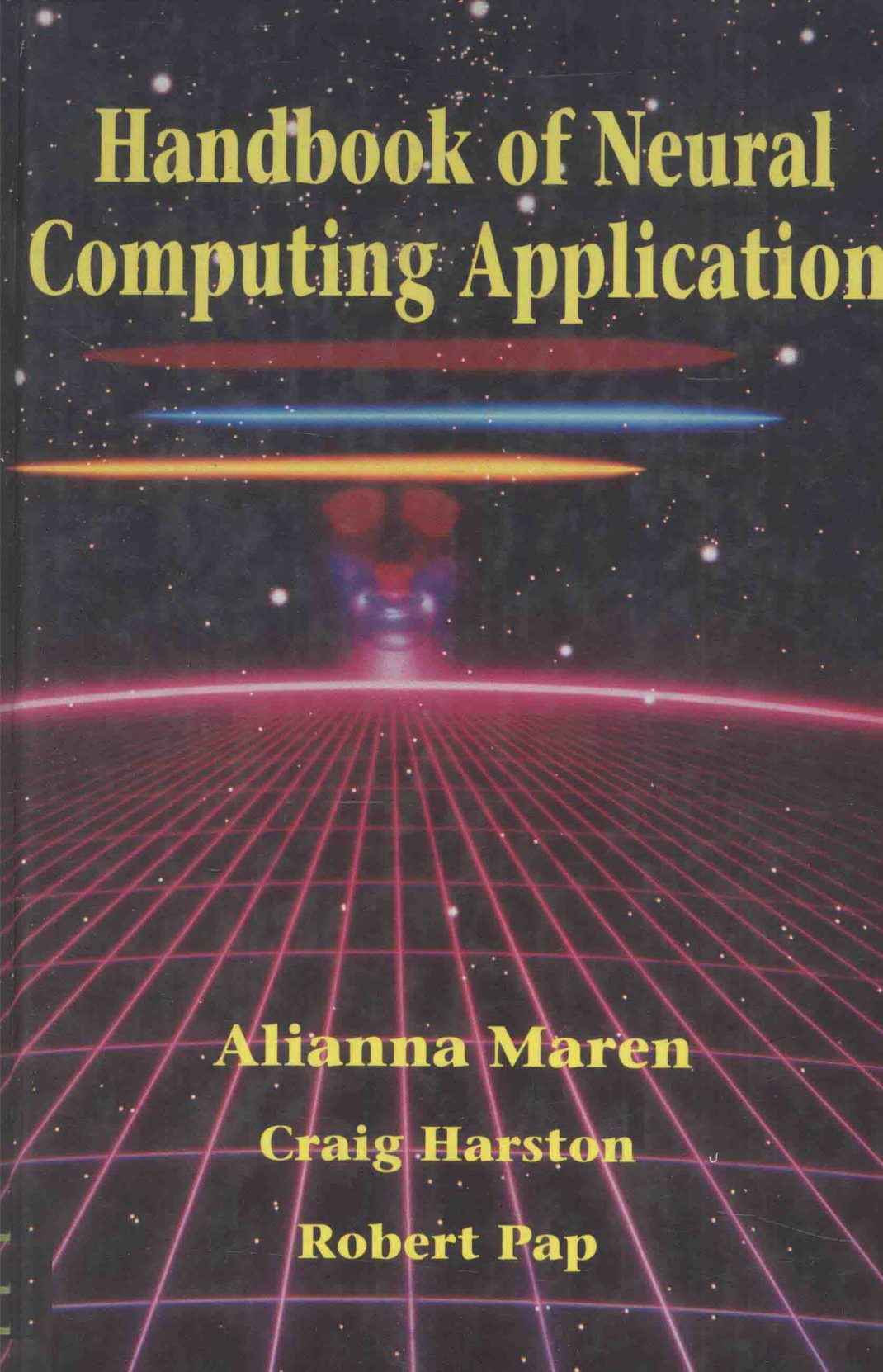
Handbook of Neural Computing Application



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HANDBOOK OF NEURAL COMPUTING APPLICATIONS

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藏书章

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ACADEMIC PRESS, INC.
Harcourt Brace Jovanovich, Publishers
San Diego New York Boston
London Sydney Tokyo Toronto

