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Artificial Neural Networks in Biomedicine



Springer

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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 Ifeakor and Piotr Szczepaniak
June, 1999.

Contents

Introduction	1
TUTORIAL AND REVIEW	9
1 The Bayesian Paradigm: Second Generation Neural Computing	11
1.1 Introduction	11
1.2 Theory	12
1.2.1 Bayesian Learning	13
1.2.2 The Evidence Framework	15
1.2.2.1 Error bars	16
1.2.2.2 Moderated outputs	16
1.2.2.3 Regularisation	17
1.2.3 Committees	18
1.3 Example Results	20
1.4 Conclusion	21
2 The Role of the Artificial Neural Network in the Characterisation of Complex Systems and the Prediction of Disease	25
2.1 Introduction	26
2.2 Diagnosis of Disease	28
2.3 Outcome Prediction	30
2.4 Conclusion	31
3 Genetic Evolution of Neural Network Architectures	39
3.1 Introduction	39
3.2 Stability: The 'Bias/Variance Problem'	40
3.3 Genetic Algorithms and Artificial Neural Networks	41
3.3.1 Description of a General Method for Evolving ANN Architecture (EANN)	42
3.3.2 Prediction of Depression After Mania	43
3.3.3 EANN and the Agreement/Transparency Choice	43
3.3.4 ANN and the Stability/Specialisation Choice	45
3.4 Conclusion	46
COMPUTER AIDED DIAGNOSIS	49
4 The Application of PAPNET to Diagnostic Cytology	51
4.1 Introduction	51
4.2 First Efforts at Automation in Cytology	52
4.3 Neural Networks	53

4.4	The <i>PAPNET</i> System®.....	53
4.4.1	Components of the <i>PAPNET</i> System.....	54
4.4.1.1	Technical factors affecting the performance of the machine.....	59
4.4.2	Performance of the <i>PAPNET</i> System.....	59
4.4.2.1	Cervicovaginal smears.....	59
4.4.3	Application of the <i>PAPNET</i> System to Smears of Sputum.....	61
4.4.4	Application of the <i>PAPNET</i> System to Smears of Urinary Sediment.....	61
4.4.5	Application of the <i>PAPNET</i> System to Oesophageal Smears.....	62
4.5	Comment.....	63
5	ProstAsure Index – A Serum-Based Neural Network-Derived Composite Index for Early Detection of Prostate Cancer	69
5.1	Introduction.....	69
5.2	Clinical Background of Prostate Cancer and Derivation of the ProstAsure Index Algorithm.....	70
5.3	Validation of PI with Independent Clinical Data.....	72
5.4	Issues in Developing PI.....	73
5.5	Conclusion.....	76
6	Neurometric Assessment of Adequacy of Intraoperative Anaesthetic.....	81
6.1	Intraoperative Awareness.....	81
6.2	Measuring Sensory Perception	82
6.3	Clinical Data	82
6.4	Results.....	83
6.5	Implementation.....	86
6.6	Clinical Deployment.....	88
6.7	Healthcare Benefit.....	89
6.8	Additional Studies.....	89
7	Classifying Spinal Measurements Using a Radial Basis Function Network.....	93
7.1	Introduction.....	93
7.2	Data.....	94
7.2.1	The Spines.....	94
7.2.2	The Measurements.....	94
7.2.3	Preprocessing the Data.....	95
7.3	Radial Basis Functions and Networks	96
7.4	Matrix Notation	97
7.5	Training RBF Networks.....	98
7.5.1	The Unsupervised Learning Stage.....	98
7.5.2	The Supervised Learning Stage	98
7.5.2.1	Regularisation as an aid to avoid over-fitting.....	98
7.5.2.2	Calculating the regularisation coefficients and the weights.....	99
7.5.2.3	Forward subset selection of RBFs	101
7.5.2.4	Input feature selection.....	102
7.6	Results.....	102
7.7	Conclusion.....	103

