ple interesting and worthwhile. Significant examples that come to mind are deferred correction and A. Brandt's FAS extension of the multigrid idea to nonlinear problems.

Simplified Newton iteration (including iterative refinement) is of especial importance in interval analysis because of the considerable pessimism of interval extensions of direct methods such as Gaussian elimination. It is better to do the initial computation using point values and to use intervals to compute corrections. Of crucial importance is the very accurate calculation of residuals. Often these residuals are inner products and in most other cases they can be so expressed by rewriting the problem. For this reason, U. Kulisch, W. Miranker, and others have advocated that in addition to the four arithmetic operations, there ought to be a built-in (microprogrammed) operation that delivers an inner product to the full precision of the computer. The paper by Rump describes algorithms for the solution of linear and nonlinear systems of equations based on this Kulisch/Miranker arithmetic, and these are implemented in the IBM program product ACRITH, on the market since March 1984. The paper of Kaucher and Miranker goes beyond this and considers the solution of equations in function space. The development in their paper is guided by an analogy between the digit-by-digit decimal expansion of a number and the term-by-term Chebyshev series expansion (for example) of a function. Both papers provide impressive examples, and together they seem to form a definitive condensation of the Kulisch/Miranker approach. However, the unfamiliar notation and terminology and the excessive formalisms are likely to deter any reader other than an interval analysis enthusiast. (This is typical of work in interval analysis and may be partly responsible for its unfortunate isolation from mainstream numerical analysis.) In addition, the substance of the Kulisch/Miranker approach has been criticized. The calculation of an inner product to full precision can be quite time-consuming because of the need for a Super-Accumulator in order to store the intermediate results to whatever precision is necessary. Also, examples have been given by W. Kahan/E. LeBlanc showing the ill effects of having to rewrite the problem so that the residuals are expressible as inner products; one such example is the rewriting of a continued fraction as the ratio of polynomials. Finally, it remains to be demonstrated that the goals of reliability and high accuracy could not be achieved instead with the use of double-precision interval arithmetic for selected intermediate results.

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24[65-02].—Gene H. Golub & Charles F. Van Loan, *Matrix Computations*, The Johns Hopkins University Press, Baltimore, Md., 1983, xvi + 476 pp., $23\frac{1}{2}$ cm. Price \$49.50 hardcover, \$24.95 paperback.

The authors admit to having taken 6 years to write this book. Those who have experienced the energy and enthusiasm which Professor Golub brings to everything will expect that a project which has occupied him for so long must lead to something special. They will not be disappointed.

One of the aims of the book was to synthesize a number of modern developments since the publication of Wilkinson's "Algebraic Eigenvalue Problem" in 1965. This new book is very different from this illustrious predecessor; it has a different purpose, and a distinctive individual style of its own. It is intended as a text for teaching, and of course for self-instruction, and is therefore copiously supplied with examples and exercises. Choosing an example at random, Section 5.2 discusses the use of Cholesky decomposition in the solution of symmetric positive definite systems. In 4 pages it includes 3 theorems, a detailed algorithm and 2 numerical examples. There follows a set of 9 problems for the reader, and a usefully annotated list of 8 references for going deeper into the topic; there is also a reference to the relevant FORTRAN programs in the LINPACK Library. The same style of presentation runs right through the book.

The layout of the book is fairly conventional, beginning with three chapters on basic matrix algebra, including norms, rounding errors and the elementary transformations. Then follow two chapters on elimination methods, and their application in special cases, such as band matrices, and a chapter on orthogonalization and least squares.

The next two chapters deal with the eigenvalue problem; rather unusually, the unsymmetric case comes first, and the specialization of the QR algorithm is then used as the main method for the symmetric case in the next chapter. Chapter 9 is concerned with the Lanczos method, and Chapter 10 with various iterative methods for solving systems of linear equations. The treatment here is quite condensed; the classical iterative methods are covered in only 8 pages, and the conjugate gradient method in 13 pages.

Finally, there are two chapters on functions of matrices, such as the computation of the matrix exponential e^A, and on a number of assorted special topics. And then, a 24-page bibliography and a useful index.

The theoretical and practical aspects of the Singular Value Decomposition are a recurrent theme throughout the book; the SVD is defined on page 16 and is fittingly very nearly the last entry on the last page of the index. With a concept of such all-pervading importance it may seem odd to the uninitiated that in a book on Matrix Computations the reader has to wait for nearly 300 pages before discovering how the SVD is actually computed.

It is suggested that the book could be used as a text for a 2-semester course in matrix computation; that would be a rather strenuous course. There are more than 450 tightly packed pages, complete with problems, and the pace is often quite brisk. It would be strong meat for an average student with no previous knowledge of the subject. But as a reference book, for one who knows something about the subject and wants to know more, it has no equal. The information it contains is accurate, easy to find and very well illustrated; and there are plenty of examples and problems to keep the reader's attention from wandering.

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