Book Reviews

Digital Filters—R. W. Hamming (Englewood Cliffs, NJ: Prentice-Hall, 1977, 226 pp.). *Reviewed by C. K. Yuen, University of Tasmania, GPO Box 252c, Hobart, Tasmania, Australia, 7001.*

For some years Richard Hamming has urged numerical mathematicians to pay more attention to the "frequency approach" for analyzing numerical algorithms. Besides numerous lectures, seminars, and conference papers, he formally presented a substantial amount of material on the topic in the second edition of his popular text, *Numerical Methods for Scientists and Engineers*, (McGraw-Hill, 1973) as "Fourier approximation—Modern theory." It seems, however, that his general approach was a little too modern for the audience. Scientists and engineers need no persuasion as to the importance of the frequency approach, but found Hamming's material a little far removed from their immediate interests. On the opposite side, numerical analysts conceded that Hamming had something for the engineers, but it really was not numerical analysis. However, Hamming is not a man to be easily discouraged.

The present book is based on the approach he used in the previous text. The material, however, has been considerably extended and updated, and its intended audience broadened. If I may presume to give it a subtitle, it would be something like "Digital filters for everyone" or "Digital filters, the nonengineering approach." For, in contrast to the usual engineering text treatment, starting with Fourier integrals and z-transforms, this book begins with digital filters directly, by demonstrating the effect produced on the amplitude of a sinusoidal function by the process of discrete convolution. Consequently, those readers who do not have a background in engineering mathematics will find the book much more comprehensible. At the same time, my engineering colleagues have remarked that they found the book "alien"—once they got used to the more difficult approach, the simple and direct method no longer appealed!

The book has 13 chapters. These may be informally grouped into four sections: a general introduction, with particular attention on the relevance to numerical analysis; nonrecursive filters; more advanced nonrecursive filters; and recursive filters. The mathematical background needed, mainly Fourier analysis in various shapes and forms, is dispersed throughout the book as the leading chapters of each part. As the author freely admits, this causes some repetition, which he defends, quite reasonably, on pedagogical grounds. Overall, the presentation is interesting and refreshing, as Hamming's books usually are. I enjoyed reading it, though I now find Hamming's practice of inserting brief comments on various subsidiary topics a little distracting, which is a reflection, perhaps, on myself as a jaded book reviewer.

The book confirms the reviewer's view of the frequency approach: it is a very good way of introducing digital filtering to nonengineers, but it goes only so far. As the book moves towards more advanced topics, more and more engineering mathematics begins to creep in, e.g., z-transforms had to be accommodated in order to teach recursive filters synthesis in Chapter 11. Even Hamming cannot make the subject easier to understand for nonengineers!

I must end this review with a criticism: given the author's stature, I find him too ready to adopt clever little tricks of somewhat uncertain value. On pp. 114–117, he recommends the use of the formula

$$H_{out} = H_{in}^2(3I - 2H_{in})$$

to "sharpen" the filter. Now the easiest way to implement this would be to filter x twice to produce y, and once more to produce z, and finally compute $3y - 2z$. Yet he recommended a more complex procedure involving four steps. Further, if one actually computes the filter coefficients for H_{out} from the H_{in} on p. 117, one finds that it contains 19 terms with two negative sidelobes whose height is about 8 percent of that of the main lobe. In other words, the filter sounds good if we look at it in the frequency domain alone, but looks more doubtful if its time-domain structure is taken into account. On pp. 178–179, he recommended the use of tapering windows in spectrum estimation whereas, as I have shown elsewhere, e.g. [1], quadratic windows perform better. Despite the above criticism, this is a valuable textbook on digital filtering. As a nonengineering introduction to digital filtering, it is unsurpassed.

References

[1] C. K. Yuen, "Quadratic windowing in the segment averaging method for power spectrum computation," *Technometrics*, vol. 20, pp. 195–200, 1978.

Qualitative Analysis of Large Scale Dynamical Systems—A. N. Michel and R. K. Miller (New York: Academic, 1977, 289 pp.). *Reviewed by M. Vidyasagar, Department of Electrical Engineering, Concordia University, Montreal, PQ, Canada H3G 1M8.*

The study of large-scale dynamical systems is currently one of the "hot" areas of system theory. In the stability analysis of such systems, a popular approach has been to view the large system at hand as an interconnection of several smaller (and presumably simpler) subsystems. One then proceeds to obtain stability conditions for the *overall* (large) system involving only the properties of the (smaller) subsystems and the interconnections. In this way, one avoids tackling the large system as a single entity.

This book presents a unified approach to the qualitative analysis of large-scale dynamical systems, using the above-mentioned philosophy. In the process, the authors amply demonstrate the universality and versatility of the approach they have chosen. This arises in two ways. First, the authors tackle several types of dynamical systems, which they describe through various classes of equations. Second, they analyze various qualitative properties of a system, including several forms of stability, boundedness, and well-posedness.

The contents of the book are as follows. Chapter II is concerned with (systems described by) ordinary differential equations. Chapter III deals with ordinary difference equations, Chapter IV deals with stochastic differential equations, and Chapter V deals with differential equations on a Banach or Hilbert space. Chapters VI and VII are devoted to input–output properties. Chapter VI contains rather general results, while Chapter VIII is concerned with integro-differential equations. Because of the wide variety of systems encompassed by these models, the authors' results are applicable to continuous-time systems, sampled-data systems, stochastic systems, systems described by partial differential equations or hybrid (mixed) equations, and operator equations. To demonstrate this variety, the authors have included several examples from control theory, circuit theory, nuclear reactor dynamics, and economics.

Considering its advanced nature not much formal background is needed to read this book. The authors have included most of the requisite background material, such as the principal tools of Lyapunov and input–output stability, semigroup theory, and M-matrices. Conceivably, a reader without any prior knowledge of "small-scale" theory could directly start reading (and benefit from) this book. However, it is believed that a reader well-versed in "small-scale" theory would best appreciate the power of the results and the subtlety of the arguments contained in this book.

The style of writing throughout is very systematic and logical. The authors have carefully avoided any repetitious details in Chapters II to V. In Chapter II, they present, in great detail, the general pattern of the arguments to follow; in subsequent chapters, they emphasize the differences rather than the similarities from this general pattern. This makes for an efficient style and a high density of information. In summary this is a well-written book on an important subject that would be a useful addition to the library of any system theorist.