Preface

This book is an update of the book "Wavelet Theory and its Application to Pattern Recognition" which was published in 2000. Three new chapters are added to this new book. The objective is to attack a challenging research topic that is related to both areas of wavelet theory and pattern recognition.

Wavelet analysis and its applications have become one of the fastest growing research areas in recent years. This is in part attributed to the pioneering work by the researchers as well as practitioners in the fields of mathematics and signal processing. Wavelet theory has been employed in many fields and applications, such as signal and image processing, communication systems, biomedical imaging, radar, air acoustics, theoretical mathematics, control system, and endless other areas. However, the research on applying the wavelets to pattern recognition is still too weak; only a few publications deal with this topic at the present. This book focuses on this challenging research topic.

The most fascinating area of signal/image processing with practical applications is pattern recognition. Making computers see and recognize objects like humans has captured the attention of many scientists in different disciplines. Indeed, machine recognition of different patterns such as printed and handwritten characters, fingerprints, biomedical images, etc. has been intensively and extensively researched by scientists in different countries around the world. The area of pattern recognition, after over five decades of continued development, is now definitely playing a very major role in advanced automation in the 21st century. Although a lot of achievements have been made in the area of pattern recognition, many problems

still have to be solved. The goal of this book is to, through mathematically sound derivations and experiments, develop some new application-oriented techniques in wavelet theory, and thereafter, apply these new techniques to solve some particular problems in the area of pattern recognition.

This book is organized into two groups, namely, Chapters 1 - 4 extend wavelet theory, while Chapter 5 through Chapter 12 deal with the application of the wavelet theory to pattern recognition, which is the core of this book. Considering the major readers of this book are scientists and engineers, thus, in some chapters/sections, we give up the exactness in mathematics temporarily.

Initially, in Chapter 1, a brief description of wavelet theory is introduced, and a comparison between the wavelet and Fourier transforms is discussed along with several pictorial examples. This chapter reviews established applications of the wavelet theory to pattern recognition. The review is not detailed, since this book concentrates on the novel research results developed by the author. However, the references are cited if additional details are desired.

Throughout Chapters 2 and 3, both the wavelet transform and wavelet bases are of critical concerns, which formulate the basic wavelet theory. In Chapter 2, the general theory of the continuous wavelet transform is addressed, and its major properties are investigated including the characterization of Lipschitz regularity of signals by the wavelet transform. Chapter 2 also primarily examines an important property by relating the processing to matched filtering concepts. Chapter 3 considers multiresolution analysis (MRA) and wavelet bases, where the basic concepts of the both are presented as well as the construction of them. As an important algorithm for implementing the discrete wavelet transform, Mallat algorithm is introduced.

After studying these basic concepts of the wavelet theory, some typical wavelet bases including the orthonormal and nonorthonormal bases are provided in Chapter 4. They benefit the application of the wavelet theory to the engineering, such as pattern recognition, image processing, etc.

By formulating the above wavelet theory and the general applications with wavelet theory, the second group of this book (Chapters 5 - 12) demonstrates more detailed applications, which become the core chapters. All of these applications were made by our research group.

Chapter 5 develops a method to identify different structures of the edges and design an algorithm to detect the step-structure edges. This technique

can be employed to contour extraction in document processing as well as 2-D object recognition.

Chapter 6 aims at studying the characterization of Dirac-structure edges with wavelet transform, and selecting the suitable wavelet functions to detect the Dirac edges. A mapping technique is applied in this chapter to construct such a wavelet function. In this way, a low-pass function is mapped onto a wavelet function by a derivation operation. In this chapter, the quadratic spline wavelet is utilized to characterize the Dirac-structure edges and an algorithm to extract the Dirac-structure edges by wavelet transform is also developed.

Chapter 7 introduces a new wavelet function called Tang-Yang wavelet, which is constructed by our research group. The characteristics of the Tang-Yang wavelet with curves are discussed. They are grey-level invariant, slope invariant and width invariant. The application of new wavelet function to curve analysis is presented.

In Chapter 8, skeletonization of Ribbon-like shapes based on the Tang-Yang wavelet function is presented. Characterization of the Ribbon-like shape with wavelet transform using the Tang-Yang wavelet is investigated. Some useful algorithms are also provided.

Chapter 9 presents an approach to feature extraction. In this way, the wavelet decomposition is used to produce wavelet sub-patterns, and thereafter, the fractal divider dimensions are utilized to find the numerical features from these sub-patterns.

Chapter 10 applies 2-D multiresolution analysis (MRA) and Mallat algorithm to form document analysis. The HL and LH sub-images are utilized to find the reference lines in a form document, furthermore, the useful information can be extracted in accordance with these reference lines. This application is verified by several concrete examples of bank checks.

Chapter 11 uses B-spline wavelet for Chinese computing, which consists of three operations, namely, (1) compression of Chinese characters, (2) enlargement of type size with arbitrary scales, and (3) generation of type styles of Chinese fonts.

Finally, Chapter 12 deals with the classification of patterns with wavelet theory, where the orthogonal wavelet series are used for the probability density estimation in the classifier design.

The main components of this book are the achievements in our research group with visiting research scholars. The professors from various universities and the graduate students at Hong Kong Baptist University have

made contributions to this book. Actually, they are co-authors of this book: Professors Jiming Liu and P. C. Yuen at Hong Kong Baptist University, Professor Seong-Whan Lee at Korea University of Korea, Professor Lihua Yan at Zhongshan (Sun Yat-Sen) University of China, Professor Ching Y. Suen at Concordia University of Canada, Professor Xinge You at Huazhong University of Science and Technology of China, Professor Z. K. Chen at Chongqing University of China, Professors Hong Ma and Bing-Fa Li at Sichuan University of China, Professor Feng Yang at the South Medical University of China.

To review the established applications of the wavelet theory to pattern recognition, in Chapter 1, some materials including figures from the published papers are quoted. I would like to thank the following authors to release the copyrights to this book: S. H. Yoon, J. H. Kim, W. E. Alexander, S. M. Park and K. H. Sohn [Yoon et al., 1998], F. Murtagh and J.-L. Starck [Murtagh and Starck, 1998], K. H. Liang, F. Chang, T. M. Tan and W. L. Hwang [Liang et al., 1999].

A specific international journal called "International Journal on Wavelets, Multiresolution, and Information Processing (IJWMIP)" was founded by myself in 2003. In Chapter 1, the following papers from IJWMIP are quoted. I would like to record my appreciation to the authors for their contributions to this book: J. Daugman [Daugman, 2003], L. H. Yang, T. D. Bui and C. Y. Suen [Yang et al., 2003b], A. Z. Kouzani and S. H. Ong [Kouzani and Ong, 2003], S. Kumar, D. K. Kumar, A. Sharma and N. McLachlan [Kumar et al., 2003], S. Kumar and D. K. Kumar [Kumar and Kumar, 2005], A. Sharnia, D. K. Kumar and S. Kumar [Sharnia et al., 2004], R. S. Kunte and R. D. S. Samuel [Kunte and Samuel, 2007], K. Muneeswaran, L. Ganesan, S. Arumugam and P. Harinarayan [Muneeswaran et al., 2005], R. Ksantini, D. Ziou, F. Dubeau and P. Harinarayan [Ksantini et al., 2006], S. E. El-Khamy, M. M. Hadhoud, M. I. Dessouky, B. M. Salam and F. E. A. El-Samie [El-Khamy et al., 2006].

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