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Editorial

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The application of advanced signal analysis tools (e.g., fractional Fourier transforms or joint time-frequency signal representations) to a wide variety of optics and photonics problems has led to a new and deeper understanding of several optical phenomena of fundamental and practical importance, including diffraction, holography, nonlinear optical processes, dispersion, and optical filtering. Signal analysis methods also constitute the basis of powerful techniques for the measurement and full characterization of ultrafast optical events or systems, which otherwise could not be characterized by conventional means. Moreover, novel analysis and synthesis methods for different photonics devices (e.g., fiber gratings, ring resonators, etc.) have been developed based on well-known continuous and discrete-time signal processing tools.

The use of different photonic technologies for processing spatial or temporal information in the optical domain is also a field of growing importance, with a strong potential for interesting applications in fields such diverse as optical telecommunications, ultrafast metrology, microwave engineering, image processing, and optical computing, to name only a few. Advantages of processing the information in the optical domain include the tremendous available bandwidth and the parallelism intrinsic to the optical approach, which translate into ultrahigh processing speeds, which otherwise are not possible.

The broad area of optical signal processing is becoming today one of the most active research areas in optics and photonics. Research in this area will have an important impact far beyond the conventional frontiers of photonic technologies. The present issue of EURASIP JASP is devoted to this increasingly important topic. Specifically, the aim of this special issue is to highlight innovative research in signal processing applied to optics and photonics problems, thus paving the way for future developments in the field. The present issue was thought of with the intention of providing an overview as complete as possible of the recent progress and current problematics in optical signal processing, while bringing the work in this area closer to the signal processing community. This was the philosophy behind the decision to prepare a special issue of the EURASIP JASP devoted to this area. In expressing this philosophy, we are very grateful to *Dr. Jacob Benesty*, who first suggested and encouraged us to proceed ahead with this special issue.

The special issue comprises both original research contributions and review papers by leaders in their respective arenas. This includes works ranging from applications of signal analysis tools to optical problems to the proposal and demonstration of innovative concepts, technologies, devices, and architectures for all-optical information processing. In particular, the current issue consists of fourteen contributions, namely, seven invited papers and seven regular contributions. The latter were selected by the Guest Editors following a suitable evaluation via a standard international peer-review process. As mentioned above, the intention was to cover most of the relevant topics in the area. Specifically, the *invited contributions* in this special issue are the following.

(1) "Active optical lattice filters" by L. R. Hunt et al.
(2) "Advanced optical processing of microwave signals" by B. Ortega et al.

(3) "Fractional transforms in optical information processing" by T. Alieva et al.
(4) "Applications of the Wigner distribution function in signal processing" by D. Dragoman.
(5) "Concepts for the temporal characterization of short optical pulses" by C. Dorrer and I. A. Walmsley.
(6) "Time-frequency (Wigner) analysis of linear and nonlinear pulse propagation in optical fibers" by J. Azaña.
(7) "A novel optical vector spectral analysis technique employing a limited-bandwidth detector" by C. K. Madsen.

Hunt et al. were invited to present and review their recent developments in active optical lattice filters. This work constitutes a relevant example of how well-known concepts of signal processing (i.e., adaptive lattice filtering) can be successfully applied in photonics. All-optical adaptive filtering devices are proposed and demonstrated. In their invited contribution, Ortega et al. give an extensive overview about their work on microwave signal processing based on photonics technologies. The authors review some recent, relevant approaches to implement high-performance transversal RF filters using optical devices such as fiber Bragg gratings, arrayed waveguide gratings, or interferometric structures. Experimental evidence of their proposals is also provided. Pasrija et al. propose the use of discrete-time signal processing tools for designing and synthesizing nonlinear optical devices. This proposal is based on the pioneer work by Madsen, where concepts of discrete-time signal analysis were applied for synthesizing linear allpass optical filters.

In their invited paper, Alieva et al. provide a comprehensive overview on the use of fractional linear integral transforms for different optical information processing applications, including phase retrieval, beam characterization, pattern recognition, adaptive filter design, encryption, watermarking, and motion detection. The contribution by Dragoman focuses on the application of phase-space representations, and in particular Wigner analysis, to a wide variety of signal processing problems with an emphasis on optical signals and systems. Her paper is a review of classical and relevant work on the use of advanced signal analysis tools in the context of optics and photonics. In their contributed paper, Bastiaans and Alieva elaborate further on the concept of Wigner distribution applied to optical systems.

In their invited contribution, Dorrer and Walmsley present an extensive review of signal analysis-based methods for the full (amplitude and phase) characterization of (ultra-) short optical pulses. It is discussed how an optical pulse can be analyzed and fully characterized through its representation in terms of correlation functions or time-frequency representations, and different methods to experimentally obtain these representations in the optical domain are discussed and demonstrated. In his work, Azaña makes use of joint time-frequency signal representations for investigating an optical problem of fundamental and practical significance, namely, the dynamics of picosecond pulse propagation through optical fibers in the linear and nonlinear regimes. A deeper insight into this problem is provided through this analysis.

