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Technical Books Section

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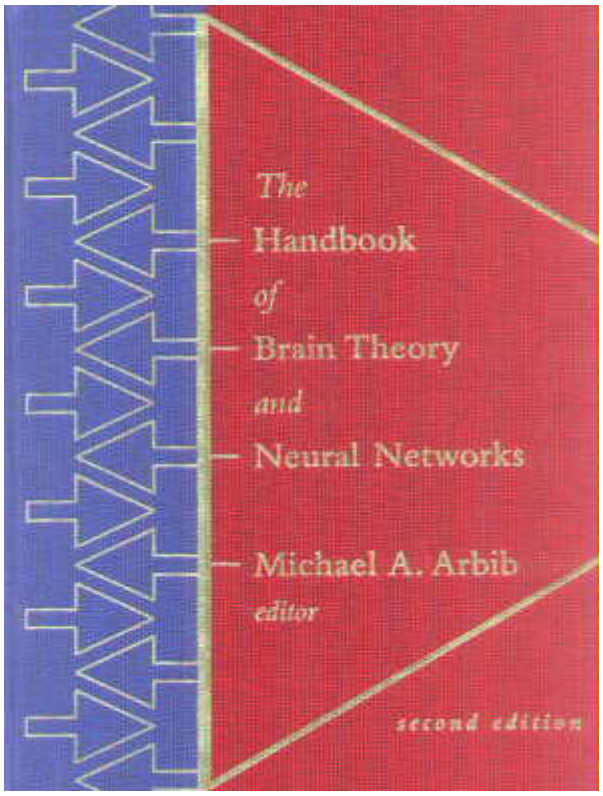
Email Dr. Thomas by clicking here

STIMULATING

The Handbook of Brain Theory and Neural Networks, 2nd edition, *Edited by* Michael A. Arbib, hard cover, 8.5" x 11.5"
The MIT Press, Massachusetts Institute of Technology, Cambridge, Massachusetts 02142 (A Bradford Book): xviii + 1290 Pages: Publication Date: 2003: ISBN 0-262-01197-2: Price - $195.00



This volume is inspired by two great questions: "How does the brain work?" and "How can we build intelligent machines?"

This "Handbook" is stimulating and it achieves its aim of ensuring that readers will not only turn to the book to get good brief reviews of topics in their own specialty, but also find many invitations to browse widely - finding parallels amongst different sub fields, or simply enjoying the discovery of interesting topics far from familiar territory.

Brain theory is centered on "computational neuroscience", but it also includes attempts to understand the brain and its function through a variety of theoretical constructs and computer analogies.

The term neural networks has been used for a century or more to describe the networks of biological neurons that constitute the nervous systems of animals, whether invertebrates or vertebrates. Since the 1940s, and especially since the 1980s, this term has been used for a technology of parallel computation in which the computing elements are "artificial neurons" loosely modeled on simple properties of biological neurons, usually with some adaptive capability to change the strengths of connections between the neurons.

The "Handbook" focuses on structural and functional "networks" whose units are in scales and finer than that of the neuron. It also samples non-neural approaches to the design and analysis of "intelligent" machines.

In between the biologists and technologists are the connectionists who use artificial neural networks in psychology and linguistics and make related contributions to artificial intelligence, using neuron-like units which interact "in the style of the brain" at a more abstract level than that of individual biological neurons.

Many texts have described limited aspects of one sub field or another of brain theory and neural networks, but no truly comprehensive overview is available. This "Handbook" fills that gap, presenting the entire range of the following topics:

(1) detailed models of single neurons;

Figure 1: This book is illustrated with several figures. This one here illustrates how the human brain recognizes human faces through correspondence maps (this figure appears on page 435 of this book)



(2) analysis of a wide variety of neurobiological systems;

(3) "connectionist" studies;

(4) mathematical analyses of abstract neural networks; and

(5) technological applications of adaptive, artificial neural networks and related methodologies.

