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Editorial

Blind source separation and multichannel deconvolution

For the last 10 years, source separation has raised an increasing interest, partly because it has been discovered that space-time approaches will play an essential role in future radio communications systems. This special issue concentrates on blind source separation and multichannel identification and deconvolution. The interesting problems related to semi-blind techniques, where the knowledge of a short learning sequence is introduced, is left aside, on purpose, for reasons of space; they are closely related to the blind techniques presented in the present issue.

Whereas most reported techniques for blind system identification make use of a selection of the output's second- and/or higher-order statistics, the maximum-likelihood approach exploits all the available information on the probability distributions of the input and the noise, aimed at a higher accuracy. This however leads to a (forbiddingly) high problem complexity – in most cases the maximum-likelihood function cannot be expressed in a numerically tractable form. Nevertheless, solutions may be obtained by simulation-based numerical techniques. The goal of the paper by Cappé et al. is to present a survey of recent stochastic algorithms, related to the expectation–maximization principle, that allows for a maximum-likelihood blind system identification; the emphasis is on the practical implementation of these techniques.

The paper by Chevalier allows for a comparison of the performance of a given source separator to what can theoretically be achieved. Spatial matched filter, least-squares separator and weighted least-squares separator are reviewed, interpreted in maximum-likelihood terms, and discussed with respect to interference or interference-plus-noise cancellation.

The next three papers are new results on the separation of instantaneous mixtures.

First, Moreau and Macchi present a contrast-based methodology that allows to take into account a common finite-alphabet property of the emitted signals. Adaptive algorithms are worked out and discussed for a prewhitening-based contrast, as well as for a contrast that requires only normalization to unit-power.

Van der Veen draws the attention to the fact that the classical data model underlying blind source separation techniques may be too naive in a digital communications context, as residual carriers may remain after demodulation to base band. However, it is shown that this very fact can be exploited to separate binary sources by means of an ESPRIT-type algorithm. The derivation is quite similar to that of the analytical constant modulus algorithm, derived earlier by the author. Actually, if the receiving array is centro-symmetric, both approaches can be combined to an algorithm with a significantly better performance.

Liu and Tong investigate the (multi-stage) constant modulus algorithm itself: they provide an analysis of the local optima of the Constant Modulus cost function e.g. with respect to the influence of the sub- or super-Gaussian character of the sources.

The last six papers deal with the blind identification or equalization of dynamical systems.

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Gorokhov and Loubaton pursue the linear prediction-type approach for the blind identification of MIMO FIR filters with strictly more outputs than inputs. Contrarily to the standard linear prediction method, a statistically optimal (yet computationally hard) least-squares identification procedure is proposed, from which a simple but accurate suboptimal scheme is deduced.

In earlier works, Xu and Tsatsanis derived batch constrained optimization techniques for direct blind multichannel equalization, with a performance close to that of the MMSE receiver. Here they derive stochastic gradient and RLS adaptive implementations, for which they show global convergence.

Tugnait presents a stochastic gradient adaptive implementation of an algorithm, proposed earlier, for the blind deconvolution of a MIMO system with non-Gaussian inputs.

Blind multichannel deconvolution algorithms are sometimes computationally expensive for practical use in digital wireless communications. However, geometric properties arising from the modulation scheme allow for the derivation of more efficient algorithms: as an extension of previous research on scalar mixtures, Torlak et al. develop an algorithm for blind source separation in a MIMO FIR context.

Broman et al. investigate the blind identifiability of dynamic systems involving mixing channels and source generating filters that can be modeled as ARMA filters. As an extension of and a complement to the existing literature, they prove that, for a number of important scenarii, second-order statistics are sufficient for the blind identification of two-input two-output systems without noise.

Regalia deepens our insight in the Godard and Shalvi–Weinstein methods for blind equalization: assuming little more than fourth-order stationarity of the equalizer input (in the real case), he shows that both approaches are actually equivalent, even for correlated inputs, non-linear channels, multiplicative noise, etc. As an application, the typical link is exploited to adapt the Godard scheme for leptokurtic sources, whereas the conventional form is only suitable for platykurtic sequences.

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Guest Editors