Guest Editorial
Special Issue on Multirate Systems, Filter Banks, Wavelets, and Applications

THE LAST decade has seen a tremendous amount of activity and emergence of applications in the areas of filter banks and wavelets. These topics are of such wide interest that there have been papers in many different journals, conferences, and workshops in diverse disciplines. However, many aspects of the theory, design, and application of filter banks and wavelets are of great interest to the circuits and systems community as well. Our editorial team felt that this was a perfect time to put together a special issue with state-of-the-art papers on these popular topics. All of the papers have been peer-reviewed according to the usual practice of this TRANSACTIONS. Almost in parallel, there is also a similar special issue (April 1998) by the IEEE TRANSACTIONS ON SIGNAL PROCESSING, with a slightly greater emphasis on applications. Many well-known authors have contributed articles to these special issues and we expect these to serve as valuable references for a long time to come.

In this Special Issue, we have 11 regular papers and 19 transactions briefs, covering a wide range of theory and applications. The paper by Chen, Liu, and Bai considers multirate systems in very general building blocks, with natural application in nonuniform filter bank design. The work by Unser and Zerubia deals with sampling theorems for signals that are not band-limited, clearly showing the connection to filter bank theory. Cotronei, Montefusco, and Puccio present the recent theory of multiwavelets using recursive matrices and a simpler notation emphasizing the importance of choice of the prefilter, and show application in compression. The next paper, by Wei and Bovik, considers the effect of vanishing moments on the phase linearity near zero-frequency, and also the effect of distributing the moments, showing how to construct nearly symmetric coiflets with performance comparable to some biorthogonal splines.

The paper by Hsu and Rao, which is an application in High Definition Television (HDTV) coding, shows how to use wavelets and lapped transforms for motion compensation. The application to image coding is also considered in the paper by Kim, Hu, and Nguyen, where the authors consider entropy constrained vector quantizers for the wavelet coefficients. The work by Kim, Lee, Isshiki, and Kunieda focuses on hardware considerations, emphasizing VLSI implementation of one–dimensional wavelet transforms using scalable, possibly pipelined, architectures.

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Gosse, Karp, de Saint-Martin, Duhamel, and Mertins consider the optimal design of filters in filter banks for minimum reconstruction error by taking into account rate distortion considerations as well as decoder complexity. The application of subband coders in speech enhancement using Kalman filtering in the subbands is considered in the paper by Wu and Chen.

Oversampled cosine-modulated filter banks offer extra freedom over maximally decimated ones, and this idea is thoroughly explored in the paper by Bolcskei and Hlawatsch. The paper by Vaidyanathan and Kirac reviews the state-of-the-art on the theory of optimal orthonormal subband coders, and then presents a theory for optimum biorthogonal subband coders.

Wavelets have been used in the past for detection and characterization of sharp signal variations. The paper by Bruce briefly reviews some of the key issues and presents new results. Edge detection is also the topic of the next paper by Sze, Liao, Hung, Fan, and Hsieh, where the detection is based on normal-changes rather than the conventional depth- and curvature-changes. Aiazzi, Alparone, Baronti, and Borri consider in their paper the design of adaptive filters for both additive and multiplicative types of noise interference, based on a pyramid and multiresolution approach. The next paper, by Hsu and Wu, shows the application of multiresolution techniques in watermarking, which is a means of hiding secret messages into images. The paper by Ching and Wu develops approximate sampling theorems which are useful for wavelet analysis of time-limited signals. In the paper by Hardin and Roach, multiwavelet orthogonal prefilters with certain approximation properties are considered.

Image compression using efficient multiplierless implementations of the wavelet transform is the topic of the paper by Kim and Li. In the paper by Starck, Murtagh, and Gastaud, new entropy measures are proposed based on the use of wavelet analysis. The use of wavelet transform in the conversion of Japanese text to speech is studied in the work by Kobayashi, Sakamoto, Saito, Hashimoto, Nishimura, and Suzuki. Tang, Li, Ma, and Liu show the application of wavelets in optical character recognition. The use of wavelet and multiresolution concepts in the reconstruction of signals from partial Fourier domain information is considered in the next paper by Rabadi and Myler.

