Perspectives in Neural Computing

Springer-Verlag London Ltd.

Also in this series:

Adrian Shepherd
Second-Order Methods for Neural Networks
3-540-76100-4

Dimitris C. Dracopoulos
Evolutionary Learning Algorithms for Neural Adaptive Control
3-540-76161-6

John A. Bullinaria, David W. Glasspool and George Houghton (Eds)
4th Neural Computation and Psychology Workshop, London,
9-11 April 1997: Connectionist Representations
3-540-76208-6

Maria Marinaro and Roberto Tagliaferri (Eds)
Neural Nets - WIRN VIETRI-97
3-540-76157-8

Gustavo Deco and Dragan Obradovic
An Information-Theoretic Approach to Neural Computing
0-387-94666-7

Thomas Lindblad and Jason M. Kinser
Image Processing using Pulse-Coupled Neural Networks
3-540-76264-7

L. Niklasson, M. Bodén and T. Ziemke (Eds)
ICANN 98
3-540-76263-9

Maria Marinaro and Roberto Tagliaferri (Eds)
Neural Nets - WIRN VIETRI-98
1-85233-051-1

Amanda J.C. Sharkey (Ed.)
Combining Artificial Neural Nets
1-85233-004-X

Dirk Husmeier
Neural Networks for Conditional Probability Estimation
1-85233-095-3

Achilleas Zapranis and Apostolos-Paul Refenes
Principles of Neural Model Identification, Selection and Adequacy
1-85233-139-9

Mark Girolami
Self-Organising Neural Networks
1-85233-066-X

Maria Marinaro and Roberto Tagliaferri (Eds)
Neural Nets - WIRN VIETRI-99
1-85233-177-1

Walter J. Freeman
Neurodynamics: An Exploration in Mesoscopic Brain Dynamics
1-85233-616-1

Paulo J.G. Lisboa, Emmanuel C. Ifeachor
and Piotr S. Szczepaniak (Eds)

Artificial Neural Networks in Biomedicine

Springer

Paulo J.G. Lisboa, BSc, PhD
School of Computing and Mathematical Sciences, Liverpool John Moore's University, Liverpool, L3 3AF, UK

Emmanuel C. Ifeachor, BSc, MSc, PhD
School of Electronic, Communication and Electrical Engineering, University of Plymouth, Plymouth, UK

Piotr S. Szczepaniak, MSc, PhD, DSc
Institute of Computer Science, Technical University of Lodz, Lodz, Poland

Series Editor
J.G. Taylor, BA, BSc, MA, PhD, FInstP
Centre for Neural Networks, Department of Mathematics, King's College, Strand, London WC2R 2LS, UK

ISBN 978-1-85233-005-7

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data
Artificial neural networks in biomedicine / Paulo J.G. Lisboa, Emmanuel C. Ifeachor, and Piotr S. Szczepaniak (eds.).
p. cm. – (Perspectives in neural computing)
Includes bibliographical references and index.
ISBN 978-1-85233-005-7 ISBN 978-1-4471-0487-2 (eBook)
DOI 10.1007/978-1-4471-0487-2

1. Artificial intelligence—Medical applications. 2. Neural networks (Computer science) 3. Diagnosis—Data processing. 4. Expert systems (Computer science) I. Lisboa, P.J.G. (Paulo J. G.), 1958- . II. Ifeachor, Emmanuel C. III. Szczepaniak, Piotr S., 1953- . IV. Series.
R859.7.A78A79 1999 99-29082
610'.285'632—dc21 CIP

Originally published by Springer-Verlag London Berlin Heidelberg in 2000

Typesetting: camera ready by editors and Florencetype Ltd., Devon

34/3830-543210 Printed on acid-free paper SPIN 10658813

Preface

Following the intense research activities of the last decade, artificial neural networks have emerged as one of the most promising new technologies for improving the quality of healthcare. Many successful applications of neural networks to biomedical problems have been reported which demonstrate, convincingly, the distinct benefits of neural networks, although many of these have only undergone a limited clinical evaluation. Healthcare providers and developers alike have discovered that medicine and healthcare are fertile areas for neural networks: the problems here require expertise and often involve non-trivial pattern recognition tasks - there are genuine difficulties with conventional methods, and data can be plentiful.