This book is printed on acid-free paper. ∞

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Academic Press, Inc.
San Diego, California 92101

United Kingdom Edition published by
Academic Press Limited
24–28 Oval Road, London NW1 7DX

Library of Congress Cataloging-in-Publication Data

Handbook of neural computing applications / Clifford R. Parten ... [et al.].
p. cm.
Includes bibliographical references.
ISBN 0-12-546090-2
1. Neural computers. I. Parten, Clifford R.
QA76.5.H35443 1990
006.3--dc20 89-48104
CIP

Printed in the United States of America
90 91 92 93 9 8 7 6 5 4 3 2 1

ACKNOWLEDGMENTS

An endeavor such as this is possible only with the support, encouragement, and active involvement of many people. I want to thank, in order, my co-authors, contributing authors and editors, the marvelous support team at the University of Tennesee Space Institute, the reviewers of this book, and my family and friends. In addition, this work was undertaken while both I and my co- authors were supported by many research contracts which allowed us to investigate neural network capabilities for many applications areas. As with any undertaking, the time was too short for everything which we wanted to include. We both hope and anticipate that the next edition will be longer and more detailed, and will cover some of the applications which we did not have the opportunity to address in this first edition.

Thanks also go first to Robert M. Pap, who came up with the idea for this book and who organized the contractual arrangements. He provided numerous insights and ideas for the structure and content of the book. Craig Harston cheerfully contributed his chapters on time and with enthusiasm. Both Bob and Craig were instrumental in involving some of our contributing authors.

Each of our contributing authors—Stanley P. Franklin, Robert L. Gezelter, Dan Jones, Steven G. Morton, Patrick K. Simpson, Harold Szu, and Paul J. Werbos—were outstanding and a joy to work with. Each provided high-quality initial chapters, and cheerfully accomodated requests for revisions. More important, they contributed their own suggestions for revisions and passed on important papers which contributed to the overall quality of this document.

Without several key people, this book simply could not have been given the shape, form, and quality which it now has. I'd like to thank Alan Rose, President of Intertext Publications, who facilitated the production of this book, and Jeanne Glasser, our copy editor, who did a heroic job of wrestling the chapters from multiple authors into a coherent whole. In addition, Ms. Glasser coordinated artwork and proofs, helped us obtain permission for reproduction of previously published material, and facilitated a smooth transition to page layout and design. Her unfailing cheerfulness and support, and amazing amount of hard work within a short time, have made this book what it is.

Dr. Robert E. Uhrig, Director of the Tennessee Center for Neural Engineering and Applications, was tremendously helpful in his support and encouragement throughout the long process. I also appreciate his willingness to use this book as the text for his course in neural networks at the University of Tennnessee/Knoxville, in order to obtain student feedback and review.

Dr. Wesley L. Harris, Vice President of UTSI, and Mr. Ray Harter, Director of Finance and Adminstration at UTSI, helped create the environment which made this book possible.

Lisa Blanks, Sherry Veazey, and Larry Reynolds of UTSI's graphics department did an outstanding job in producing the beautiful graphics which are used throughout the

book. The library staff of UTSI; Mary Lo, Marge Joseph, Carol Dace, and Brenda Brooks, helped immeasurably in obtaining needed books and resources and in checking on some of the references. I owe each of these people a great debt.

Many people have reviewed this book and offered helpful comments. I'm deeply appreciative of each of them for helping me see the forest as well as the trees. These individuals include Dr. Robert Uhrig, Dr. Harold Szu, Awatef Gacem, Bryan and Gail Thompson, Guy Lukes, Gary Kelly, and Michael Loathers. Dr. Cliff Parten and Mary Rich also provided valuable assistance.

While working on this book, I and my co-authors Robert Pap and Craig Harston were supported by several contracts for research and development in neural networks. We would like to thank each of our sponsoring organizations and contract officer technical representatives for their support. These include Richard Akita at the Naval Ocean Systems Command (N66001-89-C-7063), Dr. Joel Davis at the Office of Naval Research (N00014-90-C-0155), Ralph Kissel and Richard Dabney at the National Aeronautics and Space Agency—Marshall Space Flight Center (NAS8-38443), George Booth at the Department of Transportation/Transportation Systems Center (DTRS-57-90-C00057), Dr. Kervyn Mach at the Air Force National Aerospace Plane Joint Project Office (F33657-90-C-2206), Dr. Frank Huban at the National Science Foundation (ECS-8912896), and John Llewellen at the Department of Energy (DoE-DEFG-88-ER-12824). I and the co-authors have also been supported at various times by contracts with General Dynamics, UNISYS, and Sverdrup Technology, Inc.

