PREFACE

"One cannot learn anything so well as by experiencing it oneself."

—Albert Einstein

There are four major questions that should be answered in the preface to any textbook: (1) What is the book about? (2) Why publish another book on the particular subject, in this case artificial neural networks (or neural networks)? (3) Who is the intended audience for the book, and what are the prerequisites? (4) What is specifically contained in the book?

Question: What is the book about?

Answer: This textbook is about artificial neural networks (or neural networks). More specifically, the book covers *neurocomputing*. So the question really is, What is neurocomputing? Neurocomputing is concerned with processing information. Unlike its *programmed computing* counterpart, a neurocomputing approach to information processing first involves a *learning* process within an artificial neural network (neural network) architecture. This neural architecture *learns* or adaptively responds to inputs according to a defined learning rule. After the neural network has *learned* what it needs to *know*, the trained network can be used to perform certain tasks depending on the particular application. Neural networks have the ability to learn from their environment and adapt to it in an interactive manner similar to their biological counterparts. Neurocomputing can play an important role in solving certain problems in science and engineering that would otherwise be difficult to solve, problems such as pattern recognition, optimization, event classification, control and identification of nonlinear systems, and statistical analysis, to name a few. Therefore, this book is primarily intended for those individuals who want to understand the underlying principles of artificial neural networks for neurocomputing and want to be able to apply various neurocomputing techniques to solve problems in science and engineering.

Question: Why another book on neural networks?

Answer: The field of neural networks is vast and interdisciplinary. It has drawn interest from researchers from many different areas, and the contributions have been enormous. There are many very good books available in the area of neural networks. However, the authors felt that there was a need for a book on neural networks that scientists and engineers could specifically identify with, that is, a book for scientists and engineers who want to apply neural networks to solve complex problems. This statement should not be misconstrued to mean this book is a smorgasbord of neural architectures with their associated training algorithms. Instead, this textbook on neural networks presents a variety of neurocomputing approaches that can be used to solve a vast number of problems in science and engineering. In almost every case, a solid mathematical foundation is presented for each neurocomputing concept along with illustrative examples to accompany the particular architecture and associated training algorithm.

Question: Who is the intended audience for the book, and what are the prerequisites?

Answer: This book is primarily for courses offered in neural networks at the graduate level; however, advanced undergraduate students could manage the material in this textbook with the proper background (the second part to this answer). Moreover, practicing engineers and scientists can also learn the material through self-study. The prerequisites for the successful study of neurocomputing by using this textbook are primarily a background in linear algebra and differential equations. It would be desirable to have knowledge in the areas of random variables and stochastic processes but it is not necessary because this material is briefly (though sufficiently) covered in Appendix A.

Question: What is specifically contained in the book?

Answer: The book is divided into two major parts, detailed below. Appendix A covers the mathematical foundation for neurocomputing.

PART I: Fundamental Neurocomputing Concepts and Selected Neural Network Architectures and Learning Rules

Overview: Part I consists of Chapters 1 through 5.

Chapter 1 introduces the reader to the basic idea of neural networks and neurocomputing. Also included is a brief history of neural networks.

Chapter 2 begins with a discussion of basic models of artificial neurons that are the building blocks of neural networks. Next is a discussion of different types of activation functions followed by a presentation of the adaptive linear element (Adaline) and the multiple Adaline (Madaline). The least mean-square (LMS) algorithm is presented next; then the simple perceptron is detailed followed by a brief discussion of feedforward multilayer perceptrons. Some basic learning rules are covered next. Many of these learning rules are the basis for training more sophisticated neural network architectures. Chapter 2 concludes with an overview of selected data preprocessing methods. All the material in Chapter 2 should be thoroughly covered if the reader is not familiar with artificial neural networks. This chapter sets the stage for the in-depth coverage of selected neural network architectures and associated learning rules presented in Chapters 3 through 5.

Chapter 3 presents a variety of mapping neural networks, beginning with associative memories, followed by backpropagation used to train feedforward multilayer perceptrons. Next, more advanced training methods are given for backpropagation. Counterpropagation is then presented, and the chapter concludes with a presentation of radial basis function neural networks.

Chapter 4 discusses selected self-organizing neural networks. This includes the Kohonen self-organizing map (SOM) and learning vector quantization (LVQ). The chapter concludes with adaptive resonance theory (ART) neural networks; the ART1 network is presented in detail.

Chapter 5 presents recurrent neural networks along with temporal feedforward networks (which are also recurrent networks). The distinction is made between these temporal feedforward neural networks and those that are not multilayer feedforward networks. Included in this chapter are the Hopfield network, simulated annealing, the Boltzmann machine, the simple recurrent network (SRN), time-delay networks, and distributed time-lagged feedforward neural networks.

PART II: Applications of Neurocomputing

Overview: Part II consists of Chapters 6 through 10.

Chapter 6 presents selected neurocomputing approaches for solving constrained optimization problems. Neural networks for linear programming and quadratic programming problems are presented. The chapter concludes with a discussion of neural networks for nonlinear continuous constrained optimization problems. This section includes neural networks for nonlinear programming penalty and barrier function methods. Also included are neural networks for ordinary and augmented Lagrange multiplier methods.

Chapter 7 covers structured neural network architectures and associated learning rules for solving various matrix algebra problems. A wide variety of important matrix decompositions (or factorizations) are presented along with a neurocomputing solution for each method. Neurocomputing approaches are also given for computing the pseudoinverse of a matrix, solving the algebraic Lyapunov equation, and solving the algebraic Riccati equation.

Chapter 8 covers neurocomputing approaches for solving linear algebraic equations. The various methods include a least-squares neurocomputing approach, a conjugate gradient learning rule, a generalized robust neurocomputing approach, regularization methods for ill-posed problems with ill-determined numerical rank, matrix splittings for iterative discrete-time methods, and the total least-squares problem. Also, L_∞-norm and L_1-norm neural network approaches are presented for solving linear algebraic equations.

Chapter 9 contains many neural network architectures for statistical analysis of data, including neural networks for principal-component analysis (PCA), principal-component regression (PCR), classical least squares (CLS), neural networks for nonlinear PCA and robust PCA, a neural network approach for partial least-squares regression (PLSR), and a neural network approach for robust PLSR.

Chapter 10 covers neural networks for signal processing applications, linear and nonlinear system identification, nonlinear control, and estimation. Many different examples are explained in detail. Also included is independent-component analysis (ICA) using neural networks for blind source separation. In addition, a fast ICA algorithm is presented along with an example that applies the fast ICA algorithm to separation of digital images.

Key Features of the Book

- Most training algorithms are highlighted in the book so they can be easily referenced.
- Some of these training algorithms have an accompanying MATLAB® function implementation given in the text (also highlighted). The code is relatively short and takes only a few minutes to enter into MATLAB.
- In addition, the MATLAB neural network toolbox is used extensively to experimentally illustrate certain neurocomputing concepts.

- Some of the problems have data that reside on the McGraw-Hill Higher Education website for this book and can be easily accessed. The URL for this book is: http://www.mhhe.com/engcs/electrical/ham.
- Detailed examples are presented in most sections to illustrate the neurocomputing concept covered.
- An extensive set of problems is given at the end of each chapter (except Chap. 1). Some problems require the use of MATLAB and the MATLAB neural network toolbox. In some cases the code is provided for the MATLAB function.
- Appendix A contains a comprehensive mathematical foundation for neurocomputing.

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