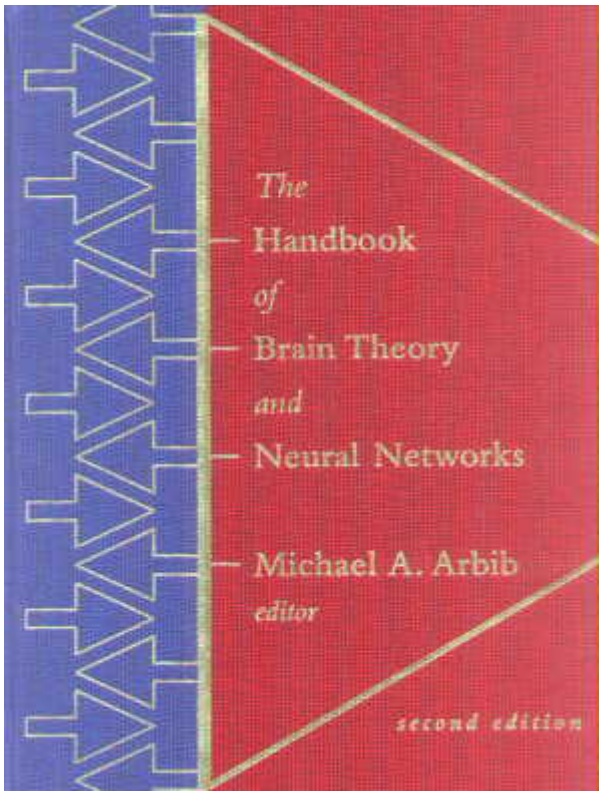
The excitement, and the frustration, of these topics is that they span such a broad range of disciplines, including mathematics, statistical physics and chemistry, neurology and neurobiology, and computer science and electrical engineering, as well as cognitive psychology, artificial intelligence and philosophy.

Much effort has gone into making the book accessible to readers with varied backgrounds (an undergraduate education in one of the above areas, for example, or the frequent reading of related articles at the level of the *Scientific American*) while still providing a clear view of much of the recent specialized research.

The book is divided into three parts - Part I, Part II and Part III. Parts I and II of the book provide a more general approach to helping readers orient themselves. More than 90% of this book is taken up by part III, which has 285 separately authored articles, covers a vast range of topics in brain theory and neural networks, from language to motor control, and from the neurochemistry to the statistical mechanics of memory. Each article has been made as self-contained as possible, but the very breadth of topics means that few reader will be expert in a majority of them.

The introductory section "How to use the Book" provides a more detailed view of the structure of the book.

Part I: Background: The Elements of Brain Theory and Neural Network



" .. Part I is introductory in nature and provides the elementary background material for readers new to computational neuroscience or theoretical approaches to neural networks considered as dynamic, adaptive systems including modeling of both brain and biological and artificial neural networks. ... "

This part provides the elementary background material for readers new to computational neuroscience or theoretical approaches to neural networks considered as dynamic, adaptive systems including modeling of both brain and biological and artificial neural networks. In other words, it presents a perspective on the "landscape" of brain theory and neural networks, including an exposition of the key concepts for viewing neural networks as dynamic, adaptive systems.

Section I.1, "Introducing the Neuron" conveys the basic properties of neurons and introduces several basic neural models.

Section I.2, "Levels and Styles of Analysis", explains the interdisciplinary nexus in which the present study of brain theory and neural networks is located, with historical roots in cybernetics and with current work going back and forth between brain theory, artificial intelligence, and cognitive psychology. The different levels of analysis involved are reviewed with schemas providing the functional units intermediate between an overall task and neural networks.

Section I.3, "Dynamic and Adaptation in Neural Networks" provides a tutorial on the concepts essential for understanding neural networks as dynamic, adaptive systems.

Part II: Road Maps: A guided tour of Brain theory and Neural Networks

It provides a series of road maps to help readers interested in a particular topic steer through the Part III articles on that topic. The road maps then provide on entrée into the many articles of Part III, with "road maps" for 22 different themes.

