

neural

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current
applications

Edited by
P. G. J. LISBOA



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Neural Networks

To my favourite living neural networks:

Catherine, Corinne and Ciarán.

To my mother. In remembrance of my father.

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Preface

Neural network technology is a relative newcomer to many application areas. Its widespread use today is fraught with difficulties in achieving optimum performance, monitoring their activity, and integrating them into existing solutions and operating environments. But most of all, there is a learning curve of a purely practical nature that is involved in understanding what neural networks are about, how they operate, and what they can do.

This book reviews some of the important commercially available applications and also provides an accelerated introduction to this fast developing field. It is intended to bring the reader some of the way up that learning curve. It presents a brief overview of basic history and principles of artificial neural networks, and describes some of the most important tools provided by this technology, together with their use in practical applications; this is followed by examples of detailed applications, some of which are already marketed, concluding with a review of current applications, and perspectives for the future.

It is hoped that in the book the reader will be able to find parallels with particular applications of interest to them, opening up new opportunities by providing a window into the current state-of-the-art of neural network applications. For each user of neural network techniques, whether experienced or inexperienced, active or aspiring, committed or sceptical, the purpose of this book will be fulfilled if it gives a new insight, inspires a new application, or provides the catalyst for new solutions to difficult problems.

The emphasis throughout the book is upon the use of artificial neural networks as a new set of tools, which have special computational properties, and how best to exploit their potential in practical applications.

All the articles are thoroughly referenced in order to give the user the opportunity to follow up the details of every aspect of the techniques and principles described.

The introduction reviews some of the motivations and history of this not so new field, indicates what neural networks are and what is new about them, and introduces the basic tools that are used in the applications that follow. In addition to the technical references, a bibliography for start-up is supplied.

Chapter 2 caters for a shorter introduction, leading straight on to specific commercial applications. One of these, explosive detection in aircraft luggage, deals with an automatic inspection problem in a high-risk situation. The other describes adaptive vibration cancellation in a non-linear system.

Chapter 3 describes a solution to the problem of resource allocation in a highly competitive environment, involving aircraft seat allocation, and makes use of algorithms especially suited to forecasting. This is another example of a neural-based solution which has proved its worth in the market-place.

Chapter 4 discusses the design of a particularly important type of structure, a 'hybrid model' which acquires knowledge in the same way as neural networks do, but is more amenable to the provision of explanation facilities. It constitutes, in effect, an 'active expert system', which is derived for yet another difficult task, medical risk assessment for life insurance underwriting.

Chapter 5 describes another example of modelling for control of systems with non-linearities, this time in greater detail and applied to a standard chemical process, pH control of a stirred tank reactor.

Inverse kinematics is central to many robotic applications, and also typical of a wide class of problems known as 'inverse problems'. These are problems where the results of certain actions are known but the correct action to achieve a desired goal is uncertain. Chapter 6 tackles this problem, and also investigates another important and difficult problem in robotics, namely modelling the transient dynamics of coupled systems, by addressing the case of a simple arm manipulator with two degrees of freedom.

The area of image processing is of particular success in the application of neural network techniques, and is also an area where even real biological systems are partly understood, providing guidance in the design of general purpose artificial vision systems.

Chapter 7 gives a short tutorial on real and artificial neural vision, from a purely operational point of view. It centres around a detailed discussion of the behaviour of arguably the two most commonly used neural network learning algorithms, back error propagation and the self-organizing Kohonen network, which are applied to hand-printed numeral recognition, thereby providing results that are easy to visualize. More advanced areas where future developments are likely are highlighted.

This is followed by yet another real-world application, this time image labelling, which represents a first step in the interpretation of natural scenes, in Chapter 8. This is a crucial step in the development

of automatic navigation systems, and involves feature detection as well as image classification.

Object recognition and the detection of image symmetries is a particularly difficult task for any vision system. Chapter 9 describes an original and very successful approach to this task, which includes automatic detection of human faces against natural scene backgrounds.

Optical character recognition is singularly well suited for solution by neural network methods, since it contains distributed, redundant information. In practice this means that we are able to perform this task with a minimum amount of conscious intervention. Chapter 10 presents what is certainly one of the most powerful and robust solutions to the recognition of handwritten digits, tested on a large database collected from live mail.

Chapter 11 is concerned with invariant pattern recognition, in contrast with an earlier chapter which looked to recognize image invariants in the form of symmetry axes. This is the problem of identifying patterns independently of the basic geometric transformations of translation, rotation and a limited amount of scaling. Conventional and neural techniques are compared, and their benefits discussed. Although applied to character recognition, the approach that is developed could just as easily be extended to problems in industrial visual inspection.

The last paper deals with the future. A close examination of the early stages of the human visual system is linked, in Chapter 12, to a model that can be implemented in silicon.

