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Guest Editorial: Machine Learning for Signal Processing

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Signal processing including analysis, understanding, detection, estimation, and modelling of the events and trends, the way they evolve, and the abnormalities and anomalies affecting them have attracted many researchers around the globe. Signal processing theory originates from mathematical foundation with astonishing applications which help information technologists discover and invent new realities branching off into communications, acoustics, speech, music, biomedical engineering, networking, control, and many other fronts in research and development. A remarkable balance between theory and applications of signal processing has been found with its enormous footprints. Linear algebra, data transforms, and signal distributions have been perhaps playing the major roles in most of these applications.

On the other hand, the pioneering works in artificial neural networks, inspired by the structure of central nervous system, by Warren McCulloch and Walter Pitts in 1940's was another

celebrated establishment in the area of data assessment and machine learning. Machine learning prefers to create generative models for the problem under study. Inference models and parameters, inherently relying on Bayesian learning, are determined by the data and their environments.

Machine Learning and information theoretic ideas can help statistical signal processing overcome the barriers of linear models, and mitigate the need for Gaussianity and stationarity assumptions. Statistical signal processing and inductive inference algorithms provide a common ground at the overlap between signal processing and machine learning which result in some elegant areas of research such as adaptive and non-linear signal processing, intelligent systems, and multitask cooperative networking.

Audio and video processing, brain computer interfacing, self-organized and cognitive information systems are very few out of many application domains of joint machine learning and signal processing systems. We may further categorize the areas where signal processing and machine learning meet as learning theory and techniques; graphical models and kernel methods; data-driven adaptive systems and models; pattern recognition and classification; distributed, Bayesian, subspace/manifold and sparsity-aware learning; multi-set data analysis and multimodal data fusion; perceptual signal processing in audio, image and video; cognitive information processing; multichannel adaptive and nonlinear signal processing, and their vast applications, including: speech and audio, image and video, music; biomedical signals and images; communications; bioinformatics; biometrics; computational intelligence; genomic signals and sequences; social networks; games, and smart grid. In addition, learning algorithms inherently involve in

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many other applications such as latent variable analysis and blind source separation.

In this special issue, there is no room to cover all the above aspects. Instead, only few topics have been explored and examined by some prominent researchers. These topics are summarized and their importance acknowledged here.

In the first paper titled “Text-informed audio source separation. Example-based approach using non-negative matrix partial co-factorization” ([10.1007/s11265-014-0920-1](https://doi.org/10.1007/s11265-014-0920-1)), the authors have attempted a text-informed speech source separation. For this purpose a new variant of the non-negative matrix partial co-factorization approach based on a so-called excitation-filter-channel speech model has been proposed. In this model the linguistic information between the speech example and the speech in the mixture are shared.

The second paper, “A model-free de-drifting approach for detecting BOLD activities in fMRI data” ([10.1007/s11265-014-0926-8](https://doi.org/10.1007/s11265-014-0926-8)), introduces a model-free method for efficiently capturing drifts in functional magnetic resonance imaging (fMRI) data. The proposed algorithm applies a first order differencing to the fMRI time series samples in order to remove the drift effect. Linear least-squares method followed by applying wavelet threshold is then used to optimally estimate the drift. In the final stage, the de-drifted fMRI voxel response is acquired by removing the estimated drift from the fMRI time-series. Its performance is assessed using simulated and motor-task real fMRI data sets obtained from both block- and event-related designs.

The method in the third paper, “Blind suppression of nonstationary diffuse acoustic noise based on spatial covariance matrix decomposition” ([10.1007/s11265-014-0922-z](https://doi.org/10.1007/s11265-014-0922-z)), involves suppression of nonstationary diffuse noise which is a popular problem. In this approach the observed spatial covariance matrix is decomposed into signal and noise. In their design the authors exploit spatial invariance instead of temporal invariance to regularize the inherent ill-posed decomposition problem.

The problem of scrutinising multiple gene expression microarray datasets for identification of the gene subsets, consistently co-expressed across them, has been tackled in the fourth paper titled “Application of the Bi-CoPaM method to five *Escherichia Coli* datasets generated under various biological conditions” ([10.1007/s11265-014-0919-7](https://doi.org/10.1007/s11265-014-0919-7)). The developed clustering technique leads to an improvement in exploiting the biological facts which differentiate between various contexts and multiple processes. Consequently, the authors draw some biological hypotheses relating some of the genes with currently unknown biological processes to their potential processes. These hypotheses can serve as pilots for future gene discovery studies.

