and imaginary parts. In an age when complex function theory is an undergraduate course, when analytic continuation in the complex energy or angular-momentum plane is commonplace in physics, when engineers use analytic transfer functions to describe electrical and mechanical systems, it seems a step backward to survey the properties of special functions with no mention of analyticity, poles, or branch points.

Secondly, the authors have relegated to the background the one notational device, ${}_pF_q$, that has done more than any other to bring order and unity into the welter of redundant definitions and notations that have accumulated during two centuries. One must thank them for a long list (Table 18.14.2) identifying hypergeometric series having various parameters with functions discussed elsewhere in the book. However, they eschew the ${}_pF_q$ notation for such series because they consider it more general (see Section 60:13 and p. 155) to specify the coefficient of x^n rather than $x^n/n!$. That is, they prefer to insert 1 as a parameter in the denominator when necessary rather than remove the $n!$ when necessary by a parameter 1 in the numerator. This is really a question of taste, not generality. Their choice has the effect that closely related functions (for example, arcsin and arctan, special cases of ${}_2F_1$) are listed with different numbers of parameters, and a linear transformation of ${}_2F_1$ can change the number of parameters. Worse yet, it has the effect that the ${}_pF_q$ notation is not used in the other chapters to show the reader that some order and simplicity underlie the chaotic throng of special hypergeometric functions. The shifted factorial or Pochhammer symbol, $(a)_n$, fares somewhat better with a chapter to itself, but in the rest of the book it gives way to semifactorials and even to the notations $n!!!$ and $n!!!!$.

What one reader deplores, another may applaud; no book can satisfy everyone in all respects. This one should please nearly everyone in most respects and should have a deservedly bright future in the Citation Index.

B. C. C.

1. M. ABRAMOWITZ & I. A. STEGUN, eds., *Handbook of Mathematical Functions*, National Bureau of Standards Applied Mathematics Series, No. 55, U. S. Government Printing Office, Washington, D. C., 1964. Reprinted by Dover Publications, New York, 1965.

2. E. JAHNKE & F. EMDE, *Tables of Higher Functions*, 6th ed. revised by F. Lösch, McGraw-Hill, New York, 1960.

3. Y. L. LUKE, *Mathematical Functions and their Approximations*, Academic Press, New York, 1975.

31[62M15]. S. LAWRENCE MARPLE, JR., *Digital Spectral Analysis with Applications*, Prentice-Hall Signal Processing Series (Alan. V. Oppenheim, Editor), Prentice-Hall, Englewood Cliffs, N. J., 1987, xx + 492 pp., 24 cm. Price $43.95.

Applied spectral analysis has undergone significant changes in recent years. While traditional spectral analysis has evolved around Fourier methods, the modern approach emphasizes parametric modeling and makes extensive use of matrix analysis. The advent of powerful hardware for numerical processing, together with the ever increasing demand for speed, accuracy and complexity, are largely responsible for this shift of emphasis.

Lawrence Marple's new book well reflects this trend. While its title states that it is a book about digital spectral analysis, its contents place an emphasis on the so-called "modern" spectral estimation. This book was written by an engineer for engineers and often sacrifices mathematical rigor for readability. The book is very clearly written, has a lucid, informal style, and it continuously stresses intuition and engineering judgment. Each of the major chapters starts with a summary of the algorithms discussed in that chapter, in a form suitable for immediate use. This is very helpful for readers who are already familiar with the theory, and who need the book mainly for reference. The book contains a diskette with 35 FORTRAN programs that are carefully prepared, well documented, and presented in a form ready to compile and run.

Here is a chapter by chapter description of the book's contents.

Chapter 1 gives a very nice historical introduction to spectral analysis, followed by some illustrations of the problems and difficulties involved in this field.

Chapter 2 provides a brief review of linear system theory, to the extent that it is used later in the book. The exposition is rather informal, in the general spirit of the book. Section 2.7 contains an interesting discussion of the relationship between continuous and discrete transforms.

Chapter 3 similarly reviews basic matrix theory. Among standard results, it includes some facts about Toeplitz matrices not frequently encountered in linear algebra texts.

Chapter 4, which reviews random process theory, is undoubtedly the weakest in the book. Here, informality often extends to inaccuracy. The author proceeds to describe properties of estimators without ever mentioning what estimation theory is all about, skipping basic definitions and facts. For a book whose main concern is estimation, this is a serious omission. The discussion of ergodicity in Section 4.4 is flawed. In fact, the reader would be better off skipping this section completely. A good presentation of ergodicity is given in the text by Grenander and Rosenblatt [1].

Chapter 5 is the only one in the book devoted to classical spectral estimation. It gives a rather concise description of the main issues involved in nonparametric spectral estimation—windowing, averaging, trade-off between variance and resolution, etc. There is an error in Eq. (5.26)—the right-hand side is incorrect in general, unless $L = N - 1$.

Chapter 6 serves as an introduction to parametric models for stationary time series, in particular AR, MA and ARMA models. This chapter is, perhaps, too concise. The reader may want to consult the book by Box and Jenkins [2] for additional material on parametric models of time series.