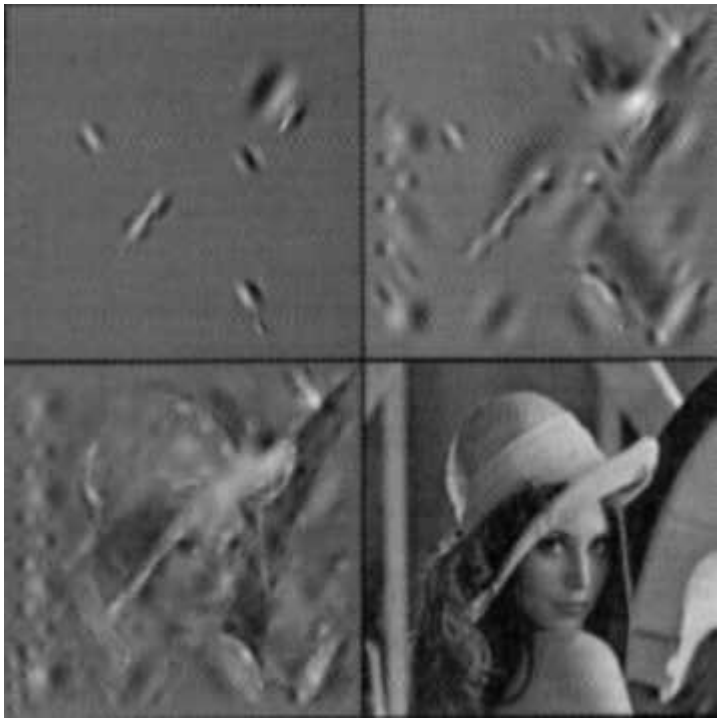
Section II.1: presents a "Meta - Map", which introduces Part II, and groups these themes under eight general headings or are in the form of 22 different road maps that, among them, place every article in Part III is a thematic perspective.

It is a simple way to approach the richness of the "Handbook", making it easy for the reader to identify one or two key road maps of special interest. Each road map starts with an alphabetical listing of the articles most relevant to the current theme. The road map may itself provides suggestions for interesting traversals of articles, but this need not provide necessary background for the articles it precedes.

The eight general headings which, in and of themselves, give some sense of the sweep of the "Handbook" are:

1) Grounding Models of Neurons and Networks

Figure 2: The figure here is an illustration of the completeness of 2D Gabor wavelets as image coding primitives. The benchmark "Lena" picture is reconstructed by progressive numbers of wavelets in linear combination, of 25, 100, 500, and 10,000. The primary facial features are effectively represented by just a handful of such wavelets (this figure appears on page 460 of this book)



A) Grounding Models of Neurons

B) Grounding Models of Networks

2) Brain, Behaviour, and Cognition

A) Neuroethology and Evolution

B) Mammalian Brain Regions

C) Cognitive Neuroscience

3) Psychology, Linguistics, and Artificial Intelligence

A) Psychology

B) Linguistics and Speech Processing

C) Artificial Intelligence

4) Biological Neurons and Networks

A) Biological Neurons and Synapses

B) Neural Plasticity

C) Neural Coding

D) Biological Networks

5) Dynamics and Learning in Artificial Networks

Figure 3: This picture is an illustration of facial feature detection by the quadrature demodulator network, which has been illustrated in the book on the previous page (this figure appears on page 462 of this book)



