

Contents

Preface	v
Chapter 1 Introduction	1
Chapter 2 Type-1 Fuzzy Logic	5
2.1 Type-1 Fuzzy Set Theory	6
2.2 Fuzzy Rules and Fuzzy Reasoning	12
2.2.1 Fuzzy Relations	12
2.2.2 Fuzzy Rules	15
2.3 Fuzzy Inference Systems	18
2.4 Fuzzy Modelling	30
2.5 Summary	31
Chapter 3 Type-2 Fuzzy Logic	33
3.1 Type-2 Fuzzy Sets	34
3.2 Operations of Type-2 Fuzzy Sets	37
3.3 Type-2 Fuzzy Systems	39
3.3.1 Singleton Type-2 Fuzzy Logic Systems	40
3.3.2 Non-Singleton Fuzzy Logic Systems	44
3.3.3 Sugeno Type-2 Fuzzy Systems	45
3.4 Summary	46
Chapter 4 Supervised Learning Neural Networks	47
4.1 Backpropagation for Feedforward Networks	48
4.1.1 The Backpropagation Learning Algorithm	48
4.1.2 Backpropagation Multilayer Perceptrons	51
4.1.3 Methods for Speeding up Backpropagation	57
4.2 Radial Basis Function Networks	59
4.3 Adaptive Neuro-Fuzzy Inference Systems	64
4.3.1 ANFIS Architecture	64
4.3.2 Learning Algorithm	67
4.4 Summary	73

Chapter 5 Unsupervised Learning Neural Networks	75
5.1 Competitive Learning Networks	75
5.2 Kohonen Self-Organizing Networks	80
5.3 Learning Vector Quantization	85
5.4 The Hopfield Network	89
5.5 Summary	92
Chapter 6 Genetic Algorithms and Simulated Annealing	93
6.1 Genetic Algorithms	95
6.2 Modifications to Genetic Algorithms	102
6.2.1 Chromosome Representation	102
6.2.2 Objective Function and Fitness	102
6.2.3 Selection Methods	104
6.2.4 Genetic Operations	105
6.2.5 Parallel Genetic Algorithm	106
6.3 Simulated Annealing	109
6.4 Applications of Genetic Algorithms	112
6.4.1 Evolving Neural Networks	113
6.4.1.1 Evolving Weights in a Fixed Network	113
6.4.1.2 Evolving Network Architectures	116
6.4.2 Evolving Fuzzy Systems	122
6.5 Summary	125
Chapter 7 Dynamical Systems Theory	127
7.1 Basic Concepts of Dynamical Systems	127
7.2 Controlling Chaos	132
7.2.1 Controlling Chaos through Feedback	138
7.2.1.1 Ott-Grebogi-Yorke Method	138
7.2.1.2 Pyragas's Control Methods	140
7.2.1.3 Controlling Chaos by Chaos	141
7.2.2 Controlling Chaos without Feedback	143
7.2.2.1 Control through Operating Conditions	143
7.2.2.2 Control by System Design	143
7.2.2.3 Taming Chaos	147
7.2.3 Method Selection	148
7.3 Summary	149
Chapter 8 Plant Monitoring and Diagnostics	151
8.1 Monitoring and Diagnosis	152
8.2 Fractal Dimension of a Geometrical Object	154
8.3 Fuzzy Estimation of the Fractal Dimension	157
8.4 Plant Monitoring with Fuzzy-Fractal Approach	158
8.5 Experimental Results	162
8.6 Summary	165

Chapter 9 Adaptive Control of Non-Linear Plants	167
9.1 Fundamental Adaptive Fuzzy Control Concept	168
9.2 Basic Concepts of Stepping Motors	171
9.2.1 Variable Reluctance Motors	172
9.2.2 Unipolar Motors	173
9.2.3 Bipolar Motors	174
9.2.4 Dynamics of the Stepping Motor	174
9.2.5 Control of the Stepping Motor	177
9.3 Fuzzy Logic Controller of the Stepping Motor	178
9.4 Hardware Implementation of ANFIS	180
9.5 Experimental Results	181
9.6 Summary	184
Chapter 10 Automated Quality Control in Sound Speaker Manufacturing	185
10.1 Introduction	185
10.2 Basic Concepts of Sound Speakers	186
10.2.1 Sound Basics	187
10.2.2 Making Sound	187
10.2.3 Chunks of the Frequency Range	190
10.2.4 Boxes of Sound	193
10.2.5 Alternative Speaker Designs	197
10.3 Description of the Problem	198
10.4 Fractal Dimension of a Sound Signal	200
10.5 Experimental Results	202
10.6 Summary	206
Chapter 11 Intelligent Manufacturing of Television Sets	207
11.1 Introduction	207
11.2 Imaging System of the Television Set	208
11.2.1 The Cathode Ray Tube	208
11.2.2 Phosphor	209
11.2.3 The Black-and-White TV Signal	211
11.2.4 Adding Color	213
11.3 Breeder Genetic Algorithm for Optimization	216
11.3.1 Genetic Algorithm for Optimization	217
11.4 Automated Electrical Tuning of Television Sets	218
11.5 Intelligent System for Control	221
11.6 Simulation Results	225
11.7 Summary	225
Chapter 12 Intelligent Manufacturing of Batteries	227
12.1 Intelligent Control of the Battery Charging Process	228
12.1.1 Problem Description	229
12.1.2 Fuzzy Method for Control	230
12.1.3 Neuro-Fuzzy Method for Control	232

12.1.4 Neuro-Fuzzy-Genetic Method for Control	234
12.2 Hardware Implementation of the Fuzzy Controller for the Charging Process	236
12.2.1 Introduction	236
12.2.2 Fuzzy Control	237
12.2.3 Implementation of the Fuzzy Controller	246
12.2.4 Experimental Results	250
12.3 Automated Quality Control of Batteries	250
12.3.1 Introduction	251
12.3.2 Fuzzy Controller	253
12.3.3 Fuzzy Control Implementation	262
12.4 Summary	266
Bibliography	267
Index	281