implementation as a parallel algorithm. The book concludes with a chapter on the singular value decomposition, including a discussion of canonical angles between subspaces.

The book is very well written. The author has aimed at an integrated treatment of his subject; he introduces theoretical material only as it is required and places running exercises in the text proper. The result, which could have been a muddle in the hands of a less skilled expositor, is a lively and pleasing narrative.

Unfortunately, there are some serious omissions. QR updating and related topics are passed over in silence. Algorithms are presented in scalar form, although the modern style of coding relegates vector and matrix-vector operations to subprograms, which can be tailored to individual computer architectures. Finally, the author is at best a casual bibliographer, which diminishes the value of the book as a reference.

But these reservations should not be allowed to obscure the fact that *Fundamentals of Matrix Computations* is a fine introduction to the ways of a matrix on a computer. It fills an important pedagogical niche, and we owe Watkins a debt of gratitude for undertaking to write it.

G. W. S.

1. G. E. Forsythe and C. B. Moler, *Computer solution of linear algebraic systems*, Prentice-Hall, Englewood Cliffs, NJ, 1967. [Review **27**, Math. Comp. **24** (1970), 482.]

2. G. H. Golub and C. F. Van Loan, *Matrix computations*, 2nd ed., The Johns Hopkins University Press, Baltimore, 1989. [Review **4**, Math. Comp. **56** (1991), 380–381.]

3. B. N. Parlett, *The symmetric eigenvalue problem*, Prentice-Hall, Englewood Cliffs, NJ, 1980. [Review **19**, Math. Comp. **37** (1981), 599.]

4. G. W. Stewart, *Introduction to matrix computations*, Academic Press, 1973.

5. J. H. Wilkinson, *The algebraic eigenvalue problem*, Oxford University Press, New York, 1965. [Review **90**, Math. Comp. **20** (1966), 621.]

17[51M20, 57Q15, 65H10, 65–04].—Eugene L. Allgower & Kurt Georg, *Numerical Continuation Methods—An Introduction*, Springer Series in Computational Mathematics, Vol. 13, Springer, Berlin, 1990, xiv+388 pp., 24 cm. Price $69.00.

As a graduate student at The University of Michigan, I remember well the excitement generated by the simplicial fixed point proofs of Scarf, Kuhn, Eaves, and Saigal. The first Ph.D. thesis I read was that of Merrill, passed along by Katta Murty, who was Merrill's advisor and my mentor. Having studied under Cleve Moler, Dave Kahaner, and Carl de Boor, I fancied myself a numerical analyst, and was predictably skeptical of these guaranteed global simplicial methods. Yet the potential power was clearly enormous, if only the ideas could be implemented in a numerically stable and computationally feasible way.

A few years later, while I was a colleague of S. N. Chow at Michigan State University, Chow, Mallet-Paret, and Yorke and Herb Keller independently proposed probability-one homotopies. These had the same potential power as simplicial methods, but were based on smooth maps. The two camps convened at a NATO Advanced Research Institute on Homotopy Methods and Global Convergence in Sardinia in June, 1981. By then the two classes of methods (simplicial and continuous) had been pronounced applicable to just about every problem under the sun, and listening to the speakers, one had the impression that nonlinear systems of equations and nonlinear constrained optimization were as routine as Gaussian elimination.

But chalkware does not solve real problems, and when the grandiose claims were not backed up, the whole subject of globally convergent homotopy algorithms was disparaged by numerical analysts and engineers. Allgower and Georg's book makes a strong case that, after two decades of hard work and many theoretical and computational successes, homotopy methods are to be taken seriously. The stigma persists, though, as the title of the book has "numerical continuation" instead of "homotopy."

The book constitutes an update of the authors' 1980 *SIAM Review* article, and is excellent in many regards: the bibliography is lengthy, historical perspective is provided throughout, the writing style is lucid, there is a wealth of material, and the presentation is balanced (with a few glaring exceptions). Chapters 3–10 deal with continuous homotopy methods (which they call "predictor-corrector"), Chapters 12–15 discuss simplicial methods (which they call "piecewise linear"), and there are six appendices with programs. The foreword says that the programs "are primarily to be regarded as illustrations" and "not as perfected library programs." The reader should take this caveat to heart! Having taught numerical analysis to thousands of students out of textbooks with "illustrative programs," and watched the ensuing computational disasters, I personally believe that such code is akin to giving someone a faulty loaded gun. Also, the expressive power of Pascal (which they mistakenly write as an acronym *PASCAL*) is so weak I cannot understand using that syntax for pseudocode.

It is difficult for the student to be critical of the master (and Allgower and Georg are masters), but I will mention a few shortcomings of the book. There are numerous errors, which invariably occur in the worst possible places—the statements of definitions and theorems. Figure 12.1.b illustrating a triangulation is wrong, and the minimization problem (P2.1) on which a whole appendix is based is unbounded. The index is not in alphabetical order, and not very complete. A listing of codes on page 5 omits one of the most widely used codes, HOMPACK. Certainly one of the major developments in the field was probability-one homotopies, yet it does not merit a chapter in the book (the philosophy of the construction of probability-one homotopies is sufficiently different from classical continuation to warrant a long chapter) and "probability-one homotopy" is not even in the index! With a few exceptions, the bibliography ignores the IEEE, AIAA, and ASME literature, and is heavily weighted with German references (not bad, just misleading).

The stated goal of the book is "to provide an easy access for scientific workers and students to the numerical aspects" of both continuous and simplicial continuation methods, and show that they "are actually rather closely related." I would say that goal has been admirably met, and everyone seriously interested in numerical continuation methods should have a copy.

LAYNE T. WATSON

Department of Computer Science
Virginia Polytechnic Institute
Blacksburg, VA 24061