A) Dynamic systems

B) Learning in Artificial Networks

C) Computability and Complexity

6) Sensory Systems

A) Vision

B) Other Sensory Systems

7) Motor Systems

A) Robotics and Control Theory

B) Motor Pattern Generators

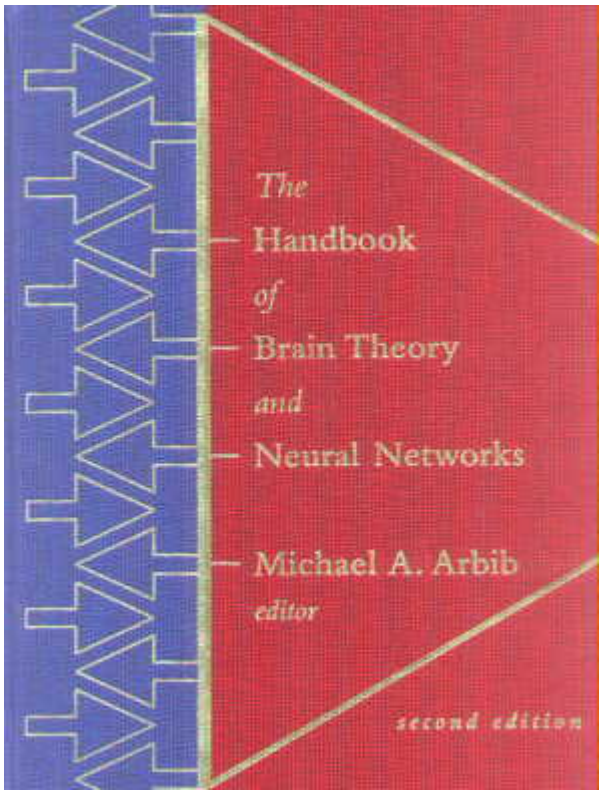
C) Mammalian Motor Control

8) Applications, implementations, and Analysis

A) Applications

B) Implementation and Analysis

Part III: Articles



" .. Part III forms the heart or almost 90% of the book. It consists of a set of 285 articles which cover the whole spectrum of Brain Theory and Neural Networks. The articles are arranged in alphabetical order which makes it easier to find a specific topic and because a given article may be relevant to more than one of the themes of Part II, a fact that would be hidden were the article to be relegated to a specific section devoted to a single theme. ... "

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The Contributors list lets one locate each article written by a given author.

Each article meets the following requirements:

(A) It is authoritative within its own sub field, yet accessible to students and experts in a wide range of other fields.

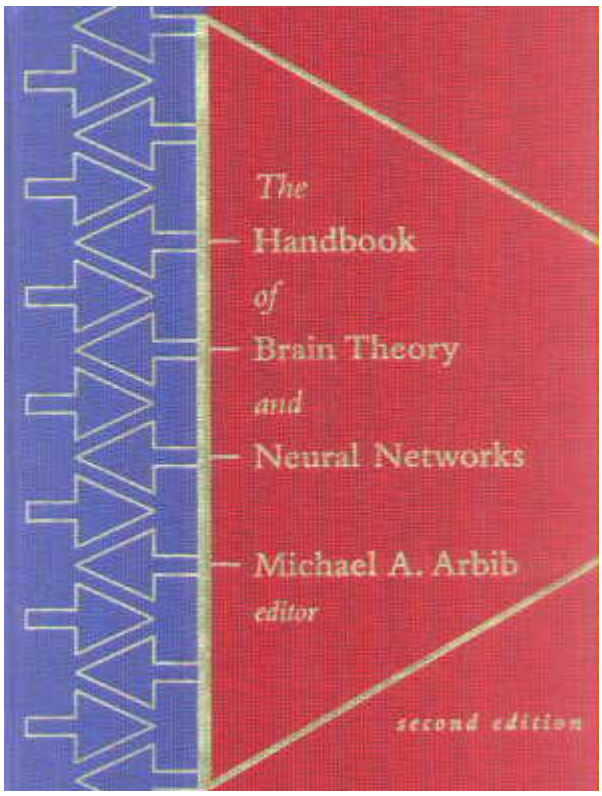
(B) It is comprehensive, yet short enough that it concepts can be acquired in a single sitting.

(C) It includes a list of references, limited to 15, to give the reader a well defined and selective list of places to go to initiate further study.

(D) It is as self-contained as possible, while providing cross references to allow readers to explore particular issues of related interest.

Most of these articles assume some prior familiarity with neural networks, whether biological or artificial and so the reader new to neural networks is encouraged to master the material in Part I before tackling Part III.

Most articles in Part III have the following structure:



" .. Most of these articles (in Part III) assume some prior familiarity with neural networks, whether biological or artificial. So the reader new to neural networks is encouraged to master the material in Part I before tackling Part III. ... "

(1) Introduction

It provides a non-technical overview of the material covered in the whole article.

(2) Intervening sections

They may be more or less technical, depending on the nature of the topic. The first and last sections give most readers a basic appreciation of the topic, irrespective of such technicalities.

(3) Final section

It provides a discussion of key points, open questions, and linkages with other areas of brain theory and neural networks.

(4) Bibliography

References are there primarily to help readers who look for an introduction to the literature on the given topic, including background material, relevant review articles, and original research citations.