The paper by Madsen introduces and analyzes a new and simple technique for characterizing both chromatic and polarization-mode dispersions in an optical channel. The technique is based on discrete-time signal analysis concepts and should prove to be very useful for applications in WDM optical communication systems. In their contribution, Cincotti et al. present a comprehensive overview of wavelet signal processing and multiplexing in the optical domain, using photonics integrated technologies. These developments are of interest for broadband multiple access networks. The work by Ut-Va Koc deals with improved adaptive equalization algorithms for the electronic compensation of chromatic and polarization-mode dispersions in fiber-optics communication links. In their paper, Llorente et al. propose and experimentally demonstrate an interesting application of the so-called real-time Fourier transformation technique, where the spectrum of an optical signal is mapped into the temporal domain via chromatic dispersion, for evaluating channel crosstalk in DWDM optical communication networks. The work by Garba et al. deals with the increasingly important topic of optical CDMA (OCDMA). In particular, different coding strategies for OCDMA are proposed and evaluated in terms of their capacity limits and noise performance for multiple-access networking.

Finally, the paper by Goren et al. introduces a novel signal analysis-based technique for synthesizing laser beams with extended depth of focus, of specific interest for scanning printed bar codes.

In the coming years, it is expected that the area of optical signal processing will become even more important from both fundamental and applied perspectives. We hope that this special issue will appeal to the signal processing community and will further stimulate work in this area. To finalize, we would like to thank all the people who have participated in the elaboration of this special issue, especially the authors of the published papers, the researchers who submitted their work for consideration, and last, but not least, the referees who helped in the revision and selection of the submitted works.

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Christi K. Madsen received the B.S. degree from The University of Texas at Austin in 1986, the M.S. degree from Stanford University, Standford, Calif, in 1987, and the Ph.D. degree from Rutgers University, Piscataway, NJ, in 1996, all in electrical engineering. She joined AT&T Bell Laboratories in 1987 and worked for the submarine systems business unit. After completing her Ph.D., she transferred to the Integrated Photonics Research Department, Bell Laboratories. Her research has focused on the application of digital filter and signal processing techniques to optical filters for high-speed, high-capacity optical communication systems. Madsen invented a class of tunable, multistage optical allpass filters that allow any phase response to be approximated and have application in chromatic and polarization-mode dispersion compensation. She has served on many conference committees and given short courses. In 2004, she was the General Chair for the Integrated Photonics Research (IPR) Conference. She was promoted to Distinguished Member of the Technical Staff at Bell Laboratories in 2002 and achieved Fellow ranking in the Optical Society of America in 2003. She holds 16 US patents and has given over 70 technical talks and papers. She is now a Professor at Texas A&M University, College Station, Tex.

Daniela Dragoman was born in 1965. She obtained the M.S. degree from the University of Bucharest, Romania, in 1989, and the Ph.D. degree from Limerick University, Ireland, in 1993. She was a Visiting Professor at the University Saint-Etienne, France, in 1997 and 2000 and was awarded the Alexander von Humboldt Fellowship in 1998, being a Visiting Professor at the University of Mannheim during 1998–1999 and 2001–2002. Presently, she is a Professor at the Physics Faculty, University of Bucharest, where she teaches integrated optoelectronic devices and the interaction of radiation with matter. She authored over 100 papers in the areas of phase space characterization of optical beams and systems, optical micromechanical devices, quantum physics, and mesoscopic devices. She is the coauthor of the books *Advanced Optoelecronic Devices*, Springer, 1999, *Optical Characterization of Solids*, Springer, 2002, and *Quantum-Classical Analogies*, Springer, 2004. She is a reviewer at several international journals of optics and photonics, and Editor for the Springer book series *The Frontiers Collection*. She was awarded in 1999 the Romanian Academy Prize "Gheorghe Cartianu."

José Azaña was born on December 8, 1972, in Toledo, Spain. He received the Ingeniero de Telecomunicación degree (a six-year engineering program) and the Ph.D. degree (in the areas of optical signal processing and fiber Bragg gratings) from the Universidad Politécnica de Madrid (UPM) in 1997 and 2001, respectively. He completed part of his Ph.D. work at the University of Toronto, Canada, and University of California, Davis, USA. From September 2001 to mid 2003, he worked as a Postdoctoral Research Associate in the Department of Electrical and Computer Engineering, McGill University, Montreal, Canada. Recently, he joined the Institut National de la Recherche Scientifique (INRS), Montreal, where he is an Assistant Research Professor in the Ultrafast Optical Processing Group. The research work of Dr. Azaña has resulted in more than 45 publications in top scientific and engineering journals and it has been recognized with several distinctions in Spain and Canada. His current research interests focus on fiber and integrated technologies for ultrafast optical signal processing and optical pulse shaping, for various applications, including optical telecommunications, ultrafast metrology, biomedical imaging, and microwave waveform manipulation.