We wish to thank Ms. Veronica Minsky, Dr. Stephen Lemar, Dr. Francois Beausays, and Dr. Bernard Widrow for allowing us advance publication of their research within this book. We further acknowledge and appreciate permission for reproduction of material published by Ablex Corporation, Donald I Fine, Inc., HarperCollins Publishers, the Institute of Electrecial and Electronics Engineers, Inc. (IEEE), the Optical Society of America, Pergamon Press, Tor Books, Springer-Verlag, and William Morrow & Co.

We also wish to express appreciation for permission to reproduce previously printed and/or copyrighted material by Dr. Robert Hecht-Nielson Dr. Kunihiko Fukushima, Dr. Teuvo Kohonen, Dr. Richard Lippmann, Ms. Anne McCaffrey, Dr. M.M. Menon and Dr. G.K. Heineman.

I also wish to thank Ms. Lucy Hayden, editor of the Journal of Neural Network Computing (Auerbach) for sponsoring my columns which have been published in that journal on a regular basis. These gave me my first opportunity to extend an in-depth exploration into the field of neural networks.

Finally, I'd like to thank my father, Dr. Edward J. O'Reilly, my sister, Ann Marie McNeil, and my friends Jean Miller, Cornelia Hendershot, Joni Johnson, and Marilyn Everett for their support and encouragement through the many hours of work on this book. Thank you, one and all.

Alianna J. Maren

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PREFACE

In 1986, when neural networks made their first strong reemergence since the days of Rosenblatt's Perceptron, there was only one comprehensive book available on neural networks—*Parallel Distributed Processing,* edited by David Rumelhart, James McClelland, and the PDP Research Group. Now, as I write this preface, I have eight additional broad-sprectrum neural networks books in front of me, including this *Handbook.* These books, published within the last two years, reflect the extraordinary growth of interest in neural networks which has developed in recent years. Each book has something special to offer. What is unique, special, and useful about this one?

First, this book allows the reader to more clearly and cohesively organize information, currently available, on neural networks. With the number of neural networks growing at nearly an exponential rate, this is absolutely necessary. As an example of this growth, we can chart the descriptions of different types of networks gathered in a single publication over the past five years. In *Parallel Distributed Processing,* Rumelhart, McClelland, et al. describe four major types of networks. In a 1987 review paper, Richard Lippmann described seven. Later that year, Robert Hecht-Nielson wrote a review which summarized the characteristics of thirteen different networks. In 1988, Patrick Simpson wrote a pair of review papers (published in 1990 as *Artificial Neural Systems*) which described about two dozen networks. This book likewise describes two dozen specific network types and they are different from the ones described by Pat Simpson.

This almost exponential growth in the number of known networks was due at first to a coalescence of knowledge which had been painstakingly developed over a more than twenty-year period. More recently, it is due to the wide variety of networks which have been developed within just the past two years. As the number of diverse types of neural networks grow, we need a cohesive framework, a context within which to view and work with these different network types.

In addition to the number of networks available, there are new developments in both implementations and applications alternatives. Although such luminaries as Carver Mead have a long-standing commitment to neural network hardware realizations, most neural network implementations (analog electronic, digital electronic, optical, and hybrid) have been developed within the last five years.

Neural networks have been applied to a wide variety of applications. A glance at the proceedings of any one of the major neural networks conferences will reveal an astonishing variety of applications areas: from speech and hand-written test recognition, sensor data fusion, robotic control, signal processing, to a multitude of classification, mapping, and optimization tasks. While many of these applications use well-known networks such as the back-propagating Perceptron network or the Hopfield/Tank network, there are many other, less well-known networks which are growing steadily in significance. These include the Adaptive Resonance Theory network, the Brain-

State-in-a-Box network, the Learning Vector Quantization network, the Neocognitron, the self-organizing Topology-Preserving Map, and many others. All of these networks are finding practical use in a wide variety of applications areas. Many are either implemented or scheduled for implementation in real systems.

