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Editorial

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Nonlinear signal processing methods continue to grow in popularity and use. This growth is due to one factor—performance. While it is true that linear methods continue to dominate in practice, nonlinear methods are making steady progress in moving from theoretical explorations to practical implementations. Clearly, the advances in computing performance have accelerated this progress by making nonlinear methods more practical. Additionally, nonlinear theory continues to grow and is yielding a firm foundation upon which nonlinear methods can be developed, optimized, and analyzed. Nonlinear methods are thus being applied to address many of the most interesting and challenging signal processing problems.

The evolution in nonlinear methods is also demonstrated by the growth of the IEEE-EURASIP Nonlinear Signal and Image Processing (NSIP) workshop. This biennial workshop was most recently held in the Inner Harbor of Baltimore, Maryland, USA, on June 3–6, 2001. The workshop attracted nearly 200 participants from around the globe and outstanding contributions from authors working on a wide array of topics. The workshop papers were exceptional in both breadth and depth.

To make the results of the NSIP workshop more widely available, the EURASIP JASP has dedicated two issues to the topic of Nonlinear Signal Processing. These issues feature expanded versions of NSIP papers. This first issue features 11 papers covering topics that include adaptive filters, communications, and biomedical applications and that build upon the theories of morphology, higher order statistics, and fuzzy relations. Although a full appreciation for the contributions in each paper can only be obtained through a careful reading of the article, a brief summary of the respective contributions is given next.

The first two papers consider nonlinear filtering theory. In the contribution by Tareq Y. Al-Naffouri and Ali H. Sayed, a unified approach to the mean-square analysis of adaptive filters with arbitrary error nonlinearities in their update equations is presented. The method, based on a fundamental energy conservation relation that holds for a large class of adaptive filters, offers new stability and convergence results in addition to the general advantages of a unified approach. The second paper considers the generalization of nonlinear filters through the use of fuzzy relations. In their contribution, Kenneth Barner, Yao Nie, and Wei An utilize fuzzy ordering and fuzzy order statistics to include information on sample spread in median, weighted median, and RCRS filters. The results show that the more general fuzzy ordering leads to improved performance in image noise smoothing applications.

The next two papers continue the theme of image processing. The first of these papers utilizes morphological methods to address image filtering and segmentation. By using morphological residues and the concept of granulometry,

Neucimar J. Leite and Sílvio J. F. Guimarães combine filtering and segmentation within the same framework. The paper represents a good example of the power and flexibility of multiscale methods in image processing. In the subsequent paper, Mark Robertson and Robert Stevenson address the temporal resolution of compressed video sequences. The authors show that frames dropped from video sequences, to achieve a desired level of compression, can be estimated from the received frames to increase temporal resolution. By casting the problem in a Bayesian framework, the authors develop a resolution enhancement method that does not propagate spatial compression artifacts, such as blocking and ringing, to the reconstructed frames.

The next three papers consider problems in communications and system identification. The first of these papers, by Seong-Cheol Jang and Patrick Loughlin, investigates the projection filtering method in the AM-FM jammers in spread spectrum communications. Security in communications systems is of critical importance, and the authors extend previously developed methods to the AM-FM case. They also provide a theoretical analysis of the AM-FM projection approach. In the next paper, Mahmut Ciftci and Douglas B. Williams describe an optimal estimation algorithm for chaotic communication systems together with a sequential channel equalization algorithm. In a real scenario, the communication channels are usually affected by noise and intersymbol interference. Since chaotic modulation schemes are significantly different from conventional schemes, usual equalizers of channel distorsions cannot be applied and specific algorithms, such as those presented in this paper, are needed. In the final paper on this topic, Rıfat Hacioğlu and Geoffrey A. Williamson consider the general problem of system identification using the discrete Volterra series. Volterra modeling is attractive since it appears as the natural extension of the widely studied discrete time-invariant linear models. However, the huge number of parameters often associated with Volterra models limits their practical utility to low-order, short-memory models. Hacioğlu and Williamson describe a fixed pole expansion technique for the Volterra kernels that permits the reduction in the number of free parameters, while improving the approximation capabilities of previously proposed models.

The final four papers in the special issue address biological signal processing applications. The first of these papers, by Jason A. Fuemmeler, Russell C. Hardie, and William R. Gardner, addresses the problem of regenerating wideband speech from narrowband signals. This is an important problem in that speech signals often pass through low bandwidth channels, leading to poor quality reproduction. The authors show that through appropriate prediction portions of the spectrum lost in the low bandwidth coding can be appropriately reconstructed, resulting in improved wideband speech quality. In the following paper, the automatic detection of speech phonation dysfunction is considered. Jesus B. Alonso, José de Leon, Itziar Alonso, and Miguel A. Ferrer show that higher-order statistics can be effectively used to parameterize voice signals. Through the use of HOS methods, the authors demonstrate a 98.3% success rate in detecting dysfunction.

The final two papers address important issues in computational genomics. As these two papers show, current challenges in genomics have much in common with those in signal processing. While the two papers use different technologies for generating data (SAGE and cDNA microarrays), both study gene expression, albeit from different perspectives. Kuznetsov sets out to characterize the stochastic nature of gene expression in eukaryotic cells while Tabus and Astola consider the problem of gene expression prediction, employing the minimal description length principle. Both of these studies constitute important steps toward understanding the nature of genomic control.

The wide array of theories, methods, and problems addressed in these papers demonstrates the wide applicability of nonlinear methods. Next month in the second special issue on Nonlinear Signal Processing and Applications, an additional set of papers will further substantiate the depth and performance of nonlinear methods. We hope that you find these papers instructive and enjoy reading them as much as we have enjoyed putting the special issues together.

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