Finally, the Conclusion summarizes the current state-of-the-art of neural network applications, listing some of the more important developments and prospects for the future.

I am indebted to Dr. J. McTavish for his invaluable assistance in proof-reading the manuscript.

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Contents

| | |
|------------------------------------------------------------------------------------------------|--------------|
| Contributors | xiii |
| Preface | xviii |
| Chapter One: Introduction | |
| by P. J. G. Lisboa | 1 |
| 1.1 Summary | 1 |
| 1.2 Motivation | 1 |
| 1.3 Historical perspective | 2 |
| 1.4 Biological neurones | 4 |
| 1.5 Artificial neurones | 5 |
| 1.6 Networks of neurones | 7 |
| 1.7 Toolkit | 9 |
| 1.7.1 <i>Hopfield network</i> | 11 |
| 1.7.2 <i>Multi-layered perceptron</i> | 15 |
| 1.7.3 <i>Kohonen network</i> | 20 |
| 1.7.4 <i>Temporal differences</i> | 23 |
| 1.8 Choosing the right algorithm | 26 |
| Chapter Two: Neural network basics | |
| by G. A. Works | 35 |
| 2.1 Summary | 35 |
| 2.2 Introduction | 35 |
| 2.3 What is a 'hard' problem? | 36 |
| 2.4 What is an ANS? | 37 |
| 2.5 ANS implementations | 41 |
| 2.6 Applications | 43 |
| 2.7 The future of artificial neural systems | 47 |
| Chapter Three: Using adaptive networks for resource allocation in changing environments | |
| by T. M. Bell, W. R. Hutchison and K. R. Stephens | 49 |
| 3.1 Summary | 49 |
| 3.2 Introduction | 49 |
| 3.3 BANKET | 53 |
| 3.4 Airline revenue management | 55 |
| 3.5 Airline marketing tactician™ (AMT) | 57 |
| 3.6 Scheduling and task management | 60 |

| | | |
|--------------------------------------------------------------------------------|----------------------------------------------------------------|-----------|
| 3.7 | Adaptive Network Aircrew Training Scheduler (ANATS) | 61 |
| 3.8 | Conclusion | 63 |
| Chapter Four: Medical risk assessment for insurance underwriting | | |
| | by S. B. Ahuja and A. Hsiung | 67 |
| 4.1 | Summary | 67 |
| 4.2 | Introduction | 67 |
| | 4.2.1 <i>Insurance underwriting</i> | 68 |
| | 4.2.2 <i>Shortcomings of existing methods</i> | 69 |
| | 4.2.3 <i>Neural modelling</i> | 71 |
| 4.3 | A neural network model for classificatory problem solving | 73 |
| | 4.3.1 <i>A knowledge representation and processing model</i> | 73 |
| | 4.3.2 <i>A spreading activation paradigm</i> | 75 |
| 4.4 | Architecture of a rating network | 77 |
| 4.5 | A connectionist expert system environment | 80 |
| | 4.5.1 <i>Structure of the domain knowledge</i> | 82 |
| | 4.5.2 <i>The knowledge specification language</i> | 83 |
| 4.6 | Conclusion | 86 |
| Chapter Five: Modelling chemical process systems via neural computation | | |
| | by N. V. Bhat, P. A. Minderman, Jr., T. McAvoy and N. Sun Wang | 91 |
| 5.1 | Summary | 91 |
| 5.2 | Introduction | 91 |
| 5.3 | Back-propagation | 93 |
| 5.4 | Steady-state example | 95 |
| | 5.4.1 <i>Model</i> | 95 |
| | 5.4.2 <i>Back-propagation net used</i> | 97 |
| | 5.4.3 <i>Optimizing reactor performance</i> | 98 |
| 5.5 | Dynamic example | 99 |
| | 5.5.1 <i>System considered</i> | 100 |
| | 5.5.2 <i>Back-propagation dynamic modelling (BDM)</i> | 101 |
| | 5.5.3 <i>Results</i> | 103 |
| 5.6 | Interpreting biosensor data | 105 |
| | 5.6.1 <i>Overview</i> | 105 |
| | 5.6.2 <i>Back-propagation results</i> | 106 |
| 5.7 | Conclusion | 108 |

