

Contents

<i>Preface</i>	(v)
<i>Acknowledgements</i>	(ix)

Chapter 1

Overview of Neural Networks

1.1	Biological vs. Electrical Brains	4
1.1.1	Layers	5
1.1.2	Communications	5
1.1.3	Inter-Layer.....	5
1.2	Introduction to Biological Neuron.....	6
1.3	Artificial Neuron	8
1.3.1	The Perceptron	9
1.4	The Hodgkin-Huxley Model	12
1.4.1	Resting Potential	12
1.4.2	The Equivalent Circuit	13
1.4.3	The Resting Conductance.....	13
1.4.4	The Action Potential.....	14
1.4.5	Computer Simulation of Neural Behavior.....	16
1.5	Why Spiking Neurons?.....	17
1.5.1	Potential Disadvantages	18
1.5.2	What Spiking Neuron Models are Available?.....	19
1.5.3	Coupled Equations Using Parameters with Real Biophysical Correlates	19
1.5.4	Coupled Equations Using Parameters with no Biophysical Correlates	19

1.6	Integrate and Fire Models.....	21
1.6.1	Spiking Neural Networks – What Do We Know?	21
1.6.2	Spike Timing Dependent Plasticity (STDP)	22
1.6.3	Network Architectures	23
1.6.4	Spike Coding.....	25
1.6.5	Complexity	27
1.6.6	Spiking Neural Networks – What Don't We Know?.....	28
1.6.7	Who is using Spiking Neurons?	29
1.6.8	Conclusion.....	29
1.7	Applications of Ann	30
	References.....	32

Chapter 2

Fundamentals of Neural Networks

2.1	Introduction	34
2.2	Basic Structure of a Neuron.....	35
2.2.1	Model of Biological Neurons	35
2.2.2	Elements of Neural Networks	36
2.3	Adaline	41
2.4	Linear Separable Patterns	42
2.5	Single Layer Perceptron	44
2.5.1	General Architecture	44
2.5.2	Linear Classification	45
2.5.3	Perceptron Algorithm.....	48
2.6	Multi-Layer Perceptron	48
2.6.1	General Architecture	48
2.6.2	Input-Output Mapping.....	49
2.6.3	XOR Realization	52
2.7	Learning Types.....	55
	Conclusions	60
	References.....	61

Chapter 3

Feedforward Neural Networks

3.1	Perceptron Convergence Procedure.....	63
3.2	LMS Learning Rule.....	67
3.3	Steepest Descent Algorithm.....	70
3.4	The Backpropagation Algorithm.....	73
3.4.1	Learning Single Layer Network.....	73
3.4.2	Multilayer Network.....	75
3.5	The Back-Propagation Algorithm – A Mathematical Approach.....	78
	Conclusions	80
	References.....	80

Chapter 4

Neural Networks Architectures

4.1	Introduction.....	82
4.2	NN Classifications.....	83
4.2.1	Feedforward and Feedback Networks.....	83
4.2.2	Supervised and Unsupervised Learning Networks.....	84
4.3	Back Propagation Algorithm.....	85
4.3.1	Delta Training Rule.....	87
4.4	Radial Basis Function Network (RBFN).....	96
4.5	Kohonen Self-Organization Network.....	102
4.6	Hopfield Network.....	104
	Conclusions	108
	References.....	109

Chapter 5

Associative Memories

5.0	Neural Networks as Associative Memory.....	110
5.1	Associative Memory.....	111

5.2	Linear Associators as Interpolative Memory	113
5.3	Hopfield Auto Associative Memory	117
5.4	Bi-directional Associative Memory	120
5.5	Associative Memory Networks	122
5.5.0	Introductory Concepts	122
5.5.1	Encoding and Decoding Single Memories	124
5.5.2	Feed Forward Associative Memory	125
5.5.3	Encoding Multiple Memories	125
5.5.4	Decoding Operation	126
5.5.5	Numerical Examples	127
5.6	Recurrent Associative Memory – Discrete Hopfield networks	128
5.6.1	Structure	128
5.7	Example of the Hopfield Network behavior for $m = 3$	129
5.8	Another example of Hopfield network (from Lytton)	131
5.8.1	Retrieval of Numerical Patterns Stored in a Recurrent Binary Associative Memory (Hopfield Network)	131
5.9	The Energy Landscape	134
5.10	Example of a Two-Neuron Recurrent Associative Memory	135
	Conclusions	136
	References	137
 Chapter 6		
Introduction to Fuzzy Sets: Basic Definitions and Relations		
6.1	Introduction	138
6.1.1	Fuzzy Membership Functions	143
6.1.2	Alpha-Cut Fuzzy Sets	148
6.1.3	Extension Principle	148
	Conclusion	153
	References	154

Chapter 7**Introduction to Fuzzy Logic**

7.1	Predicate Logic	156
7.1.1	Tautologies	160
7.1.2	Contradictions	160
7.1.3	Deductive Inferences	161
7.2	Fuzzy Logic	162
7.3	Approximate Reasoning	164
	Conclusion.....	166
	References.....	166

Chapter 8**Fuzzy Control and Stability**

8.1	Basic Definitions	169
8.1.1	Inference Engine	171
8.1.2	Defuzzification	174
8.2	Fuzzy Control Design.....	174
8.3	Analysis of Fuzzy Control Systems.....	176
8.4	Stability of Fuzzy Control Systems	181
8.4.1	Lyapunov Stability	184
8.4.2	Stability Via Interval Matrix Method.....	189
	Conclusion.....	193
	References.....	193

Chapter 8A**Advanced Process Control**

8A.1	What is Advanced Control	197
8A.2	Process Models.....	198
8A.3	Mechanistic Models.....	199
8A.4	Black Box Models	200
8A.5	Qualitative Models	201

8A.6	Statistical Models	201
8A.7	Model Based (Modern) Automatic Control.....	202
8A.7.1	PID Control.....	203
8A.7.2	Predictive Constrained Control	205
8A.7.3	Multivariable Control.....	206
8A.7.4	Robust Control and the Internal Model Principle	207
8A.7.5	Globally Linearising Control	208
8A.8	Statistical Process Control.....	209
8A.8.1	Conventional SPC	209
8A.8.2	Algorithm SPC.....	210
8A.8.3	Active SPC.....	210
8A.9	Dealing with Data Problems.....	210
8A.9.1	Inferential Estimation.....	211
8A.9.2	Data Conditioning and Validation.....	212
8A.9.3	Data Analysis	212
8A.10	Higher Level Operations	213
8A.10.1	Process Optimisation.....	213
8A.11	Process Monitoring, Fault Detection, Location and Diagnosis	214
8A.12	Process Supervision via Artificial Intelligence Techniques	214
8A.13	Advanced Control.....	216
8A.14	Current Research and Future Trends	217
	References.....	218

Chapter 8B

Fuzzy Logic Application

Application 1: Fuzzy Logic and Anti-Lock Braking System.....	223
Application 2: Web-based Fuzzy Neural Networks for Stock Prediction.....	228
Application 3: A Neuro-Fuzzy System for Speech Recognition	237
Appendix – A Fuzzy Logic : An Introduction to Fuzzy Logic	245
Appendix – B Self-Organizing Maps (SOM)	264
Appendix – C Hopfield Networks.....	276