IET Signal Processing

Special Issue On
Compressive Sensing and Robust Transforms

Compressive sensing is a research area that has intensively developed over the last few years. It is used in applications where the amount of samples is significantly lower than that required by the Nyquist-Shannon theorem. The samples can be taken randomly, but the signal has to be sparse in one of its domains. If this and some additional constraints are satisfied, the signal can be accurately reconstructed even in the case when a significant number of samples are missing. The algorithms used for signals reconstruction, can be generally divided into two groups, namely, the convex optimization and greedy algorithms. It is important to note that the missing samples could be the result of sampling strategy or could appear as a consequence of discarding impaired signal samples. The second case may originate from using the L-estimation based robust statistics. After the L-estimation is applied, the original signal is reduced to the non-noisy, randomly distributed set of samples. We can see that this is the point where Compressive Sensing and robust estimation theory complement each other. Thus, if we combine these two areas, we are able to denoise signals corrupted by heavy-tailed noise, hence obtaining ideally filtered signal. Obviously, the analysis performed within the robust statistics theory can be very useful and applicable to the Compressive Sensing. The idea of this Special issue was to bring attention to these complementary areas and to get all the benefits from the comprehensive studies of robust statistics, which preceded Compressive Sensing Theory and was intensively investigated fifteen years ago.

This Special issue consists of nine papers.

S. Stankovic, L. Stankovic and Orovic, propose a new algorithm for Compressive Sensing reconstruction. It is based on the L-estimation theory and uses the property that the sum of generalized deviations of estimation errors has different behavior at the signal and non-signal frequencies. The estimation errors are obtained from the robust transform formulations. The reconstruction is reduced to determination of the reference level that clearly separates the generalized deviations at signal and non-signal frequencies.

An interesting comparative analysis of Compressive Sensing approaches in an implantable wireless Doppler device is proposed by Sejdic et al. Three different basis functions are considered: Fourier basis, discrete Prolate spheroidal and modulated discrete Prolate spheroidal sequences.

Orovic, Stankovic, and Thayaparan consider the problem of instantaneous frequency estimation in the case of sparse signals. The case when the significant numbers of samples are missing is studied. Namely, when the highly concentrated time-frequency distribution is applied, the instantaneous frequency estimation is possible using just a few sample of the auto-correlation function. Different instantaneous frequency laws are considered.

L. Stankovic et al, propose a simple and efficient adaptive variable step algorithm applied directly to the concentration measures. It is used within the standard reconstruction algorithms. It has been shown that this approach is also efficient for approximately sparse and noisy signals.

Signal decomposers based on the asynchronous sigma-delta modulator (ASDM) are considered by Can, Sejdic, and Chaparro. The decomposer based on the modified ASDM represented by recursive equation, together with the Prolate spheroidal functions interpolator, allows reconstruction of the original signals.

Alkishriwo, Akan, and Chaparro, propose the discrete linear chirp transform. It is used to decompose nonstationary signals into intrinsic mode chirp functions. This approach allows a parametric estimation of the instantaneous frequency that is robust to noise and can be used for signals that are sparse in the time-frequency domain.

An adaptive method for components instantaneous frequency estimation which uses the time support information from the short-time Renyi entropy is proposed by Sucic, Lerga, and Boashash. A double-directional component tracking and extraction is used for components separation. The instantaneous frequency estimation is based on the intersection of confidence intervals approach. The proposed method performance is tested both on synthetic and real-life multicomponent signals.

An interesting application is proposed by Candel, Ioana, and Reeb, where sparse representation of channels impulse response is considered. A method for turbulence characterization is proposed. It consists of two stages: the first stage deals with the design of robust waveforms for sensing of turbulent phenomena, while the second one represents the decomposition of the turbulence impulse response.

Compressive Sensing based estimation schemes for rapidly time-varying channels in OFDM systems, are presented in the paper of Liu, Mei, and Du. The methods are designed for non-diagonal matrix providing more precise representation of fast fading channels. A modified Compressive Sensing algorithm is adopted for this purpose. These methods improve performance for fast time-varying channels in OFDM systems.