| | |
|----------------------------------------------------------------------|------------|
| Chapter Six: The application of neural networks to robotics | |
| by A. Guez, Z. Ahmad and J. Selinsky | 111 |
| 6.1 Summary | 111 |
| 6.2 Introduction | 111 |
| 6.3 The inverse kinematic problem in robotics | 111 |
| 6.3.1 <i>Problem statement</i> | 112 |
| 6.3.2 <i>The proposed method</i> | 112 |
| 6.3.3 <i>Examples</i> | 114 |
| 6.3.4 <i>Conclusion</i> | 117 |
| 6.4 Learning of robot dynamics using a hierarchical neural network | 117 |
| 6.4.1 <i>Dynamic model</i> | 117 |
| 6.4.2 <i>Proposed learning method</i> | 118 |
| 6.4.3 <i>Simulation results</i> | 120 |
| 6.4.4 <i>Conclusion</i> | 121 |
| Chapter Seven: Neural networks in vision | |
| by P. J. G. Lisboa | 123 |
| 7.1 Summary | 123 |
| 7.2 Introduction | 123 |
| 7.3 Biological neural networks for vision | 124 |
| 7.4 Artificial neural models | 129 |
| 7.5 Kohonen networks | 131 |
| 7.6 Back error propagation | 137 |
| 7.7 Feature extraction | 140 |
| 7.8 Comparison with statistical classifiers | 142 |
| 7.9 Overview of applications and conclusion | 143 |
| Chapter Eight: Image labelling with a neural network | |
| by W. A. Wright | 149 |
| 8.1 Summary | 149 |
| 8.2 Introduction | 149 |
| 8.3 Network | 151 |
| 8.4 Implementation | 152 |
| 8.5 Results | 157 |
| 8.6 Conclusion | 160 |
| Chapter Nine: Object recognition with optimum neural networks | |
| by M. Bichsel and P. Seitz | 163 |
| 9.1 Summary | 163 |
| 9.2 Introduction | 164 |

| | | |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------|
| 9.3 | Measuring the information flow in neural networks: the conditional class entropy | 165 |
| 9.4 | Extension to general sigmoid activation functions | 169 |
| 9.5 | A teaching algorithm for the construction of optimum neural networks: minimizing conditional class entropy | 169 |
| 9.6 | Shift-invariant classification of symmetry axes in binary patterns | 173 |
| 9.7 | Detection of human faces | 175 |
| 9.8 | Conclusion | 180 |
| | | |
| Chapter Ten: Handwritten digit recognition with a back-propagation network | | |
| by Y. Le Cun, B. Boser, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard and L. D. Jackel | | 185 |
| 10.1 | Summary | 185 |
| 10.2 | Introduction | 185 |
| 10.3 | Zipcode recognition | 186 |
| 10.4 | Pre-processing | 187 |
| 10.5 | The network | 188 |
| 10.6 | Results | 191 |
| 10.7 | Conclusion | 193 |
| | | |
| Chapter Eleven: Higher-order neural networks for invariant pattern recognition | | |
| by S. J. Perantonis | | 197 |
| 11.1 | Summary | 197 |
| 11.2 | Introduction | 197 |
| 11.3 | Invariant 'dynamical' associative memories | 198 |
| 11.4 | Invariant associative memory properties of the Hopfield network and the autoassociating perceptron | 200 |
| 11.5 | Digit recognition using the Hopfield network and the autoassociating perceptron | 203 |
| 11.6 | The role of image fuzzing in improving the basins of attraction | 207 |
| 11.7 | Invariant pattern recognition using high-order networks | 212 |
| 11.8 | Invariant pattern recognition by the method of moments | 218 |
| 11.9 | Digit recognition using third-order networks and Zernike moment classifiers | 219 |
| | 11.9.1 <i>Invariant recognition of typed digits</i> | 222 |

| | | |
|-----------------------------------------------------|----------------------------------------------------|------------|
| 11.9.2 | <i>Invariant recognition of handwritten digits</i> | 225 |
| 11.10 | Conclusion | 227 |
| Chapter Twelve: The bionic retina and beyond | | |
| | by J. G. Taylor | 233 |
| 12.1 | Summary | 233 |
| 12.2 | Introduction | 233 |
| 12.3 | The retina | 235 |
| 12.4 | The primary visual cortex | 245 |
| 12.5 | Bionic processing | 246 |
| 12.6 | Conclusion | 247 |
| Chapter Thirteen: Conclusion | | |
| | by P. J. G. Lisboa | 251 |
| 13.1 | Trends | 251 |
| 13.2 | Meek, myth or mirth? | 253 |
| 13.3 | Application areas | 255 |
| | 13.3.1 <i>Business and finance</i> | 255 |
| | 13.3.2 <i>Automated inspection and monitoring</i> | 256 |
| | 13.3.3 <i>Computer vision</i> | 256 |
| | 13.3.4 <i>Speech processing</i> | 257 |
| | 13.3.5 <i>Robotics and control</i> | 258 |
| | 13.3.6 <i>Optimization problems</i> | 258 |
| | 13.3.7 <i>Medical applications</i> | 259 |
| 13.4 | Perspectives | 260 |
| Appendix A: Glossary | | 269 |
| Index | | 275 |