Intelligent Control Based on Flexible Neural Networks

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Intelligent Control Based on Flexible Neural Networks

by

MOHAMMAD TESHNEHLAB
Faculty of Electrical Engineering,
K.N. Toosi University,
Tehran, Iran

and

KEIGO WATANABE
Department of Mechanical Engineering
Saga University,
Japan

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Contents

ANN	artificial neural network
BP	back-propagation
BSF	bipolar sigmoid function
LF	linear function
PID	proportional, integral and derivative
MNN	multilayered neural network
NNC	neural network controller
SF	sigmoid function
USF	unipolar sigmoid function

This book grew out of our research on artificial neural networks, which we have developed over the past few years. We wanted to produce a work which researchers and students of this area would find useful. The main framework of the book is based on a newly introduced series of neural networks which can be extensively used in a variety of theoretical and practical problems. We would like to thank our friends and colleagues for their useful and constructive suggestions, which helped to improve the text.

We are also grateful to Dr. M. Niaraki for his discussions on the biological concept of neurons in a very systematic manner. In addition, thanks are due to Dr. K. Izumi and Dr. J. Tang for their assistance and helpful advice. We also thank Professor S.G. Tzafestas, the executive editor of this series, and Catherine Murphy, Science & Technology Division of Kluwer Academic Publishers, for instigating and supporting us during the evolvement of the manuscript.

Finally, we would like to express our deepest sense of gratitude to our patient wives, for their encouragement and tolerance, to our children for their understanding and cooperation, and to our parents for their prayers that made it possible to us to undertake and accomplish this work.

This book presents the further developed foundations of artificial neural networks using new approaches throughout. These approaches are inspired by biological neuron concepts. Here, we are directly concerned with neuron models which are mimics of the biological neuron cell body and its basic functions. In some cases, the differences and deficiencies of conventional artificial neural networks compared with new approaches, which are more aligned to the performance abilities of the biological network, are discussed in detail. Generally, the newly developed paradigms of artificial neural networks have strongly contributed to the discovery, understanding, and utilization of potential functional similarities between human and artificial information processing systems. The study of the literature shows how far the relatively advanced brain models could be used to simplify the neural network controller synthesis for non-linear and complex systems such as technical processes. The conventional neural network controller is fairly complicated, even for those systems that are easily handled by humans. However, some scientists started to explore the simplification of neural network controllers by using this idea in complicated applications. The ultimate research objective of these efforts is to develop a general theory and to implement massively parallel interconnected systems which can process the information with an efficiency comparable to that of the human brain.

To achieve the main objective, it is necessary to focus on the study of artificial neural systems. These systems are physical cell bodies which can acquire, store, and utilize experimental knowledge. Actually, this assumption has been proven in this book. The book makes use of abstractions from findings on the neuron and ideas concerning the biological cell body. Generally speaking, the knowledge is in the form of stable states in networks that can be recalled in response to certain codes. We have mainly focussed on the foundations of such networks.

The fundamentals of conventional and the new interpretations of networks theory, algorithms for information acquisition and retrieval, examples, simulations of new approaches, and implementation issues, are included in several chapters of the book.

The book is aimed at students and researchers interested in the acquisition and retrieval of experiential knowledge in interconnected networks containing cells of processing elements and their links. Each chapter is self-sufficient, assuming that the reader is already familiar with the fundamental concepts developed in chapter 2. Every effort has been made to include stimulating examples in each chapter and this is especially true with chapters 4 to 8. This will help the reader to easily and efficiently grasp the main concepts of the new approaches. Those chapters that focus on adaptive control and optimization, implicitly assume that the intelligent control utilizes artificial neural networks, which in turn are trainable over time to achieve the predetermined goals in non-linear, complex and noisy environments, the dynamics of which must ultimately be learned in real time. This kind of control cannot be achieved by simple methods and the new approaches can be counted as a considerable improvement in the existing control theory.

This book, with its multi-method approach, not only provides the students and researchers with an overview of conventional artificial neural networks, but also discusses the new approaches in depth and in an easy manner. The new approaches, called flexible neural networks, provide an optimal network which is incorporated in the framework of artificial intelligent controller. Artificial neural networks are discussed in some detail, but more emphasis has been placed on the new approaches as potential intelligent controllers.

Keigo Watanabe and Mohammad Teshnehlab
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