The fifth contribution, “Blind separation of orthogonal mixtures of spatially-sparse sources with unknown sparsity levels and with temporal blocks,” ([10.1007/s11265-014-0918-8](https://doi.org/10.1007/s11265-014-0918-8))

addresses the problem of blind separation of a static, linear orthogonal mixture has been addressed. This process is not based on statistical assumptions (such as independence), but on the sparsity of the sources. Unlike in some established solutions to this problem, in this paper two pre-processing stages for improving the algorithm's performance have been proposed. The authors verify by experiment that the improved algorithm outperforms the recovery rate of alternative source separation methods for such contexts, including K-SVD, a leading method for dictionary learning.

Next, in “Sparse coding with anomaly detection” ([10.1007/s11265-014-0913-0](https://doi.org/10.1007/s11265-014-0913-0)) paper, a solution to the problem of simultaneous sparse coding and anomaly detection has been pursued. This is based on the assumption that the majority of the data vectors comply with a sparse representation model, whereas any anomaly is caused by an unknown subset of the data vectors - the outliers - which significantly deviate from this model. The proposed approach utilizes the Alternating Direction Method of Multipliers to recover simultaneously the sparse and the outlier components for the entire collection. This approach provides a unified solution for both jointly sparse and independently sparse data vectors. An application to detection of irregular heartbeats from electrocardiogram has been demonstrated.

In the seventh paper, “learning incoherent subspaces: classification via incoherent dictionary learning,” ([10.1007/s11265-014-0937-5](https://doi.org/10.1007/s11265-014-0937-5)) the authors present a new method for learning discriminative incoherent subspaces from data based on so called supervised iterative projections and rotations. They employ the algorithm to learn incoherent sub-spaces that model signals belonging to different classes. The method is effectively used as a feature transform for supervised classification.

Finally, the eighth paper, “Entropy power inequality for learning optimal combination of kernel functions,” ([10.1007/s11265-014-0899-7](https://doi.org/10.1007/s11265-014-0899-7)) deals with designing an appropriate kernel for some specific data. This problem is highly demanded by many workers in machine learning. The approach in this study follows the notion of Gaussianity evaluated by entropy power inequality for kernel learning. Using a number of benchmark datasets, it is shown that the classification performance of the method is comparable or superior to other conventional multiple kernel learning methods.

We hope that the following eight papers, which cover a number of areas within joint signal processing and machine learning research arena, will generate new seeds for future thoughts.

Guest Editors



Saïd Sanei Received his PhD in Signal Processing from Imperial College London, UK. He has been a member of academic staff in Iran, Singapore, and the UK. He has published three monographs and over 300 papers in peer reviewed journals and conference proceedings. His research includes adaptive filtering, cooperative learning, multiway, multimodal, and multichannel signal processing with applications to biomedical, audio,

biometrics, and communication signals. He served as an Associate Editor for the IEEE Signal Processing Letters. Currently, he is the Deputy Head of Department of Computing, University of Surrey, UK, an Associate Editor for the IEEE Signal Processing Magazine and the Journal of Computational Intelligence and Neuroscience.



Paris Smaragdis Is a faculty member of the Computer Science and the Electrical and Computer Engineering departments at the University of Illinois at Urbana-Champaign. He completed his graduate and postdoctoral studies at MIT, where he conducted research on computational perception and audio processing. Prior to the University of Illinois he was a senior research scientist at Adobe Systems and a research scientist at Mitsubishi Electric Research Labs, during which he was

selected by the MIT Technology Review as one of the top 35 young innovators of 2006. His research interests lie in the intersection of machine learning and signal processing, especially as they apply to audio problems.