Kim, Lee, Kang, and Ko propose the region-based wavelet transform as an approach to the compression of arbitrary-

shaped images. A new technique for the design of two channel linear phase quadrature mirror filter (QMF) banks is proposed by Goh and Lim, whereby considerable efficiency is obtained by switching and reordering of blocks used in the polyphase form. Next, Lu, Antoniou, and Xu consider the direct quadratic design of two-dimensional diamond shaped filter banks. A typical problem in subband adaptive filtering techniques is the crosstalk and consequent convergence problems, created by imperfect alias cancellation. The paper by Higa, Ochi, and Kinjo addresses this difficulty and shows how the analysis filters can be chosen to significantly alleviate this problem. The design of small-side-lobe filter banks in multitone data communications is addressed in the paper by Martin. The paper by Zhu, Ahmad, and Swamy proposes a new approach for designing near-perfect QMF banks, with the novelty that FIR and IIR filters are combined in an effective way. The reconstruction of signals from nonuniform samples is of interest in many applications. In the paper by Ford and Etter, a novel technique for such reconstruction with a wavelet basis is proposed. The joint optimization of space and frequency segmentation for image coding is considered in the paper by Nuri.

It is our hope that this Special Issue will provide a state of the art view of the field, while opening up further research and applications. We also take this opportunity to thank the many reviewers who contributed in a timely manner to make this issue possible.

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Prof. Nguyen was a recipient of a fellowship from Aerojet Dynamics for advanced studies. He received the IEEE TRANSACTIONS IN SIGNAL PROCESSING Paper Award (image and multidimensional Processing area) for the paper he co-authored with Prof. P. P. Vaidyanathan on linear-phase perfect-reconstruction filter banks in 1992, and received the NSF (National Science Foundation) Career Award in 1995. He is currently an Associate Editor for the IEEE TRANSACTIONS IN SIGNAL PROCESSING and for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS II, and has also served on the *DSP Technical Committee* for the CAS Society. He is a member of Tau Beta Pi and Eta Kappa Nu.

P. P. Vaidyanathan (S'80–M'83–SM'88–F'91) was born in Calcutta, India, on October 16, 1954. He received the B.Sc. (Hons.) degree in physics and the B.Tech. and M.Tech. degrees in radiophysics and electronics, all from the University of Calcutta, India, in 1974, 1977, and 1979, respectively, and the Ph.D degree in electrical and computer engineering from the University of California at Santa Barbara in 1982.

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Dr. Vaidyanathan served as Vice-Chairman of the Technical Program Committee for the 1983 IEEE International Symposium on Circuits and Systems, and as the Technical Program Chairman for the 1992 IEEE International Symposium on Circuits and Systems. He was an Associate Editor for the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS for the period 1985–1987, and is currently an Associate Editor for the journal IEEE SIGNAL PROCESSING LETTERS and a Consulting Editor for the journal *Applied and Computational Harmonic Analysis.* He has been a Guest Editor in 1998 for special issues of the IEEE TRANSACTIONS ON SIGNAL PROCESSING and the IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS II, on the topics of filter banks, wavelets, and subband coders. He has authored a number of papers in IEEE journals, and is the author of the book *Multirate Systems and Filter Banks* (Englewood Cliffs, NJ: Prentice Hall). He has written several chapters for various signal processing handbooks. He was a recipient of the Award for Excellence in teaching at the California Institute of Technology for the years 1983–1984, 1992–1993, and 1993–1994. He also received the NSF's Presidential Young Investigator Award in 1986. In 1989, he received the IEEE ASSP Senior Award for his paper on multirate perfect-reconstruction filter banks. In 1990, he was a recipient of the S. K. Mitra Memorial Award from the Institute of Electronics and Telecommunications Engineers, India, for his joint paper in the IETE journal. He was also the coauthor of a paper on linear-phase perfect reconstruction filter banks in the IEEE TRANSACTIONS ON SIGNAL PROCESSING, for which the first author (Truong Nguyen) received the Young Outstanding Author award in 1993. He was elected a Fellow of the IEEE in 1991. He received the 1995 F. E. Terman Award of the American Society for Engineering Education, sponsored by Hewlett Packard Company, for his contributions to engineering education, especially the book *Multirate Systems and Filter Banks*, and has been chosen a distinguished lecturer for the IEEE Signal Processing Society for the year 1996–1997.