Book Reviews

Adaptive Blind Signal and Image Processing: Learning Algorithms and Applications—A. Cichocki and S. Amari (Chichester, U.K.: Wiley, 2002) *Reviewed by Jagath C. Rajapakse*

Blind Signal and Image Processing (BSIP) is an exciting and emerging research topic in fields such as neural networks, advanced statistics, data mining, and biomedical signal/image processing and, over the past decade, has established solid theoretical foundations and many real-world applications. The "blind" processing of signals, based on unsupervised learning and in principal, do not assume any prior information in the form of desired training data, signal distributions or parameters of mixing systems.

The main objective of the present book is to provide a comprehensive treatment of the problems, algorithms, and applications in BSIP, which are presented in three major areas: Blind Signal Separation and Extraction (BSS/BSE), Independent Component Analysis (ICA), and Multichannel Blind Deconvolution with filtering and Blind channel Equalization (MBD/BE). The authors present definitions and identify the principles and techniques related to each area, in detail.

This book provides an extensive introduction to the advanced techniques used in all areas of BSIP and offers a general overview of the fundamentals of ICA, BSS/BSE, and MBD/BE models and algorithms as well as the basic mathematical background needed to understand and utilize them. The book delves into the techniques of second and higher order statistics, blind spatial and temporal decorrelation, robust whitening, blind filtering, matrix factorizations, robust

Independent and principal component analysis (PCA), minor component analysis (MCA), sparse representations, automatic dimension reduction, features extraction in high-dimensional data, noise reduction, and related problems. The algorithms are presented with clear descriptions and sufficient mathematical detail and analysis; some interesting benchmarks are made available to compare performance of various unsupervised learning algorithms. Moreover, the book often provides illustrative examples to demonstrate the characteristics and performances of the described algorithms. The computer simulations are also presented for the validity and comparison of the derived learning algorithms.

The authors present the book as a textbook, which can be considered also as monograph since many new results are brought together for the first time. The authors are well-known experts in the areas of ICA/BSS, PCA, and MBD/MBE. In this monograph, they detail all the relevant theory behind their pioneering work in areas like natural gradient approaches and adaptive learning algorithms for various applications. The text presents extensive recent results and ideas, mainly developed by the authors and their collaborators, and they present further developments published in the book, for the first time. With explanations and references to earlier techniques, the authors collate their findings in BSIP into a complete textbook. Furthermore, the book provides a wide coverage of various applications of BSIP in biomedical signal processing image processing, telecommunications, audio and, etc.

The book consists of 12 chapters, an extensive list of references, appendices, and a CD-ROM. Each chapter of the book is presented in step-by-step and self-contained manner and easy to follow independently from other chapters. Many elegant illustrative diagrams, graphs, and plots that accompany the presentation of basic concepts and algorithms offer valuable help for understanding the principles of BSS, ICA, and MBD. Important algorithms are summarized and presented clearly in useful tables. Illustrative examples and computer implementation and simulations are provided for most algorithms. The accompanying CD-ROM includes an electronic interactive version of the book with hyperlinks, full-color figures, and text and a user friendly MATALB package for performing ICA and BSS/BSE.

The advanced topics of the book include the following:

- independent component analysis using various criteria, models, and higher order statistics techniques;
- multistage robust blind separation of colored sources using second-order statistics;
- robust blind decorrelation and orthogonalization;
- neural and information-theoretic approaches to multichannel blind deconvolution with channel blind equalization;
- natural gradient and Lie group approaches;
- generalized total and data least squares problems;
- sparse representation of signals, constrained matrix factorization and minimum p-norm problems;
- MATALB package illustrating performance of some selected ICA/BSS algorithms.

Researchers, students, and practitioners from a variety of disciplines, who have interest in BSIP, will find this accessible volume both helpful and informative. This is a self-contained and complete volume on the subjects of BSS, PCA, ICA, and MBD. The authors present many real-world applications in these areas and compare and discuss the pros and cons of various approaches and techniques. Compared with other ICA books, this book has much depth in mathematical and graphical interpretations in the subject matter and covers the broad subject of BSIP; more than 1300 references on these areas are collected in a book for the first time. This book is a step toward making the subject of BSIP not only a common field of research but also a reference for those looking for new challenging topics and applications. I highly recommend the book to any reader interested in blind signal and image processing.

Qualitative Analysis and Synthesis of Recurrent Neural Networks—A. N. Michel and D. Liu (New York: Marcel Dekker, 2002) *Reviewed by R. Romero and F. Gomide*

Feedforward neural networks can only learn static input–output mappings, a form well suited to represent spatial characteristics that are independent of time. Time, however, is important in many practical circumstances. An approach that has been suggested to extend feedforward networks for temporal processing is to provide the memory requirements of dynamics through time delays. When endowed with feedback connections, the neural networks provide arbitrary dynamics and topologies with hidden neurons. Recurrent neural networks differ from feedforward neural networks in that they have at least one feedback loop in its processing path. Feedback introduces a profound modification on the learning capability and performance because it introduces dynamics in the network behavior. Stability is a key issue in neurodynamics.