The intense research activities in medical neural networks, and allied areas of artificial intelligence, have led to a substantial body of knowledge and the introduction of some neural systems into clinical practice. An aim of this book is to provide a coherent framework for some of the most experienced users and developers of medical neural networks in the world to share their knowledge and expertise with readers.

Despite the significant number of research projects, artificial neural networks have not yet received widespread acceptance in medicine and healthcare. This is due, to a large extent, to problems associated with the safety critical nature of the medical domain. As yet, we do not have a full understanding of how neural networks actually reach specific conclusions, and most medical neural networks developed so far have not undergone extensive clinical evaluations. Against this background, it is easy to see why there are very few neural systems in routine clinical use.

This book is a survey of accomplished applications of neural network methods to biomedical diagnosis, medical data analysis and related areas. It comprises tutorial articles, and self-contained case studies. The latter involve the specialisation of neural networks to the solution of specific clinical problems, usually in collaboration with medical experts and other healthcare workers. Some of the applications are mature and can be viewed as good models of how to develop medical neural systems, including the stages which a successful artificial intelligent system should go through. We hope that the presentation of such mature applications in the book will facilitate the transfer of neural networks technology into clinical practice.

The authors include users and developers: medical doctors, engineers, scientists and industrialists from Europe and the USA. The medical neural systems described include some that are now in routine clinical use and some that have reached an advanced stage of development, having undergone extensive clinical evaluations. These include the Papnet, a medical neural network system which has been approved by the US Food and Drug Administration (FDA) for the quality control of smears to assist clinicians in the area of diagnostic cytology (cancer detection and cancer diagnosis), and the neural network-based system, ProstAsure which is used for the early detection of prostate cancer in men. The latter system also provides an insight into a likely growth area for medical neural networks and other intelligent systems in the next century, namely as a key component of a remote, on-line data processing and analysis service. As patient records and data become readily available in digital format such a service is likely to become an integral part of an on-line healthcare delivery systems.

The book covers a wide range of other medical applications of neural networks, including EEG and evoked potential analysis (e.g. for tumour detection, assessment of brain dysfunction, and assessment of intra-operative anaesthesia), analysis of spinal injury and functional electrical stimulation, patient monitoring in intensive care units, pathological speech analysis, diagnosis of different types of cancer and genetic disorders, and diabetic retinopathies studies. We find that most of the applications exploit the pattern recognition capability of neural networks, diagnosing or detecting the presence of specific diseases or to determining the outcome of a disease. Neural networks have also been used at a lower level for front-end, event detection and classification prior to high level decision making.

Many of the applications confirm the importance of data pre-processing as an important factor in the successful training and use of medical neural networks in the real-world. Data pre-processing simplifies the network and imparts it with domain knowledge by extracting high level features, often those that are used by human experts, to enhance the efficiency of learning and performance during use. The basic neural network methods covered in this book include a variety of architectures and learning paradigms – e.g. the Multi-Layer Perceptron, Bayesian networks, self-organising networks and the Fuzzy Artmap.

The book contains 19 chapters, arranged in 4 thematic sections:

- Tutorial;
- Computer aided diagnosis;
- Signal Processing;
- Image Processing.

Each section includes a brief introduction to put the materials into context, and each chapter features at least one biomedical application of neural networks. Each chapter covers some, or all, of the following aspects:

An overview of the medical condition at the focus of the study;

- An introduction to the technical aspects of neural computing which need to be resolved in order to arrive at a solution, written in a self-contained manner;
- The impact of practical issues such as missing data, low prior probabilities for certain classes, the structuring of decision making processes and data pre-processing;
- Validation issues, including benchmarking results using alternative methods, relating them to a 'gold' standard;
- Issues relating to the acceptance of neural systems by healthcare practitioners.

This book is of interest to clinicians, engineers, managers, academics, and students who are interested in medical applications of neural networks and their transfer into clinical practice.

Finally, the Editors are grateful to the authors for their hard work and for sharing their experiences so readily. We thank Nick Power for his painstaking efforts in assembling the camera ready copy of this book, and the staff of Springer Verlag for their understanding, patience and support throughout this project

Paulo Lisboa, Emmanuel Ifeachor and Piotr Szczepaniak
June, 1999.

Contents