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Book review:

WAVELET THEORY AND HARMONIC ANALYSIS
IN APPLIED SCIENCES
by

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Editors

The book originated from the First Latinamerican Conference on Mathematics in Industry and Medicine, held in Buenos-Aires in 1995. The editors have invited authors of selected papers dealing with wavelet and harmonic analysis, as well as their applications in biomedicine and physics, to extend their presentations in order to create chapters of the book. Since the authors are experts specializing in different scientific fields, the contents of the book is quite varied and so it is primarily suitable for scientists already familiar with theoretical foundations of wavelet methodology.

Let us recall that wavelet analysis is a particular time- or space-scale representation of signals with a wide range of applications in physics, signal processing and applied mathematics. Its success is due to the fact that most of real life signals are nonstationary and they often cover a wide range of frequencies, usually strongly correlated with the thne duration of segments of their appearence. The standard Fourier analysis becomes inadequate for treating such signals while both continuous and discrete wavelet transforms prove their great flexibility and efficiency. It is worth emphasizing, however that continuous and discrete wavelets have almost opposite properties resulting in quite different ranges of applications (see e.g. Meyer, 1991; Vetterli, Kovacevic, 1995; Strang, Nguyen, 1996). The former are very efficient at detecting specific features in signals or images while the latter are extremely fast and economical in data compression.

The book contains both theoretical and applied results from the field. Each of its three parts may find readers interested in recent results presented by experienced theoreticians or practitioners.

Thus, Part I devoted to theoretical results consists of six chapters. The first one deals with estimates of singular integral operators using the relatively heavy machinery of Hardy-Littlewood maximal functions on sections. The second chapter presents relationships between the spaces of real functions for which the mean oscillation over cubes is bounded and the wavelet coefficients in terms of Carleson type conditions. The authors treat readers gently enabling them to track the line of reasoning. In the third chapter the authors propose to implement the semidiscrete wavelet transforms associated with orthogonal spline

wavelets. They analyze given signals in the context of an extended multiresolution analysis structure and use the so called undecimated discrete wavelet transforms to organize the available numerical information. The chapter is indeed reader friendly and may be studied both by theoreticians and application oriented readers. The fourth chapter introduces the concept of oblique wavelets and multiwavelets which are neither orthogonal nor semiorthogonal nor biorthogonal as it is usually assumed in the wavelet analysis. In spite of some disadvantages resulting from the nonzero average of oblique wavelets they are found to be very useful in perfect reconstruction filter banks. Chapter 5 is a survey of Riesz bases and lattices and, in my opinion, could be regarded as a good theoretical introduction to the advanced wavelet theory and its application in the analysis of signal regularity. In Chapter 6 the authors propose the wavelet Galerkin method as a powerful tool of analysis of partial differential equations. A model problem is chosen in the form of the Korteweg de Vries equation and its linearized version.

Part II of the book deals with biomedical applications of wavelet transforms. Two chapters (9 and 10) are devoted to epileptic EEG analysis while two others (Chapters 7 and 8) are more or less related to ECG signals processing. Application of continuous wavelet transforms to the ECG signal presented in Chapter 7 covers two problems: detection of ventricular late potentials both after and before the QRS complex, and classification cases including results of the drugs action on heart activity. The second chapter dealing with cardiac signals is not related to wavelet methodology. The authors consider indepedently time domain methods (SDNN index, Poincare map) and frequency domain methods (ARMA models, FFT, Blackman - Tuckey method) in order to analyze the variability of cardiorespiratory signals. In the chapters devoted to processing of EEG signals the authors present their results dealing with application of Gabor filters and chaos theory (estimation of Lyapunov largest exponent) to clinical data (Chapter 9) as well as wavelet methodology (multiresolution analysis based on the energy functions and entropy - Chapter 10). All these methods could contribute to the identification of the source of epileptic activity and its propagation in the brain.

The last part of the book brings some applications of wavelet theory in physical sciences. In Chapter 11 the authors propose to use neural networks with wavelets as activation functions (as in Zhang, Benveniste, 1992) to model nonlinear processes including identification of chaotic attractors. Chapter 12 is devoted to modeling asymptotic behaviors of electrostatic potential in electronic semiconducting device combining a semiconductive region and an oxide region with a common interface. The approximation used by the author of this chapter is based on modified Fourier analysis. Chapter 13 deals with an estimation problem arising from the study of wave propagation in solids. The type of model employed by the authors is based on viscoelastic model deriving stress-strain relations in the space-frequency domain using the Boltzmann equation for a continuous superposition of standard linear solids. The method is followed by

the numerical algorithm and results of numerical experiments. The last chapter presents results of numerical modelling of Maxwell's equations. The algorithm is based on interactive hybrid finite element decomposition procedure and is used to model the earth's electric conductivity distribution basing on measurements of natural electric and magnetic fields on the earth surface. The number of applications presented in this part of book is rather small and such areas as sound and acoustic, spectroscopy, shape and motion analysis (see e.g. Meyer, 1991; Meyer, Roques, 1993; Combes, Grossmann, Tchamitchian, 1989) which have become virtually the classical fields of wavelet applications are completely absent.

This very brief review shows the variety of subjects covered by the contents of the book, quite typical for conference-based volumes. Despite this inherent variety I consider the book a valuable contribution and I expect that its particular parts can find quite numerous customers. The book contains no elementary introduction to the domain. Nevertheless, one may easily find many papers and books which could introduce a potential reader to wavelet theory and methodology. My advice is to start with the introductory papers by Rioul, Vetterli (1991) and Heil, Walnut (1989) or proceedings, like Reginska, Swierniak (1996), followed by popular books - Hubbard (1996) or Meyer (1993). More advanced material can be found e.g. in Daubechie (1992), Chui (1992) or Kaiser (1994). The study of special issues of IEEE journals - *IEEE Trans. Infor. Theory* (1992) and *Proceedings IEEE* (1996) may be considered as the next step to the world of wavelets. The reviewed book may play the same role. It may also serve as a good source of references in the particular discussed subjects.

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