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The study of neurodynamics may follow two directions, depending on the nature of the nonlinear dynamical model associated to a neural network. Deterministic neurodynamics adopts deterministic neural network models. They are described by a set of nonlinear differential (difference) equations that define the exact evolution of the models as a function of time. Stochastic neurodynamics assumes noisy neural network models. The purpose of this book is to present a systematic analysis of the qualitative behavior and synthesis techniques of a class of deterministic recurrent neural networks. In the authors' view, recurrency is used to differentiate fully interconnected feedback networks from networks with partial feedback connections induced by sparsity constraints. Analysis of qualitative behavior means the study of the differential equations describing these networks in terms of the existence, uniqueness, and continuation of solutions of such equations. Synthesis means derivation of learning rules and guidelines to design networks with reduced number of undesirable spurious memories. Essentially, it is a book on the deterministic neurodynamics of Cohen–Grossberg–Hopfield networks and their variations. We may safely state that the book provides a comprehensive study of this class of recurrent neural network models.

The organization of the book reflects the expressive knowledge of the authors on the subject. It begins by summarizing the key issues addressed, the class of recurrent neural network models of interest, global and local stability analysis, and proceeds studying the qualitative effects of parameter perturbations, the effect of time delays, learning methods and the effects of interconnection constraints. Bibliographical references at the end of each chapter include citations to original papers and sources of mathematical foundations, but especially to the authors' own work. The authors find "futile and undesirable to undertake an encyclopedic effort involving the many variants of recurrent neural networks encountered in the literature," but the book lacks a chapter that overviews the current status of recurrent neural networks as a whole. Such a chapter could provide an overview of the major recurrent structures, the main learning paradigms, and an analysis of their dynamic behavior. More precisely, the book contains a preface, nine chapters and an index. Chapter 1 introduces and motivates the reader to appreciate the subject of the book. In Chapter 2, some existing recurrent neural network models are presented, focusing on fully interconnected recurrent neural networks. The analog and discrete Hopfield neural network model are addressed in details in the context of associative memories. Two generalizations of this model are considered. The authors show that the Hopfield model is a special case of the Cohen–Grossberg model. This chapter serves as a basis for remaining chapters. In Chapter 3, are investigated the global qualitative properties of the generalized analog Hopfield neural networks. Questions about existence, uniqueness and continuation of solutions of the equations modeling the networks; the locations of equilibria of a network; the total number of asymptotically stable equilibria and global stability properties of a network are addressed. In Chapter 4, all of the questions addressed in Chapter 3 are investigated for the case of analog and discrete-time neural networks which constitute linear systems operating on a closed hypercube in R^n, including also local stability properties of an equilibrium.

In Chapter 5, a review of systems described by ordinary differential and difference equations, respectively, is made. After that, the authors assume the philosophy of viewing the analog Hopfield model [the neural network (S)] as an interconnection of n single neuron subsystems. The aim is to analyze the entire system (the analog Hopfield Model) in terms of the qualitative properties of each subsystem S_i and the system representing the interactions among the neurons. Thanks to obtained results, it is possible to determine the locations and the properties of all the equilibria. In Chapter 6, qualitative effects of parameter perturbation are considered. A study of the robust stability properties of systems whose equilibrium locations are invariant and not invariant under perturbations, are presented, respectively, in an original way. The Chapter 7 is dedicated to a qualitative analysis of the Hopfield and Cohen–Grossberg networks with time delays. The authors present some results to guarantee global stability for Hopfield neural network with identical delays and for Cohen–Grossberg neural network with multiple delays. They propose a condition that, if satisfied, assures that Hopfield (Cohen–Grossberg) neural networks without delays and with delay are both globally stable, and both have identical equilibria with the same local stability properties at each equilibrium. Chapter 8 provides very interesting results about associative memories synthesis problems. Two synthesis approaches, the Eigenstructure Method and that based on Perceptron Training Algorithm, are important contributions of this chapter. Finally, in Chapter 9, synthesis of sparsely interconnected artificial neural networks is investigated since they imply easier VLSI implementations. The Eigenstructure Method and Perceptron Based Training Algorithm, proposed in a previous chapter, are modified for the synthesis of these networks. In particular, the synthesis of a neural network, where the sparsity requirements for the connection matrix lead to cellular neural networks, is investigated.

Graduate students working in various areas of science and engineering would strongly benefit from the book. It is especially suitable for those who have an introductory background on neural networks and their mathematical foundations. Sound notions of dynamical systems and Liapunov stability theory would be particularly helpful to fully appreciate the book content. The format, organization and content form a coherent and recommendable book to all readers with interest in recurrent neural network analysis, design and applications.