8	GEORGIA: An Overview	105
8.1	Introduction.....	106
8.2	The Medical Decision Support System.....	107
8.3	Learning Pattern Generation.....	109
8.4	Software and Hardware Implementation.....	110
8.5	Re-Training and Re-Configuring the MDSS.....	111
8.6	Introducing GEORGIA's Man-to-Computer Interface.....	111
8.7	Conclusion.....	114
9	Patient Monitoring Using an Artificial Neural Network.....	117
9.1	Overview of the Medical Context.....	117
9.2	Basic Statistical Appraisal of Vital Function Data.....	118
9.3	Neural Network Details.....	120
9.3.1	Default Training	121
9.4	Implementation.....	123
9.5	Clinical Trials	124
9.6	Clinical Practice	125
10	Benchmark of Approaches to Sequential Diagnosis.....	129
10.1	Introduction.....	129
10.2	Preliminaries	130
10.3	Methods	132
10.3.1	The Probabilistic Algorithm.....	132
10.3.1.1	The diagnostic algorithm for first order markov chains – the Markov I algorithm	132
10.3.1.2	The diagnostic algorithm for second order markov chains - the Markov II algorithm	133
10.3.2	The Fuzzy Methods	135
10.3.2.1	The algorithm without context - fuzzy 0.....	135
10.3.2.2	The algorithm with first-order context - fuzzy 1A	135
10.3.2.3	The reduced algorithm with first-order context - fuzzy 1B	135
10.3.2.4	The algorithm with second-order context - fuzzy 2A	135
10.3.2.5	The reduced algorithm with second-order context - fuzzy 2B.....	136
10.3.3	The Neural Network Approach	136
10.4	A Practical Example - Comparative Analysis of Methods.....	137
10.5	Conclusion.....	138
11	Application of Neural Networks in the Diagnosis of Pathological Speech	141
11.1	Introduction.....	141
11.2	The Research Material and the Problems Considered.....	142
11.2.1	Dental Prosthetics.....	142
11.2.2	Maxillofacial Surgery.....	143
11.2.3	Orthodontics.....	144
11.2.4	Laryngology	144
11.3	The Signal Parameterisation.....	145
11.4	The Application of the Neural Networks and the Results.....	147

11.5	Conclusion.....	149
SIGNAL PROCESSING		151
12	Independent Components Analysis.....	153
12.1	Introduction.....	153
12.2	Theory	153
12.2.1	The Decorrelating Manifold	155
12.2.2	The Choice of Non-Linearity.....	156
12.2.3	Model-Order Estimation.....	158
12.3	Non-Stationary ICA.....	158
12.3.1	Illustration.....	161
12.4	Applications.....	163
12.4.1	Source Separation	164
12.4.2	Source Number and Estimation	164
12.5	Conclusion.....	166
13	Rest EEG Hidden Dynamics as a Discriminant for Brain Tumour Classification.....	169
13.1	Introduction.....	170
13.2	Characterising Hidden Dynamics.....	171
13.3	The Clinical Study.....	174
13.4	The Minimum Markov Order	176
13.5	Conclusion.....	179
14	Artificial Neural Network Control on Functional Electrical Stimulation Assisted Gait for Persons with Spinal Cord Injury	181
14.1	Introduction.....	182
14.2	Methods	183
14.3	Results.....	187
14.4	Discussion	191
15	The Application of Neural Networks to Interpret Evoked Potential Waveforms	195
15.1	Introduction.....	195
15.2	The Medical Conditions Studied.....	196
15.3	The Evoked Potentials	196
15.4	The Relationship Between the CNV and the Medical Conditions.....	197
15.5	Experimental Procedures.....	198
15.6	Data Pre-Processing	198
15.7	Feature Extraction.....	199
15.8	Normalisation.....	200
15.9	The Artificial Neural Networks.....	200
15.9.1	The Simplified Fuzzy ARTMAP.....	200
15.9.2	The Probabilistic Simplified Fuzzy ARTMAP.....	204
15.9.3	ANN Training and Accuracy.....	205
15.9.3.1	Small numbers of training vectors	205
15.9.3.2	Simplified fuzzy ARTMAP.....	205
15.9.3.3	Committees of ANNs.....	206

