Handbook of Blind Source Separation

Independent Component Analysis and Applications

Edited by P. Comon and C. Jutten

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About the editors

The two editors are pioneering contributors of ICA. They wrote together the first journal paper on ICA, which appeared in *Signal Processing*, published by Elsevier in 1991, and received a best paper award in 1992, together with J. Hérault.

Pierre Comon is Research Director with CNRS, Lab. I3S, University of Nice, France. He has been Associate Editor of the *IEEE Transactions on Signal Processing*, and the *IEEE Transactions on Circuits of Systems I*, in the area of blind techniques. He is now Associate Editor of the *Signal Processing* journal, published by Elsevier. He has been the coordinator of the European network "ATHOS" on High-Order Statistics. He received the Monpetit prize from the French Academy of Sciences in 2005 (rewarding works with industrial applications), and the Individual Technical Achievement Award from Eurasip in 2006. He is Fellow of the IEEE, Emeritus Member of the SEE, and member of SIAM. He authored a paper in 1994 on the theoretical foundations of ICA; this paper still remains among the most cited both on the subject of ICA and/or blind techniques, in the whole signal processing community.

Christian Jutten is Professor at the University Joseph Fourier of Grenoble, France. He is currently associate-director of GIPSA-lab, a 300-people laboratory focused on automatic control, signal, images and speech processing. He has been Associate Editor of the *IEEE Transactions on Circuits and Systems I*, in the area of Neural Networks and Signal Processing techniques. He is currently Associate Editor of *Neural Processing Letters*, published by Kluwer. He was the co-organiser of the first international conference on Blind Source Separation and Independent Component Analysis, in 1999 (ICA 99). He was the coordinator of two European projects, one of them (BLISS) focused on Blind Source Separation and Applications. He received the Blondel Medal of the SEE in 1997 for his contributions in blind source separation. He is Fellow of the IEEE and Senior Member of Institut Universitaire de France. He co-authored a set of two papers in 1991, with J. Hérault and P. Comon, on the first algorithm for blind source separation and on theoretical foundation, which still remains in the top five papers cited on the subject of ICA and/or blind techniques, and in the whole signal processing community.

Preface

In signal processing, a generic problem consists in separating a useful signal from noise and interferences. Classical approaches of the twentieth century are based on *a priori* hypotheses, leading to parameterized probabilistic models. Blind Source Separation (BSS) attempts to reduce these assumptions to the weakest possible.

As shown in this handbook, there are various approaches to the BSS problem, depending on the weak *a priori* hypotheses one assumes. The latter include either statistical independence of source signals or their sparsity, among others.

In order to prepare this book, among the best worldwide specialists have been contacted to contribute (cf. page xxiii). One of them, Serge Degerine, has passed away unexpectedly Q1 during the writing of Chapter 7. We would like to dedicate this book to his memory.

This handbook is an extension of another book which appeared in 2007 in French, and published by Hermes. The present version contains more chapters and many additions, provided by contributors with international recognition. It is organized into 19 chapters, covering all the current theoretical approaches, especially Independent Component Analysis, and applications. Although these chapters can be read almost independently, they share the same notations and the same subject index. Moreover, numerous cross-references link the chapters to each other.

Pierre Comon and Christian Jutten

Glossary

$\mathbf{x}$	vector of components x_p, $1 \leq p \leq P$
s, x, y	sources, observations, separator outputs
N	number of sources
P	number of sensors
T	number of observed samples
$\star$	convolution
$\mathbf{A}$	matrix with components A_{ij}
$\mathbf{A}$, $\mathbf{B}$	mixing and separation matrices
$\mathbf{G}$, $\mathbf{W}$, $\mathbf{Q}$	global, whitening, and separating unitary matrices
$\check{g}$	Fourier transform of g
$\widehat{\mathbf{s}}$	estimate of quantity $\mathbf{s}$
p_{x}	probability density of $\mathbf{x}$
ψ	joint score function
φ_i	marginal score function of source s_i
Φ	first characteristic function
Ψ	second characteristic function
$\mathbb{E}\mathbf{x}$, $\mathbb{E}\{\mathbf{x}\}$	mathematical expectation of $\mathbf{x}$
$I\{\mathbf{y}\}$ or $I(p_{\mathrm{y}})$	mutual information of $\mathbf{y}$
$K\{\mathbf{x};\mathbf{y}\}$ or $K(p_{\mathrm{x}};p_{\mathrm{y}})$	Kullback divergence between p_{x} and p_{y}
$H\{\mathbf{x}\}$ or $H(p_{\mathrm{x}})$	Shannon entropy $\mathbf{x}$
$\mathscr{L}$	likelihood
$\mathscr{A}$, $\mathscr{B}$	mixing, and separating (nonlinear) operators
$\mathrm{cum}\{x_1, \ldots, x_P\}$	joint cumulant of variables $\{x_1, \ldots, x_P\}$
$\mathrm{cum}_R\{y\}$	marginal cumulant of order R of variable y

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$\mathbf{Q}^{\mathrm{T}}$	transposition
$\mathbf{Q}^{\mathrm{H}}$	conjugate transposition
$\mathbf{Q}^{*}$	complex conjugation
$\mathbf{Q}^{\dagger}$	pseudo-inverse
Υ	contrast function
$\mathbb{R}$	real field
$\mathbb{C}$	complex field
$\widehat{\mathbf{A}}$	estimator of mixing matrix
$\operatorname{diag}\mathbf{A}$	vector whose components are the diagonal of matrix $\mathbf{A}$
$\operatorname{Diag}\mathbf{a}$	diagonal matrix whose entries are those of vector $\mathbf{a}$
$\operatorname{trace}\mathbf{A}$	trace of matrix $\mathbf{A}$
$\det\mathbf{A}$	determinant of matrix $\mathbf{A}$
$\operatorname{mean}\mathbf{a}$	arithmetic average of component of vector $\mathbf{a}$
$\check{s}(\nu)$	Fourier transform of process $s(t)$
$\otimes$	Kronecker product between matrices
${\scriptstyle\otimes}$	tensor product
$\bullet_j$	contraction over index j
$\operatorname{krank}\{\mathbf{A}\}$	Kruskal's k-rank of matrix $\mathbf{A}$

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