Anthony T. S. Ho Holds a Personal Chair in Multimedia Security and is currently Head of Department of Computing, University of Surrey since 2010. He also leads the Multimedia Security and Forensics research group in the Department. He is also a Guest Professor of Wuhan University of Technology, China. Professor Ho was the recipient of the Institution of Engineering and Technology (IET) Innovation in Engineering Award under

the Security category for his research and commercialization work on digital watermarking in 2006. Professor Ho obtained his PhD

in Digital Image Processing from King's College London in 1983. Professor Ho has published more than 140 articles in international journals and conference proceedings as well as 8 international patents granted related to watermarking and steganography. Professor Ho is the Editor-in-Chief of the International Journal of Information Security and Applications (JISA) published by Elsevier. He is also an Associate Editor for IEEE Signal Processing Letters, as Area Editor for Signal Processing: Image Communication and Associate Editor for EURASIP Journal of Image and Video Processing. Professor Ho was General Chair for the 8th International Workshop on Digital Watermarking (IWDW) held at the University of Surrey in 2009 and co-Editor for two Springer Proceedings on Digital Watermarking from IWDW08 and IWDW09. He is a Fellow of Institution of Engineering and Technology (FIET), Fellow of Institute of Physics (FInstP), Fellow of British Computer Society (FBCS) and Senior Member of IEEE.



Asoke K. Nandi Joined Brunel University London in April 2013 as the Head of Electronic and Computer Engineering. He received a PhD from the University of Cambridge, UK, and since then has worked in many institutions, including CERN, Geneva; University of Oxford, UK; Imperial College London, UK; University of Strathclyde, UK; and University of Liverpool, UK. His research spans many different topics, including automatic

modulation recognition in radio communications for which he received the Mountbatten Premium of the Institution of Electrical Engineers in 1998, machine learning, and blind equalization for which he received the 2012 I.E. Communications Society Heinrich Hertz Award from the Institute of Electrical and Electronics Engineers (USA). He is a Finland Distinguished Professor at the University of Jyväskylä. In 1983 Professor Nandi was a member of the UA1 team at CERN that discovered the three fundamental particles known as W^+ , W^- and Z^0 , providing the necessary evidence for the unification of the electromagnetic and weak forces, which was recognized by the Nobel Committee for Physics in 1984. He has received many awards, and he has been honoured with the Fellowship of the Royal Academy of Engineering (UK) and the Institute of Electrical and Electronics Engineers (USA). He is a Fellow of five other professional institutions, including the Institute of Physics (UK), the Institute of Mathematics and its Applications (UK), and the British Computer Society. He has published over 200 journal papers (total publications: 500). His publications have been cited well over 16,000 times and the h -index of his publications is 60 (Google Scholar).



Jan Larsen Received the M.Sc. and Ph.D. degrees in electrical engineering from the Technical University of Denmark (DTU) in 1989 and 1994. Dr. Larsen is Associate Professor of Digital Signal Processing at Department of Applied Mathematics and Computer Science, DTU. Jan Larsen has authored and co-authored more than 150 papers and book chapters within the areas of machine learning, signal processing, and cognitive systems with application to audio, multimedia, sensor

data, monitoring, biomedical, data/web-mining, and pattern recognition. According to [Google Scholar](#), Jan Larsen's research impact is as of January 7, 2015 summarized as follows: 3059 citations, h-index equal to 30, and i-10 index equal to 75. He has participated in more than ten national and international research and innovations programs and has served

as reviewer for many international journals, conferences, publishing companies and research funding organizations. Currently he coordinates the strategic the research project CoSound (2012-2016) and participate as principal investigator in four other research projects. As regards synergistic activities, he took part in conference organizations, among others the IEEE Workshop on Machine Learning for Signal Processing (formerly Neural Networks for Signal Processing) 1999-2014 and as Technical Program Chair of the European Signal Processing Conference (EUSIPCO 2010). He is director of the Danish Sound Innovation Network (2009-), past chair of the IEEE Machine Learning for Signal Processing Technical Committee of the IEEE Signal Processing Society (2005-2007), and chair of IEEE Denmark Section's Signal Processing Chapter (2002-). He is a senior member of The Institute of Electrical and Electronics Engineers. Other professional committee participation includes Steering committee member of the Audio Signal Processing Network in Denmark, 2006-. Editorial Board Member of Signal Processing, Elsevier, 2006-2007; and guest editorships involves IEEE Transactions on Neural Networks; Journal of VLSI Signal Processing Systems; and Neurocomputing. For a complete CV, see <http://people.compute.dtu.dk/janla>