Chapters 7, 8, and 9, give an extensive exposition of autoregressive (AR) estimation. AR modeling is an extremely popular technique, and there is a very rich literature on the subject. The author's choice of material here is well balanced, and both the theoretical and practical aspects of AR estimation are well explained. I have two minor comments about the material in these chapters. In Section 8.8, the author does not alert the reader to the difficulties associated with noise subtraction. Additive noise does not just increase the zero correlation term. It affects the probability distribution of all the estimated correlations, hence a simple subtraction of the noise variance from the zero correlation seldom yields acceptable results. In Section 9.3, the author quotes conditions for convergence of the LMS that are known to be incorrect for AR processes. In fact, conditions for convergence of the LMS algorithm for general AR processes are still unknown.

Chapter 10 is devoted to autoregressive moving average (ARMA) estimation. ARMA estimation is considerably more difficult than AR estimation. Simple algorithms, based on linear approximations, are relatively inaccurate. High performance algorithms (such as maximum likelihood) are iterative in nature, prone to convergence problems, and require intensive computations. Therefore, they are seldom used in real-time applications. The author concentrates on relatively simple algorithms, the performance of which is known to be inadequate in many cases. For ARMA estimation, the book by Box and Jenkins [2] is probably still the best reference.

Chapter 11 describes Prony's method and some of its variants.

Chapters 12 and 13 deviate from the parametric approach, concentrating on methods based on the estimated covariance matrix. These methods take advantage of the special eigenstructure of the covariance matrix, and most of them are restricted to sinusoidal signals in white noise. Chapter 12 presents the simplest of these methods—the so-called minimum variance algorithm. Chapter 13 presents more advanced methods, such as Pisarenko harmonic decomposition and the multiple signal classification (MUSIC) method of Schmidt.

Chapter 14 summarizes the estimation methods for single time series, and attempts at giving them a unified description (in Table 14.1).

Chapters 15 and 16 are devoted to two specialized topics: estimation of multiple time series, and two-dimensional spectral estimation. Multiple time series have not received a decent treatment in textbooks since Hannan's classic text [3]. Unfortunately, Hannan's book has never gained popularity in the engineering community. Chapter 15 in Marple's book thus serves to fill a certain gap in this area. Similarly, two-dimensional spectral estimation has received only little treatment. Chapter 16 in Marple's book is fair, but it considerably overlaps with Chapter 6 in the book by Dudgeon and Mersereau [4].

In summary, Marple has succeeded in organizing the vast material available in the technical literature, and presenting it in a very readable form. The book should prove a useful reference. As a text for, say, an engineering graduate course, it should be supplemented by additional reading, to better cover the theoretical aspects. As a book for self-study, it is very good, provided the reader has some background in random process and estimation theory.

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1. U. GRENANDER & M. ROSENBLATT, *Statistical Analysis of Stationary Time Series*, Wiley, New York, 1957.

2. G. E. P. BOX & G. M. JENKINS, *Time Series Analysis, Forecasting and Control*, Holden-Day, San Francisco, 1976.

3. E. J. HANNAN, *Multiple Time Series*, Wiley, New York, 1970.

4. D. E. DUDGEON & R. M. MERSEREAU, *Multidimensional Digital Signal Processing*, Prentice-Hall, Englewood Cliffs, N. J., 1984.

32[65–06].—A. ISERLES & M. J. D. POWELL (Editors), *The State of the Art in Numerical Analysis*, The Institute of Mathematics and its Applications Conference Series, Vol. 9, Oxford Univ. Press, Oxford, 1987, xiv + 719 pp., 24 cm. Price $98.00.

A welcome tradition seems to be evolving in England to organize a conference once a decade to review progress made in numerical analysis during the past ten years. The volume under review contains the proceedings of the third such conference, held at the University of Birmingham, April 14–18, 1986. (For the two preceding conferences, see [1], [2].) An attempt has again been made to survey the entire field of numerical analysis. This resulted in 23 contributions, written by acknowledged experts, covering such areas as numerical linear algebra (eigenvalues, statistical applications, sparse matrices), approximation theory (multivariate approximation, splines, best approximation and regression analysis, complex elementary functions), optimization (linear and quadratic programming, nonlinear constraints), nonlinear equations (tensor methods, bifurcation problems, secant updating techniques), the influence of machine architectures on numerical analysis (vector and parallel processors), ordinary differential equations (stability theory, stiff problems, order stars), integral equations (Fredholm and Volterra equations, boundary integral equations), and partial differential equations (multigrid, Galerkin, and finite element methods, free and moving boundary problems, nonlinear conservation laws).

W. G.

1. J. WALSH (ed.), *Numerical Analysis: An Introduction*, Academic Press, London, 1966.

2. D. A. H. JACOBS (ed.), *The State of the Art in Numerical Analysis*, Academic Press, London, 1977. [Review **26**, *Math. Comp.*, v. 32, 1978, p. 1325.]

33[41–06].—J. C. MASON & M. G. COX (Editors), *Algorithms for Approximation*, Clarendon Press, Oxford, 1987, xvi + 694 pp., 24 cm. Price $125.00.

This volume contains 12 invited and 29 contributed papers presented at an international conference at the Royal Military College of Science in Shrivenham, England, during July 15–19, 1985. Practical and algorithmic aspects of approximation are given particular emphasis. The contributions are organized in three primary sections: I. Development of Algorithms, II. Applications, III. Software, the first two being further subdivided into subsections 1. Spline approximation and smoothing, 2. Spline interpolation and shape preservation, 3. Multivariate interpolation, 4. Least square methods, 5. Rational approximation, 6. Complex and nonlinear approximation, 7. Computer-aided design and blending, and 8. Applications in numerical anaysis, 9. Applications in partial differential equations, 10. Applications in other disciplines, respectively.

W. G.