wide audience of potential users of splines.

LARRY L. SCHUMAKER

Department of Mathematics
Vanderbilt University
Nashville, TN 37240

23[49M30, 65K10].—ELDON HANSEN, *Global Optimization Using Interval Analysis*, Monographs and Textbooks in Pure and Appl. Math., Vol. 165, Dekker, New York, 1992, xvi + 230 pp., $23\frac{1}{2}$ cm. Price \$110.00.

The book under review presents techniques for the solution of global optimization problems (with several suspected local minima) and of nonlinear systems of equations with several solutions.

The systematic search for methods which solve the global optimization problem probably began in 1975 with Dixon and Szegö [4]. Ten years ago, the general consensus of researchers in the optimization community was that the complete solution of smooth, nonconvex global optimization problems was beyond tractability. (For the related problem of finding all zeros of nonlinear equations, this was explicitly expressed, e.g., in §2.1 of the book by Dennis and Schnabel [3].)

Therefore, research on global optimization has concentrated on heuristic or stochastic methods for finding good local (and hopefully global) minima, and some of these methods could be proved to produce a global solution with probability $1-\varepsilon$ in finite time, growing rapidly with decreasing ε. See, e.g., Kirkpatrick et al. [7], Levy et al. [8, 9], Byrd et al. [2], and the recent book by Törn and Žilinskas [13].

The situation turned out to be somewhat better for nonlinear systems, where homotopy methods were quite successful in locating several zeros, and for 'generic' polynomial systems it could even be proved that all zeros are found. Excellent treatments of homotopy methods can be found in Zangwill and Garcia [14] and Allgower and Georg [1]. However, for general systems, homotopy methods may fail, too.

In the meantime, two powerful approaches for solving global optimization problems have been developed, which are deterministic in the sense that (assuming exact arithmetic and enough storage) they are guaranteed not to miss any global minimizer. One approach is based on dc-functions, i.e., differences of convex functions, and exploits convexity properties; see the recent books by Horst and Tuy [6] and Pardalos and Rosen [11]. The latter book reports on the successful solution of global quadratic programs with up to 330 variables and 50 constraints.

The other approach is based on interval analysis, and was pioneered by the author of the present book [5]. Theory and algorithms for solving nonlinear systems of equations with several solutions are treated in the reviewer's book [10], and large-scale results for chemical engineering problems in dimensions 18 to 177 were recently reported by Schnepper and Stadtherr [12]. Applications of interval analysis to global approximation so far appeared only in journals and conference proceedings; the book under review is therefore a welcome addition to the literature.

Since interval methods are hardly known in the optimization community, the first part of the book gives a thorough introduction to interval analysis. The main advantage of interval techniques lies in their capacity to provide global information about functions over large regions (box-shaped), e.g., strict bounds on function values, Lipschitz constants, higher derivatives, and thus allows one to estimate the effects of using linear or quadratic approximations to a function. While the bounds are sometimes very wide, they can be proved to be always realistic when the boxes are narrow enough. Therefore, in the applications, interval techniques are combined with branch and bound techniques, which split boxes adaptively until the overestimation problems become insignificant.

The techniques developed are then applied, in turn, to the solution of nonlinear systems, global unconstrained optimization, and global constrained optimization, with an increase in complexity in the three problems. In order that the methods are efficient, Jacobians of nonlinear systems, and hence Hessians for optimization problems, must be provided explicitly (though the methods also work, slowly, with first-order or even zeroth-order information only). Ultimately, everything is reduced to the solution of systems of linear interval equations. For realistic bounds on the solutions of these systems, it is necessary to precondition the system by an explicit inverse matrix, which limits the dimension of the problems which can be solved to several hundreds.

Everything is well motivated, and many small examples are provided which can be checked with pencil and paper. For proofs of more difficult theoretical results references are given to the literature. The algorithmic aspect is treated in detail, so that it is fairly easy to write programs based on the descriptions given. It is emphasized that when the interval arithmetic is implemented with outward directed rounding, then the results of the algorithms are mathematically correct in spite of the rounding errors made by the computer, a fact which might be relevant in some applications.

The test problems discussed by the author have dimension ≤ 10 only, apart from a quadratic problem and a single example in 27 dimensions; and the constrained problems treated have only toy dimensions (the constrained Example 13.9, with 18 dimensions, is reduced to 5 dimensions, unconstrained). This is annoying, since it gives a wrong impression on the range of problems solvable by interval methods. The presentation of the test results is also rather careless; for some of the problems in §9.15, the initial box is not specified, and on p. 148 it is admitted that the results were obtained by an old implementation less efficient than later versions (which probably incorporate all tricks mentioned in the chapter).

It is surprising that hardly any use is made of classical optimization theory or algorithms; the only tools from optimization used are the Fritz John first-order optimality conditions. This is an indication that one can expect much further improvements by combining the methods treated with more of the traditional methods, and in particular with dc-methods. The future of the subject, once firmly rooted in the established tradition, looks very bright.

Altogether, I think that this book is an excellent introduction to interval techniques for the solution of global optimization problems and of nonlinear systems of equations with several solutions, though it takes only the first step towards good general-purpose global optimization software.

ARNOLD NEUMAIER

Institut für Angewandte Mathematik
Universität Freiburg
D-79104 Freiburg, Germany

1. E. L. Allgower and K. Georg, *Numerical continuation methods: an introduction*, Springer, Berlin, 1990.

2. R. H. Byrd, C. L. Dert, A. H. G. Rinnooy Kan, and R. B. Schnabel, *Concurrent stochastic methods for global optimization*, Math. Programming **46** (1990), 1–29.