15.10	Validation Issues.....	206
15.10.1	Technical Aspects of Validation.....	206
15.10.2	Clinical Aspects of Validation.....	206
15.11	Results.....	207
15.12	Implementation Considerations.....	207
15.13	Future Developments	208
IMAGE PROCESSING.....		211
16 Intelligent Decision Support Systems in the Cytodiagnosis of Breast Carcinoma.....		213
16.1	Introduction.....	213
16.2	Previous Work on Decision Support in this Domain.....	215
16.3	The Data Set in this Study.....	215
16.3.1	Study Population.....	215
16.3.2	Input Variables.....	216
16.3.3	Partitioning of the Data.....	217
16.4	Human Performance	217
16.5	Logistic Regression	218
16.6	Data Derived Decision Tree.....	219
16.7	Multi-Layer Perceptron Neural Networks.....	220
16.8	Adaptive Resonance Theory Mapping (ARTMAP) Neural Networks	222
16.8.1	Potential Advantages of ARTMAP	222
16.8.2	ARTMAP Architecture and Methodology	222
16.8.3	Results from the Cascaded System.....	225
16.8.4	Symbolic Rule Extraction	225
16.9	Assessment of the Different Decision Support Systems	226
17 A Neural-Based System for the Automatic Classificaton and Follow-Up of Diabetic Retinopathies.....		233
17.1	Introduction.....	233
17.2	The DRA System.....	235
17.3	Hybrid Module	237
17.4	Committee Algorithms.....	239
17.4.1	New Selection Algorithms.....	240
17.4.1.1	Greedy selection.....	241
17.4.1.2	Pseudo-exhaustive selection	241
17.4.2	Sequential Cooperation.....	242
17.4.3	Experimental Results.....	243
17.5	Related Work	245
17.6	Validation of the DRA System.....	245
17.7	Conclusion.....	246
18 Classification of Chromosomes: A Comparative Study of Neural Network and Statistical Approaches		249
18.1	Introduction.....	249
18.1.1	Chromosome Analysis and its Applications.....	249
18.1.2	Chromosome Classification	250

18.1.3	Experimental Data.....	251
18.2	The Neural Network Classifier	252
18.2.1	Representation of Chromosome Features	252
18.2.2	Network Topology and Training	253
18.2.3	Incorporating Non-Banding Features.....	254
18.3	Classification Performance.....	255
18.3.1	Classification Experiments.....	255
18.3.2	Comparison with Statistical Classifiers.....	256
18.3.3	The Influence of Training-Set Size	256
18.4	The Use of Context in Classification.....	258
18.4.1	The Karyotyping Constraint	258
18.4.2	Applying the Constraint by a Network.....	259
18.4.3	Results of Applying the Context Network	260
18.5	Conclusion and Discussion	261
18.5.1	Comparison with Statistical Classifiers.....	261
18.5.2	Training Set Size and Application of Context	262
18.5.3	Biological Context.....	263
19	The Importance of Features and Primitives for Multi-dimensional/Multi-channel Image Processing	267
19.1	Introduction.....	267
19.2	The Image Data Level	269
19.3	From Image Data to Symbolic Primitives.....	269
19.4	Region Segmentation Quality and Training Phase.....	270
19.5	Validation of Image Segmentation	271
19.6	Segmentation Complexity and Quantitative Error Evaluation.....	273
19.7	Feature Description.....	275
19.8	Feature Selection.....	276
19.9	A Preliminary Overview of Application Results	278
19.10	Conclusion.....	281
Index.....		283