transform $f(t) = \int_0^\infty e^{-xt} g(x)\,dx$. Suppose one approximates $f(t)$ by a Padé-type approximation where the degree of the denominator polynomial exceeds that of the numerator polynomial. Then an approximation for $g(x)$ as a series of exponentials follows by inversion of the approximation for $f(z)$. It is stated that this idea is due to Longman in a paper published in 1972. Actually an application of this idea was used by Longman in 1966. I recognize, there is some danger in saying who expressed an idea first. However, the reviewer gave several applications of this idea in papers published in 1957, 1962, 1963, and 1964. See [2, Volume 2, Section 16.4] for details.

The volume is well written and organized. It is valuable both for the information it provides and for pointing out directions for future research. For anyone interested in rational approximations, the book is a must on one's bookshelf.

Y. L. L.

1. Y. L. Luke, *The Special Functions and Their Approximations*, Vols. 1, 2, Academic Press, New York, 1969.

2. Y. L. Luke, *Mathematical Functions and Their Approximations*, Academic Press, New York, 1975. Also in Russian, Izdat. "Mir", Moscow, 1980.

3. Y. L. Luke, *Algorithms for the Computation of Mathematical Functions*, Academic Press, New York, 1977.

14 [8.00, 2.00, 3.00].—W. J. Kennedy & J. E. Gentle, *Statistical Computing*, Marcel Dekker, New York, 1980, xi + 591 pp., $23\frac{1}{2}$ cm. Price $26.50.

Historically, statistical practice was limited by what was computationally feasible. Modern computing capability has expanded the horizons on computational feasibility to where what might have been the toys of mathematical statisticians in the past have become part of today's common statistical practice. This success and aim have been the fruits and the goal of the field of statistical computing.

The technique of nonlinear regression epitomizes the toy that is now common practice. It also illustrates the fragmentation that statistical computing suffered from. That is, contributors have come from many disciplines, from those in applications like chemical engineers, to those in operations research and numerical analysis, mathematicians, economists, and, finally, statisticians themselves. These advances have appeared in a great variety of publications. Many wheels have been reinvented many times.

The publication of this book, I believe, is a milestone, although it is not the first in its field (Hemmerle, [1]). Kennedy and Gentle have done an outstanding job of assembling the best techniques from a great variety of sources, establishing a benchmark for the field of statistical computing. Its imperfections will be discussed later.

Disregarding four preparatory chapters on the fundamentals of computing, the authors treat four main topics in depth:

1. Computing probabilities and percentile points.
2. Random numbers and simulation.
3. Linear models computations.
4. Nonlinear regression and optimization.

The final two chapters deal with robust methods and techniques for multivariate statistical analysis.

In the discussion of the first topic, methods are presented to satisfy most of the needs of statisticians. Some topics in numerical analysis are discussed in context: root finding, series approximations, continued fractions and quadrature.

For the second main topic, the authors begin with a discussion of generating the uniform distribution and the testing of random number generators. Following an explanation of general techniques, algorithms for generating from many nonuniform distributions are given. The list is reasonably up to date: most algorithms are the state of the art to 1977, some to 1978 and 1979. Here the authors have done a creditable job with a difficult topic.

The material on linear models computations is split into three chapters. The first chapter introduces Cholesky, Gram-Schmidt, Gaussian elimination/sweeps, and Householder transformations. Application of these techniques to the regression problem forms the middle chapter. The final chapter deals exclusively with classification models. The more conventional material has been treated elsewhere by Lawson and Hanson [2] and especially well by Stewart [4]. However, the last chapter on this topic has not and a great wealth of work is summarized. Of the 114 references for this chapter, 108 are to journal articles, conference proceedings, theses and reports; four of the remainder are statistics texts.

The last topic, covered in a single chapter, begins with the fundamentals of minima, saddle points and gradients. The discussion then moves to the elements of iterative search algorithms: direction, step size and convergence. A number of algorithms for unconstrained minimization are explained in detail. The important special case of nonlinear least squares is then covered extensively. Eighteen test problems are included, and the references for this chapter number 167.

This book is also intended to be a textbook for a graduate level course. The authors clearly have tried to write to such an audience (or lower). But so much of the material is at such an advanced level that it is better described as a reference work. I find it to be an adequate text, partly for personal reasons, but unquestionably superior to the alternative: no text. The many problems given at the end of each chapter are an obvious aid.

My major criticism of this book is that it is not very statistical. Computational techniques can be found in texts on mathematical statistics (Rao [3, p. 302]); the authors, statisticians, appear to have avoided any statistics beyond the bare necessities. In the long discussion of unconstrained minimization, maximum likelihood, the main interest of statisticians, is barely mentioned. The standard asymptotic theory of maximum likelihood (as well as exceptions) and their relationship to the computational problem would be both valuable and instructive here. Also overlooked is the relationship between conditioning and the associated statistical problem. In least squares, for example, solving the normal equations is ill conditioned when X^TX is nearly deficient in rank, hence an accurate solution may be unattainable. But a large condition number, measured by, say $\|X^TX\| \cdot \|(X^TX)^{-1}\|$, indicates that the entries of $(X^TX)^{-1}$ are unexpectedly large, hence the variances of the least squares estimates are likely to be large, and, hence, any computationally accurate solution would still be statistically crude. This relationship is stronger in maximum likelihood estimation.

Secondly, the distinct value of books written by those distinguished in a given field are their opinions and experiences. The authors have chosen to be diplomatic. They include some inferior techniques for completeness. Comparisons of techniques, their requirements and tradeoffs appear unemotional and neutral (a plus for the left-brained) but also indecisive and not compelling (and sometimes incomplete). They avoid the fray regarding regression computations on p. 325; their opinions and experiences are missed. For the most part, I miss the comments based on experience, which I compare to Stewart [4, p. 93 and pp. 152–154]. Notable exceptions are the discussion of checking regression computations on p. 329 and the advantages of GFSR on p. 162.

To summarize, *Statistical Computing* by Kennedy and Gentle is comprehensive: both broad and deep. It can replace for me the small library of books and articles I have heretofore needed. I bought a copy of this book before the editor sent me a second copy for review. That purchase has not been regretted.

JOHN F. MONAHAN

Department of Statistics
North Carolina State University
Raleigh, North Carolina 27650

1. W. H. HEMMERLE, *Statistical Computations on a Digital Computer*, Blaisdell, Waltham, Mass., 1967.

2. C. L. LAWSON & R. J. HANSON, *Solving Least Squares Problems*, Prentice-Hall, Englewood Cliffs, N. J., 1974.

3. C. R. RAO, *Linear Statistical Inference and Its Applications*, Wiley, New York, 1965.

4. G. W. STEWART, *Introduction to Matrix Computations*, Academic Press, New York, 1973.

ABCDEFGHIJ–CM–8987654321