In addition to formal references to the literature, each article contains numerous cross-references to other articles in the "Handbook". These may occur either in

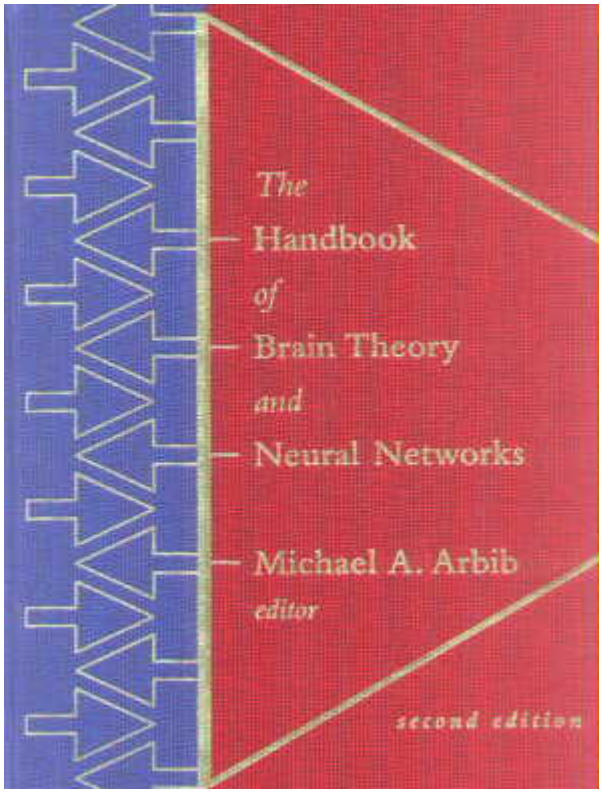
a) the body of the article, in the form - THE TITLE OF THE ARTICLE IN SMALL CAPS OR

at the end of the article, designated as "Related Reading".

(5) In addition

The reader will find suggestions for related reading and just prior to the list of references in each article, a mention of the road map(s) in which the article is discussed as well as background material, when the article is more advanced.

Summary



" .. I am sure that readers will not only turn to the book to get good brief reviews of topics in their own specialty, but also find many invitations to browse widely - finding parallels amongst different sub fields, or simply enjoying the discovery of interesting topics far from familiar territory. ... "

(1) Part I provides a general perspective on the basic concepts of brain theory and neural networks.

(2) Part II provides an overview of some theme
& the Meta - map helps to choose road maps in Part II
& a road map helps to choose articles in Part III. It can also be used as an explicit guide for systematic study of the article under review.

(3) Part III provide information on a specific topic. Further exploration can be done through
& further use of road maps
& by following cross-references in Part III.
& by looking up items of interest in the Subject Index and the alphabetical list of Contributors on page 1241 which lists all articles to which each author has contributed.
& or simply by letting serendipity take its course as one browses through Part III at random.

The authors of the articles come from a broad spectrum of disciplines - such as biomedical engineering, cognitive science, computer science, electrical engineering, linguistics, mathematics, physics, neurology, neuroscience, and psychology - and have worked hard to make their articles accessible to readers across the spectrum.

The new edition differs radically from the old in the following ways:
& The new edition has 285 Articles in Part III, as against the 266 articles of the first edition.
& Only 9 articles of the new edition are reprinted unchanged.
& Some 135 have been updated (or even completely rewritten) by their original authors, and more than 30 have been written anew by new authors.
& In addition, there are over 100 articles on new topics
& There is a shift of emphasis from applications of artificial neural networks (from astronomy, to steel making) and to greatly increase the coverage of models of fundamental neurobiology and neural networks approaches to language, and new papers have been added which are now listed in the Road Maps on Cognitive Neuroscience, Neural Coding, and Other Sensory Systems (i.e., other than Vision for which coverage has also been increased).
& The new edition is a self-contained introduction to brain theory and neural networks in all its current breadth and richness.
& The new edition not only appears in print but also has its own website.

I am sure that readers will not only turn to the book to get good brief reviews of topics in their own specialty, but also find many invitations to browse widely - finding parallels amongst different sub fields, or simply enjoying the discovery of interesting topics far from familiar territory.



-Sherin S. Thomas
Sherin S. Thomas is currently working as a Senior Resident in the Department of Biochemistry at the Maulana Azad Medical College, New Delhi. She completed her MBBS (graduation in medicine and surgery) in 1994 and completed her specialization (MD in Biochemistry) in 2001.
Dr. Thomas is an avid reader of books, journals etc. on a wide variety of topics, especially on Brain theory and neural networks and Computational Molecular Biology. She is a passionate book lover. Her other interests include listening to music and spending time with her five cats and three dogs.

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-Editor-in-Chief

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