The use of neural networks in signal processing is becoming increasingly widespread, with applications in areas such as filtering, parameter estimation, signal detection, pattern recognition, signal reconstruction, system identification, signal compression, and signal transmission. *Applied Neural Networks for Signal Processing* is the first book to provide a comprehensive introduction to this broad field.

The book begins by covering the basic principles and models of neural networks in signal processing. The authors then discuss a number of powerful algorithms and architectures for a range of important problems and go on to describe practical implementation procedures. A key feature of the book is that many carefully designed simulation examples are included to help guide the reader in the development of systems for new applications. The book will be an invaluable reference for scientists and engineers working in communications, control, or any other field related to signal processing. It can also be used as a textbook for graduate courses in electrical engineering and computer science.

Applied Neural Networks for Signal Processing

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Contents

Preface

During the past decade neural networks have begun to find wide applicability in many diverse aspects of signal processing, for example, filtering, parameter estimation, signal detection, system identification, pattern recognition, signal reconstruction, time series analysis, signal compression, and signal transmission. The signals concerned include audio, video, speech, image, communication, geophysical, sonar, radar, medical, musical, and others. The key features of neural networks involved in signal processing are their asynchronous parallel and distributed processing, nonlinear dynamics, global interconnection of network elements, self-organization, and high-speed computational capability. With these features, neural networks can provide very powerful means for solving many problems encountered in signal processing, especially in nonlinear signal processing, real-time signal processing, adaptive signal processing, and blind signal processing.

From an engineering point of view, this book aims to provide a detailed treatment of neural networks for signal processing by covering basic principles, modeling, algorithms, architectures, implementation procedures, and well-designed simulation examples. This book is organized into nine chapters.

Chapter 1 presents basic models of neural networks for signal processing and related fundamentals such as stability theory, learning algorithms, and dynamics analysis. These basic models include mainly: the discrete-time Hopfield neural network, the continuous-time Hopfield neural network, cellular neural networks, multilayer-perceptron networks, self-organizing systems, radial basis function networks, and high-order neural networks.

Chapter 2 focuses on neural networks for filtering. This chapter includes essentially two parts. First, we show how to use neural networks to perform the computations required in various filtering algorithms such as the least-squares algorithm, the recursive least-squares algorithm, the constrained least-squares algorithm, and the total-least-squares algorithm. Next, we present the fundamentals of neural networks for the design and the implementation of nonlinear filters.

Chapter 3 is devoted to neural network approaches for maximum entropy spectral estimation, harmonic retrieval, two-dimensional spectral estimation, multichannel spectral estimation, and higher-order spectral estimation.

In Chapter 4, we discuss neural networks for signal detection. We deal in detail with applications of neural networks to the design, realization, preprocessing, and postprocessing of signal detection.

The main purpose of Chapter 5 is to present neural networks for signal reconstruction. We emphasize applications of neural networks to the implementation of optimal reconstruction algorithms and the development of nonlinear and blind reconstruction algorithms.

Chapter 6 is devoted to the adaptive extraction of the eigenvectors corresponding to the largest and smallest eigenvalues of the autocorrelation matrix of a signal. These two kinds of eigenvectors are referred to as the principal components and minor components, respectively. Their adaptive extraction is a preliminary requirement in adaptive signal processing. A detailed review of adaptive unsupervised learning algorithms for extracting the principal components and minor components is given in this chapter.

Chapter 7 deals with neural networks for array signal processing. We show how to use neural networks to perform the computations required for estimating the directions of arrival (DOA) of sources. The DOA estimation methods to be considered in this chapter include the maximum likelihood technique, the alternating projection maximum likelihood technique, the MUSIC method of Schmidt, and the propagator method of Marcos. In addition, another important problem of array signal processing – beamforming – is also considered in this chapter. The emphasis is put on neural networks for computing the optimal weights of beamformers in real time.

In Chapter 8, various neural network approaches for system identification are presented. Real-time system identification, nonlinear system identification, and blind system identification are all dealt with on the basis of key features of neural networks.

Chapter 9 is devoted to neural networks for signal compression. Neural networks for the real-time implementation of the optimal linear predictive coding algorithm, for nonlinear predictive coding systems, for the Karhunen–Loève transform coding, for wavelet transform coding, and for vector quantization are reported in this chapter.

We hope that this book serves not only as a reference for professional engineers and scientists (majoring in communications, radar, sonar, automatic control, and other fields related to signal processing) but also as a textbook for graduate students in electronics engineering and computer science.

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