Not only has the number of applications grown, but also our knowledge of the ways in which various networks can be used for applications has increased. For example, the back-propagating Perceptron network has long been used as a classifier. However, this network can also perform signal segmentations, noise filtering, and complex mappings (in some cases, measurably better than algorithmic and/or rule-based systems). As another example, the Topology-Preserving Map has been used for sensory mapping. More recently, it has also been used for optimization tasks and for sensor data fusion. This extension of our awareness of the potential uses for different neural networks is one of the motivating factors for writing this book.

The *Handbook of Neural Computing Applications* may be conceptually divided into five parts. The first part (Chapters 1-6), forms a background and context for the exploration and study of different neural networks. In addition to chapters on the history and biology of neural networks, we cover the three key aspects which define each neural network type and function; structure, dynamics, and learning. We make the distinction between micro-, meso-, and macro-levels of structural description. These different levels of descriptive detail permit us to focus our attention on the neuronal, network, and system levels of structural organization respectively. By identifying various structural classes of networks (e.g. multilayer feedforward networks), we create an overall structure, or topology for organizing our knowledge of networks; for comparing, say, a back-propagating Perceptron with a Boltzmann machine, or a Hopfield network with a Brain-State-in-a-Box network. This allows people to organize their knowledge about the many neural networks more clearly and cohesively than ever before.

In Chapters 7-13, which form the second conceptual part of this book, we delve into specific neural network types. We describe each network in terms of its underlying concept, structure, dynamics, learning, and performance. We point out some of the most significant applications of each major network type. For certain key networks (e.g. the Hopfield, and later, the back-propagating Perceptron), we identify ways in which researchers have suggested improvements to the basic network concept. This allows network developers to build networks which have better storage, or which learn faster, or which yield more accurate results than was provided by the original network models.

Neural network implementations are a special issue; distinct from discussion of network types. In the third part of this book, we offer four chapters on selecting, configuring, and implementing neural networks. Chapter 14, contributed by Drs. Dan Jones and Stanley P. Franklin, discuss how to determine whether a neural network might be the right tool for a given application, and which networks to consider for various applications tasks. Chapter 15 deal with how to configure and optimize the back-propagation network, which is still the network of choice for 70% (or more) of current neural networks applications. Steven G. Morton, president of Oxford Computer, Inc. and developer of the Intelligent Memory Chip, provides a comparative discussion of analog and digital electronic implementation alternatives in Chapter 16. Dr. Harold L. Szu, inventor of the Cauchy machine and a long-time researcher in optical neural networks, discusses optical implementation possibilities in Chapter 17.

In the remaining chapters of this book, we address specific applications issues. While some of the applications chapters have been written by myself or my co-authors, we are especially privileged to have several contributed chapters written by outstanding experts in their applications domain. Dr. Paul J. Werbos, inventor of the back-propagation method for network learning (as well as several more advanced methods, such as the back-propagation of utility through time), has contributed a chapter on neurocontrol which is accessible to both control engineers who want an introduction to neural networks, and to neural networks researchers who want to learn about the potential of using a neurally-based approach for control. To my knowledge, this is the best introduction to neurocontrol available.

Patrick K. Simpson is probably the world's leading expert in using neural networks for sonar signal processing, and has contributed a chapter on that topic. Many of the processes which he describes could be applied to other types of spatio-temporal pattern recognition as well. Dr. Dan Jones, a physician with a background in electrical engineering and signal processing, has explored how neural networks can be used to aid medical diagnoses. Robert L. Gezelter, who specializes in system design with an emphasis on test and verification issues, has contributed (with Robert Pap) a unique and timely chapter on neural networks for fault diagnosis, which is prefaced by an introduction by Dr. Werbos. In addition to these guest chapters, Craig Harston, Robert Pap, and I have written chapters dealing with neural networks for spatio-temporal pattern recognition, robotics, business, data communications, data compression, and adaptive man-machine systems.

The last chapter in this book is a look to the future— "Neurocomputing in the Year 2000." As we approach the end of the second millennium, we are witnessing an accelerated degree of technical and societal change. This chapter explores the possibilities—from the mundane to the outrageous—of how our future will be influenced by neural computing technology.

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September, 1990

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