Guest Editors

Srdjan Stanković, University of Montenegro
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Biographies

Srdjan Stanković received the B.S. (Hons.) degree in Electrical Engineering from the University of Montenegro, in 1988, the M.S. degree in Electrical Engineering from the University of Zagreb, Croatia, in 1991, and the Ph.D. degree in Electrical Engineering from the University of Montenegro in 1993. He is a Full Professor at the University of Montenegro, where he was also the Dean of the Faculty of Electrical Engineering. His research interests include the areas of: Time-frequency signal analysis, Compressive sensing, and Multimedia systems. He has more than 200 publications, among them more than 70 journal papers. A significant number of Prof. Stankovic's papers deal with time-frequency analysis and its applications. He has introduced time-frequency distributions with complex-lag argument (in his paper published in the IET Electronics Letters), which has been widely studied within the scientific and research community. Currently he is working in the area of Compressive sensing and its generalization to the time-frequency signal domain (he has already written 10 papers on this topic). The Chapter 6 of his book "Multimedia Signals and Systems", published by Springer 2012, is completely devoted to Compressive sensing. Additionally, he has published several textbooks and coauthored three monographs on time-frequency signal analysis (in English). He was the Guest Editor of the Signal Processing for the special issue on Fourier related transforms, as well as the Lead Guest Editor of the EURASIP Journal on Advances in Signal Processing for the special issue ”Time-frequency analysis and its applications to multimedia signals”. From 2005 to 2009 Dr. Stanković was serving as an Associate Editor of the IEEE Transactions on Image Processing. He established a number of joint research collaboration with prominent academic institutions. Namely, in 1998 he spent a period of time with the Department of Informatics at the Aristotel University in Thessaloniki. In 1999-2000, he was on leave at the Darmstadt University of Technology, with the Signal Theory Group, supported by the Alexander von Humboldt Foundation. In 2002, he spent three months at the Department of Computer Science, the University of Applied Sciences Bonn-Rhein-Sieg, as an Alexander von Humboldt Fellow. From 2004 to 2006, he stayed several times with the E3I2 Laboratory, ENSIETA, Brest, France. From 2007 to 2010 he visited Centre for Digital Signal Processing research at King's College London, Laboratory of Mathematical Methods of Image Processing, at Moscow State University Lomonosov, and Center for Advanced Communications at Villanova University, PA, as well as GIPSA Laboratory at INPG Grenoble. Dr. Stanković received the Best scientific project leader award of Montenegro in 2011.

Thayananthan Thayaparan earned a B.Sc. (Hons.) in physics at the University of Jaffna, Srilanka, M.Sc. in physics at the University of Oslo, Norway in 1991, and a Ph.D. in atmospheric physics at the University of Western Ontario, Canada in 1996. From 1996 to 1997, he was employed as a Postdoctoral Fellow at the University of Western Ontario. In 1997, he joined the Defence Research and Development Canada - Ottawa, Department of National Defence, Canada, as a Defence Scientist. His research interests include advanced radar signal and image processing methodologies and techniques against SAR/ISAR (synthetic aperture radar/inverse SAR) and

HFSWR (high-frequency surface-wave radar) problems such as detection, classification, recognition, and identification. His current research includes SAR/ISAR imaging algorithms, robust Fourier-based transform and time-frequency analysis for radar imaging and signal analysis, hardware and software realization of robust transforms, instantaneous frequency estimation, radar micro-Doppler analysis, and noise radar technology. Dr. Thayaparan is a Fellow of the IET (Institute of Engineering & Technology). Currently, he is an Adjunct Professor at McMaster University, Canada. Dr. Thayaparan received IET Premium Award for Signal Processing for the best paper published in 2009-2010. Dr. Thayaparan is currently serving in the Editorial Board of IET Signal Processing. He has authored or coauthored over 210 publications in journals, proceedings, and internal distribution reports. As a principal writer, he wrote 3 editorials for the international journals IET Signal Processing (Institute of Engineering and Technology) and IET Radar, Sonar & Navigation.

Victor Sucic received the Bachelor of Engineering degree (Electrical and Computer Engineering, with the First Class Honours) and the PhD degree (Electrical Engineering) from Queensland University of Technology, Brisbane, Australia, where he was working within the Signal Processing Research Center. He worked as a lecturer/researcher at several Australian universities, and since 2005, he has been with the Faculty of Engineering, University of Rijeka, Croatia, where he is the Signals and Systems Division Chair. Victor Sucic has authored a number of research publications related to non-stationary signals processing. His main research interest is the time-frequency signal analysis, and his publications includes several papers related to the instantaneous frequency estimation, signal denoising, estimation of noisy and multicomponent signal parameters, all published in leading signal processing journals. Professor Sucic has served as a reviewer for a number of journals and conferences in the field of signal processing.
He was a technical program co-chair of the 9th International Workshop on Systems, Signal Processing and their Applications, and the track and special session chair of the 11th International Conference on Information Science, Signal Processing and their Applications.