

Preface

The human brain, consisting of nearly 10^{11} neurons, is the center of human intelligence. Human intelligence has been simulated in various ways. Artificial intelligence (AI) pursues exact logical reasoning based on symbol manipulation. Fuzzy logics model the highly uncertain behavior of decision making. Neural networks model the highly nonlinear infrastructure of brain networks. Evolutionary computation models the evolution of intelligence. Chaos theory models the highly nonlinear and chaotic behaviors of human intelligence.

Softcomputing is an evolving collection of methodologies for the representation of ambiguity in human thinking; it exploits the tolerance for imprecision and uncertainty, approximate reasoning, and partial truth in order to achieve tractability, robustness, and low-cost solutions. The major methodologies of softcomputing are fuzzy logic, neural networks, and evolutionary computation.

Conventional model-based data-processing methods require experts' knowledge for the modeling of a system. Neural network methods provide a model-free, adaptive, fault tolerant, parallel and distributed processing solution. A neural network is a black box that directly learns the internal relations of an unknown system, without guessing functions for describing cause-and-effect relationships. The neural network approach is a basic methodology of information processing. Neural network models may be used for function approximation, classification, nonlinear mapping, associative memory, vector quantization, optimization, feature extraction, clustering, and approximate inference. Neural networks have wide applications in almost all areas of science and engineering.

Fuzzy logic provides a means for treating uncertainty and computing with words. This mimics human recognition, which skillfully copes with uncertainty. Fuzzy systems are conventionally created from explicit knowledge expressed in the form of fuzzy rules, which are designed based on experts' experience. A fuzzy system can explain its action by fuzzy rules. Neurofuzzy systems, as a synergy of fuzzy logic and neural networks, possess both learning and knowledge representation capabilities.

This book is our attempt to bring together the major advances in neural networks and machine learning, and to explain them in a statistical framework. While some mathematical details are needed, we emphasize the practical aspects of the models and methods rather than the theoretical details. To us, neural networks are merely some statistical methods that can be represented by graphs and networks.

They can iteratively adjust the network parameters. As a statistical model, a neural network can learn the probability density function from the given samples, and then predict, by generalization according to the learnt statistics, outputs for new samples that are not included in the learning sample set.

The neural network approach is a general statistical computational paradigm. Neural network research solves two problems: the direct problem and the inverse problem. The direct problem employs computer and engineering techniques to model biological neural systems of the human brain. This problem is investigated by cognitive scientists and can be useful in neuropsychiatry and neurophysiology. The inverse problem simulates biological neural systems for their problem-solving capabilities for application in scientific or engineering fields. Engineering and computer scientists have conducted extensive investigation in this area. This book concentrates mainly on the inverse problem, although the two areas often shed light on each other. The biological and psychological plausibility of the neural network models have not been seriously treated in this book, though some background material is discussed.

This book is intended to be used as a textbook for advanced undergraduate and graduate students in engineering, science, computer science, business, arts, and medicine. It is also a good reference book for scientists, researchers, and practitioners in a wide variety of fields, and assumes no previous knowledge of neural network or machine learning concepts.

This book is divided into 25 chapters and two appendices. It contains almost all the major neural network models and statistical learning approaches. We also give an introduction to fuzzy sets and logic, and neurofuzzy models. Hardware implementations of the models are discussed. Two chapters are dedicated to the applications of neural network and statistical learning approaches to biometrics/bioinformatics and data mining. Finally, in the appendices, some mathematical preliminaries are given, and benchmarks for validating all kinds of neural network methods and some web resources are provided.

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A book of this length is certain to have some errors and omissions. Feedback is welcome via email at kldu@ieee.org or swamy@encs.concordia.ca. MATLAB code for the worked examples is downloadable from the website of this book.

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