In order to develop a fast algorithm for efficient computation of the DFT, the fast Fourier transform (FFT) algorithm is developed in Chapter 4. This chapter includes some interesting numerical examples and applications on digital signal processing.

Chapter 5 deals with a class of nonsinusoidal orthogonal functions consisting of the Rademacher, Haar, and Walsh functions. The notion of sequency as a generalized frequency is introduced, and the frequency is used as a parameter to distinguish individual functions that belong to sets of nonsinusoidal functions.

The sixth chapter is devoted to the study of the Walsh–Hadamard transform (WHT) and algorithms to compute it. The concept of the Walsh spectra and their properties are presented with physical significance. Special attention is given to the analogy between the Walsh–Hadamard and the discrete Fourier transforms.

In Chapter 7, a study is made of the generalized Haar, Slant, and discrete cosine transforms. Fast algorithms to compute these transforms are developed.

The last three chapters are primarily concerned with applications of orthogonal transforms to the generalized Wiener filtering, data compression, and feature selection in pattern recognition. It is shown that orthogonal transforms can be used to generalize Wiener filtering to digital signal processing with an emphasis on reduction of computational requirements. Applications of data compression in the areas of image processing and electrocardiographic data processing are discussed. Two pattern recognition experiments are included in the final chapter.

All chapters are provided with problems for solution and a set of references to the original papers and books. The authors have produced an excellent textbook on a subject that is receiving increasing attention in all areas of signal processing and can be strongly recommended to electrical and computer engineering students.

Walsh Functions and Their Applications—K. G. Beauchamp (New York: Academic, 1975, 236 pp.). *Reviewed by Lokenath Debnath, Departments of Mathematics and Physics, East Carolina University, Greenville, NC 27834.*

The Walsh functions were invented by the American mathematician J. L. Walsh in 1923. These functions are defined on the interval $0 \leq x \leq 1$ and assume only the values $+1$ and -1. They have many properties similar to those of the Haar functions and trigonometric series, and form a complete orthogonal system. These functions are now most widely used in communication engineering and other applied sciences.

With some reader background in the Fast Fourier transforms, this book gives a self-contained systematic treatment of the theory and applications of the Walsh, Haar, and related transforms.

The book begins with a chapter on orthogonal functions and their simple properties. The next three chapters deal with the Walsh function series, Walsh transformation, and the Haar functions. These functions are compared with the sine–cosine functions used in Fourier analysis. These chapters also cover the properties of the discrete transforms and the derivation of past transform algorithms with programs for implementation on the digital computers.

Chapters 5 and 6 are concerned with the details of the Walsh spectral analysis, sequency filtering, correlation, and convolution. With respect to the operation of correlation and convolution, there is a striking difference between the Walsh transform theory and the Fourier analysis. This effects the way in which filtering of discrete sampled data is carried out and discussed with reference to the classical process of filtering originally due to Wiener. In fact, these chapters are devoted to the general principles of sequency analysis and filtering that form the basis of many applications of the Walsh theory of functions.

The last two chapters describe applications of Walsh transforms to various problems in communications, image processing and pattern recognition, electromagnetic radiation, radar systems, speech processing, and medical signal processing.

The first appendix on Fortran 4 subroutines for the fast Walsh, fast Haar, and other transforms and the second on Tables for Modulo -2 addition $R \oplus S$ are added at the end of the book. A set of important references to the original papers and books is included at the end of each chapter. However, [1]–[3] escaped the notice of the author.

In summary, this book is well written and successful and certainly represents a welcome addition to the literature. Despite the lack of problems and exercises, it can be used as an excellent text on the subject. However, the book would become more useful for the students if problems and exercises had been included. It should also occupy a place on the shelves of applied mathematicians, computer scientists and engineers as a useful reference book.

References

[1] Balashov and Rubinshtein, "Series with respect to Walsh system and their generalization," *J. Soviet. Math.*, vol. 1, pp. 727–763, 1973.
[2] N. J. Fine, *Encyclopaedic Dictionary of Physics*, Supplement, vol. 4. New York: Pergamon, 1971.
[3] ——, *Proc. Symposium on Applications of Walsh Functions*, 1970–1973.

Digital Filters—Richard W. Hamming (Englewood Cliffs, NJ: Prentice-Hall, 1977, 226 pp.). *Reviewed by Samuel D. Stearns, Sandia Laboratories, Albuquerque, NM 87115.*

In writing this textbook on digital filters, Richard Hamming has been able to draw on his own rich and varied background in numerical analysis, computing, statistics, and applied mathematics. Probably no living author can claim to so much experience and so many fundamental contributions in the disciplines that are basic to modern digital signal processing. Hamming's ability to draw from this experience and to illustrate clearly the fundamental ideas of digital filtering makes this an unusually good text for one new to the subject. Using this text, the reader can build a solid foundation in the theory as well as an appreciation for some of the applications.

Most texts on digital signal processing are meant especially for electrical engineers, but this one is not. The author has purposely tried to steer clear of engineering jargon and to introduce the necessary engineering fundamentals such as the frequency domain, the transfer function, the Fourier series and integral, etc. One of Hamming's reasons for doing this is to make the subject matter available to those in nonengineering disciplines such as statistics, numerical analysis, physics, economics, etc.

The first five chapters of *Digital Filters* are devoted to introductory material. The frequency approach is introduced, and the sine and cosine functions are presented as the eigenfunctions to be used with linear digital systems. The Fourier series is introduced and discussed in detail, with emphasis on the different forms of the series, convergence, etc. There is also some introductory discussion on convolution, Gibbs phenomenon, and data windows.

Chapters 6 and 7 are on nonrecursive filter design. Simple and practical design methods, including the design of filters with ripple-free gain characteristics, are presented. At the end of Chapter 6, there is some interesting new material on sharpening the response of a filter by making multiple passes through the same filter. Chapter 8 returns to a discussion of the properties of signals and covers mainly the sampling theorem and the Fourier integral, and Chapter 9 returns again to a discussion of windows for nonrecursive filters, with emphasis on the Kaiser window. Chapter 10 is on the discrete Fourier transform, with a section on the FFT. The remaining three chapters are on recursive digital filter design (Butterworth, Chebyshev, and Elliptic) plus some practical details, including finite word-length effects.

The book is not primarily for advanced readers; it sticks mainly to fundamentals and omits some of the material on optimum filter designs, spectral analysis methods, etc., found in other modern texts. There is a relatively small number of practical exercises. But the beginning reader and the student in digital signal processing will appreciate Hamming's ability to select and order the fundamentals and his ability to present the basic ideas of digital filtering in a style that is easy and pleasant to follow.