3. J. E. Dennis and R. B. Schnabel, *Numerical methods for unconstrained optimization and nonlinear equations*, Prentice-Hall, Englewood Cliffs, NJ, 1983.

4. L. C. W. Dixon and G. P. Szegö, *Towards global optimization*, Elsevier, New York, 1975.

5. E. R. Hansen, *Global optimization using interval analysis—the multidimensional case*, Numer. Math. **34** (1980), 247–270.

6. R. Horst and H. Tuy, *Global optimization: deterministic approaches*, Springer, Berlin, 1990.

7. S. Kirkpatrick, C. D. Gelatt, and M. P. Vecchi, *Optimization by simulated annealing*, Science **220** (1983), 671–680.

8. A. V. Levy and S. Gomez, *The tunneling method applied to global optimization*, Numerical Optimization 1984 (P. T. Boggs et al., eds.), SIAM Publications, Philadelphia, PA, 1984, pp. 213–244.

9. A. V. Levy and A. Montalvo, *The tunneling algorithm for the global minimization of functions*, SIAM J. Sci. Statist. Comput. **6** (1985), 15–29.

10. A. Neumaier, *Interval methods for systems of equations*, Cambridge Univ. Press, Cambridge, 1990.

11. P. M. Pardalos and J. B. Rosen, *Constrained global optimization: algorithms and applications*, Lecture Notes in Comput. Sci., vol. 268, Springer, Berlin, 1987.

12. C. A. Schnepper and M. A. Stadtherr, *Application of a parallel interval Newton/generalized bisection algorithm to equation-based chemical process flowsheeting*, Lecture at the conference *Numerical Analysis with Automatic Result Verification*, Lafayette, LA, Feb. 1993.

13. A. Törn and A. Žilinskas, *Global optimization*, Lecture Notes in Comput. Sci., vol. 350, Springer, Berlin, 1989.

14. W. I. Zangwill and C. B. Garcia, *Pathways to solutions, fixed points, and equilibria*, Prentice-Hall, Englewood Cliffs, NJ, 1981.

24[90B05, 90C35].—JAMES R. EVANS & EDWARD MINIEKA, *Optimization Algorithms for Networks and Graphs*, 2nd ed., Dekker, New York, 1992, x + 470 pp., $23\frac{1}{2}$ cm. Price \$59.75.

This book gives a treatment of network optimization that manages to be both inviting and mathematically rigorous. Though network optimization courses vary according to individual interests and preference, the topics covered in this book are likely close to the right ones for the majority of the courses of that title taught in mathematics, engineering, and possibly even computer science departments:

- Basic Graph Theory
- Basic Data Structures and Complexity
- Minimum Spanning Trees and Branchings
- Shortest Paths
- Minimum-Cost Flows
- Maximum Flows
- Matchings (including maximum-weight matchings in arbitrary graphs)
- Chinese Postman
- Traveling Salesman Problem
- Location
- PERT

A major strength of the book is its gentle approach, making it very readable. Each chapter begins with several motivating applications handled by the models in the chapter. The algorithms are stated nicely and rigorously proved correct. Details of the algorithms applied to examples are included. The exercises include algorithm execution, theory, applications, with emphasis on the first of the three.

A second strength of the book is the accompanying software package, for use on DOS machines. I know of none more extensive for use in such a course. The software is easy to use and well documented. Unfortunately, it provides no graphics.

The book is appropriate for an introductory course at the undergraduate or even the graduate level. It should not be taken as a complete research reference, however. Treatment of network optimization advances of the last decade is scant. (One obvious omission is the mention of strongly polynomial methods for minimum-cost flows.)

The authors' preface includes the following apt description:

> ... The focus is on an intuitive approach to the inner workings, interdependencies, and applications of the algorithms. Their place in the hierarchy of advanced mathematics and the details of their computer coding are not stressed....

I think this book succeeds in providing the novice a broad and enticing introduction to the subject of network optimization.

COLLETTE COULLARD

Department of Industrial Engineering
and Management Sciences
Northwestern University
Evanston, IL 60208

25[42–01, 42A38, 65T10].—JAMES S. WALKER, *Fast Fourier Transforms*, Studies in Advanced Mathematics, CRC Press, Boca Raton, FL, 1991, xiv + 319 pp., 24 cm. Price $59.95.

This is another addition to the growing textbook literature on the FFT, and the emphasis here is on the interplay between the FFT and classical Fourier analysis and on applications of the FFT to the practice of Fourier analysis. A very attractive feature of this book is the inclusion of computer software, called *Fourier Analysis Software*, in the form of a disk that can be used on any PC operating under DOS version 2.1 and up. With this software the reader can generate computer images of Fourier series, Fourier transforms, filtered Fourier transforms, and convolutions.

After giving a brief summary of the basic theory of Fourier series in Chapter 1, the author introduces the discrete Fourier transform, together with discretizations of Fourier sine and Fourier cosine series, in Chapter 2. Chapter 3 presents the heart of the matter, the fast Fourier transform, but it concentrates on Buneman's methods, which, in the author's opinion, deserve more prominence. The topic of Chapter 4 is applications of Fourier series, for instance to the heat and wave equations, to Schrödinger's equation for a free particle, and to filters in signal processing. Chapter 5 discusses the fundamentals of Fourier transforms, Fourier inversion, and convolution and covers also Poisson summation, the sampling theorem, and aliasing. An introduction to Fourier optics is given in Chapter 6. Appendix A contains the user's manual for *Fourier Analysis Software* and Appendix B lists some computer programs written in the language QuickBASIC.

The book is well paced for students of applied areas such as electrical engineering and physics, and this is mainly the audience the author had in mind, since mathematical technicalities are kept to a minimum.

H. N.