Book Reviews

The following review was selected from those recently published in various IEEE journals, magazines, and newsletters. They are reprinted here to make them conveniently available to the many readers who otherwise might not have access to them. Each review is followed by an identification of its source.

A Friendly Guide to Wavelets—G. Kaiser (New York: Birkhäuser, 1994). *Reviewed by William Kilmer*

I wholeheartedly recommend this book for a solid and friendly introduction to wavelets, for anyone who is comfortable with the mathematics required of undergraduate electrical engineers. I shall review the book's two parts separately.

I. Basic Wavelet Analysis

I have used Part I (200 pages) of Kaiser's book as my text, for large parts of three graduate/undergraduate electrical engineering courses on wavelets and signal theory, at the University of Massachusetts, Amherst. The book's appeal is that it covers all of the fundamental concepts of wavelets in an elegant, straightforward way. It contains simple proofs of important intermediate results (e.g., Proposition 7.8 on orthogonalization of bases), which are needed for quick access to special topics such as spline wavelets (which the book does not cover). It offers truly enjoyable (friendly!) mathematical exposition that is rich in intuitive explanations, as well as clean, direct, and clear in its theoretical developments. And there aren't many typos.

Several of my students found that a good self-study short course for engineers who want to understand the basics of wavelets consists of Chapter 2 (windowed Fourier transforms), 3 (continuous wavelet transforms), 7 (multi-resolution analysis), and 8 (Daubechies' orthonormal wavelet bases). In a short lecture course on wavelets, I supplemented these chapters with material on spline and biorthogonal-spline wavelets, to equip my students for knowledgeable use of some special MATLAB Wavelets Toolbox families. I also supplied a number of frequency-spectrum and wavelet plots for my more graphics-minded engineers. For spline and biorthogonal-spline wavelet material, I relied on the competing books, *Wavelets and Subband Coding*, by Vetterli and Kovacevic, and *Ten Lectures on Wavelets*, by Daubechies. For use as a text in a wavelets course, however, the first of these books is too specialized to filter banks; and the second, though a prize winner for mathematical exposition, is too difficult for most engineers. For problems, I found Kaiser's straightforward end-of-chapter exercises excellent for consolidating the textual material, and he promises that his Web page, at www.wavelets.com, will soon contain extra problems and examples.

In addition to Kaiser's Chapters 2, 3, 7 and 8 (noted above), a full course on wavelets should include his Chapters 1 (mathematical background), 4 (generalized frames: a key to analysis and synthesis), 5 (discrete time-frequency analysis and sampling), and 6 (time-scale analysis of wavelets on discrete time-scale grids). Chapters 4-6 might seem of less-urgent interest to some practicing engineers than material supporting use of various software packages. However, the further one gets into the wavelet literature, the more one realizes how necessary a solid conceptual knowledge of frames and associated grids is to understanding the increasingly wide variety of applications. Kaiser's treatment of these subjects is masterful. If the reading seems a bit abstract for engineers in Chapter 4, they can make it concrete by doing all of Exercise 4.1, which guides them to an expression of the ideas in Chapters 1 through 4 in terms of two- and three-dimensional vectors.

The short section in Chapter 7 on wavelet packets is a gem. It beautifully packages some important practical relationships that are often handled in ways that are cumbersome by comparison.

II. Physical Wavelets

Part II (87 pages) contains somewhat more advanced results on wavelet electromagnetics, and on applications to acoustics, and to radar and scattering. It concerns physical wavelets, which are functions of space-time constrained by differential equations. These equations are Maxwell's equations in Chapters 9 and 10, and acoustic equations in Chapter 11. The wavelets in Chapter 9 are electromagnetic pulses, parameterized by their point and time of emission or absorption, their duration, and the velocity of the emitter or absorber. The duration acts as a scale parameter. Kaiser shows that every electromagnetic wave can be composed from such wavelets. In Chapter 10, he applies the conformal group concept of Chapter 9, in which all of the group operations have a direct physical interpretation, to radar and scattering. This enables him to give a powerful new formulation of electromagnetic imaging with radar. This work is now continuing, with timely applications to laser-beam propagation through turbulent media, such as the atmosphere.

The book's results on acoustic waves, in Chapter 11, give a one-to-one correspondence between physical wavelets and a family of time wavelets. The relatedness of the acoustic and electromagnetic material in Part II can be seen from Kaiser's article in the February, 1996, issue of IEEE Antennas and Propagation Magazine, where generalized radar and sonar ambiguity functions are applied to wideband (short-pulse) and narrowband signals, targets, and radar platforms executing arbitrary, nonlinear motions.

In summary, Kaiser has written an excellent introduction to the fundamental concepts of wavelets. For a book of its length and purpose, I think it should be essentially unbeatable for a long time.

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