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Handbook of Blind Source Separation: Independent Component Analysis and Applications, P. Common and C. Jutten (Editors), Academic Press, 856 pages, hardbound, 2010, ISBN: 978-0123747266. *Reviewed by Ignacio Santamaria, (nacho@gtas.dicom.unican.es), University of Cantabria.*

Since the appearance of the first papers on independent component analysis (ICA) and blind source separation (BSS) several decades ago, the field has made tremendous progress in terms of theory, algorithms, and applications. It has now reached the point where it can be considered a mature and well-understood topic that has demonstrated its power in a number of real-world applications. The purpose of this handbook, edited by two pioneering contributors to the field, is to bring together in-depth surveys reporting the state of the art of BSS techniques. It presents a comprehensive account of the available knowledge in this maturing field, covering in depth the various existing approaches to tackle the BSS paradigms, their theoretical foundations, and main applications.

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The handbook consists of 19 chapters written by some of the most prominent researchers and experts on BSS techniques. The first nine chapters cover the more standard material, describing the various existing approaches to tackle the BSS problems. After an introductory chapter that states the problem and reviews the history and genesis of the BSS field, Chapter 2 treats in detail separation methods based on mutual information, which is at the core of many contrasts functions and is suitable for both instantaneous and convolutive mixtures.

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Contrast functions based on cumulants and specifically tailored for multiple-input single-output as well as multiple-input multiple-output mixing systems are studied in Chapter 3. In Chapter 4, the structure of the likelihood function for ICA problems is unveiled, providing a clear understanding of the important concept of equivariance and the use of natural gradient techniques to optimize contrast functions over the Stiefeld manifold created by the whiteness constraint. Prewhitening is a typical preprocessing step used in most ICA algorithms to transform the observations into another vector with unit covariance matrix. Since the sources are not only uncorrelated but also higher-order independent, tensor decomposition methods can be used as prewhitening-based algebraic ICA algorithms: this is the topic discussed in Chapter 5.

Chapter 6 considers implementation aspects of iterative ICA algorithms, which are mainly based on gradient and Newton iterations but also exploit additional information about the structure of the problem. The use of deflation techniques and the optimal selection of the step size are among the topics discussed in this chapter.

Chapter 7 considers the different time-structure of the source signals as a means to separate the sources. When the second-order temporal statistics of the sources exhibit sufficient diversity, it is possible, as discussed in this chapter, to separate even Gaussian sources. After presenting the main algorithms pertaining to this category [e.g., second-order blind identification (SOBI) and the algorithm for multiple unknown signals extraction (AMUSE)], the chapter discusses some identifiability issues and presents performance measures and bounds. The separation of nonstationary sources or improper complex-valued Gaussian sources is briefly touched upon.

Convolutive mixtures are the focus of Chapter 8, where the mixing matrix is replaced by a MIMO linear time-invariant filter. Time- and frequency-domain methods are shown to extend, in many cases, the contrast functions from instantaneous mixtures to the convolutive case.

Chapter 9 discusses again the use of tensor decomposition methods for ICA, and complements Chapter 5 by addressing the identification of underdetermined mixtures for which the number of sources is larger than the number of sensors. The tensor tools are again reviewed and different mathematical formulations of the problem are presented and analyzed.

The second part of the book (Chapters 10–14) reviews the state of the art on the more recent approaches that exploit some

prior knowledge about the sources. Chapter 10 considers again underdetermined mixtures when the sources are known to admit a sparse representation in a given dictionary. Specific ICA techniques that exploit the source sparsity, such as the use of Lp-norms, matching pursuit techniques or clustering-based algorithms are described and their performance illustrated in several examples.

Chapter 11 reviews the use of spatial quadratic time-frequency representations to recover nonstationary (both deterministic and stochastic) signals. These algorithms overcome the classical statistical independence assumption and typically involve the selection of specific time-frequency points upon which either algebraic methods or approximate joint diagonalization techniques can be applied.

Chapter 12 follows a principled Bayesian approach that assigns some prior probability to the model parameters (sources and mixing matrix) and derives afterwards the posterior that blends the information provided by the prior and the observations. Some relevant and useful priors are described and applied to real-world problems such as spectrometry and hyperspectral imaging.

The situation when the sources are known to be nonnegative (for instance, the amount of signal power contributed by each note in musical audio signal processing) is treated in detail in Chapter 13. Starting from the well-known nonnegative matrix factorization algorithm using multiplicative updates, several extensions and modifications are extensively discussed.

Finally, Chapter 14 is devoted to the case of nonlinear and, in particular, postnonlinear mixtures: a linear mixture system followed by a memoryless and invertible nonlinearity. Besides its theoretical interest, postnonlinear mixtures arise in a number of practical problems. The chapter presents solutions that exploit the structural constraints on the problem and/or the prior information on the sources. A pure Bayesian approach is also discussed.

The final five chapters examine several BSS applications. Chapter 15 starts considering the application of these techniques to channel equalization in digital communications. It specifically focuses on semiblind techniques for single-input single-output channels, when only a short training sequence is available at the receiver.

Chapter 16 presents an overview of different applications, including the analysis of hyperspectral images taken from the surface of the planet Mars. It also emphasizes the importance of a correct interpretation of the results provided by ICA algorithms in practice.

Application to the spectrum monitoring of radio communications on the high-frequency band are described in Chapter 17. This problem involves the separation of non-Gaussian cyclostationary sources, which poses some new challenges to the application in practice of these techniques.

In Chapter 18, the authors focus on the use of ICA techniques to biomedical systems, probably one of the earliest fields of application of ICA to real problems (together with audio/speech processing as discussed in the last chapter). The chapter mainly reviews advances in functional brain imaging and electrocardiogram signal analysis.

The final chapter is devoted to applications of ICA to audio signal processing. It shows how the independence and sparsity assumptions typically made in source separation algorithms are quite realistic in audio processing, thus paving the way for successful BSS applications.

The reader will benefit from the fact that all 19 chapters composing this handbook can be read almost independently. It is also fortunate that some effort has been devoted to use a common notation and cross-references linking the chapters, which increases its value as a comprehensive reference textbook on the subject. In short, the *Handbook of Blind Source Separation* is a valuable reference for engineers, researchers and practitioners in the field of blind adaptive techniques. Moreover, this handbook may also be used in teaching graduate courses on blind signal processing and is a perfect systematic introduction for Ph.D. students starting the area.

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