

Contents

Part I: Foundations of Computational Intelligence

1	Foundations of Computational Intelligence	3
1.1	Introduction	3
1.2	Evolutionary Algorithms	3
1.2.1	Genetic Programming	7
1.2.2	Estimation of Distribution Algorithm	11
1.2.3	Population-Based Incremental Learning	13
1.2.4	Probabilistic Incremental Program Evolution	14
1.3	Swarm Intelligence	18
1.3.1	Particle Swarm Optimization	19
1.3.2	Ant Colony Optimization	21
1.4	Artificial Neural Networks	23
1.4.1	Architecture and Learning Algorithm	24
1.4.2	Multilayer Perceptron	26
1.4.3	Back-Propagation Algorithm	27
1.4.4	Evolutionary Algorithm Based Training	28
1.4.5	Self Organizing Feature Maps	29
1.4.6	Radial Basis Function	30
1.4.7	Recurrent Neural Networks	30
1.4.8	Adaptive Resonance Theory	31
1.5	Fuzzy Systems	31
1.5.1	The Definition of Fuzzy Sets	32
1.6	Takagi-Sugeno Fuzzy Model	32
1.6.1	Universal Approximation Property	33
1.6.2	Fuzzy Expert Systems - Design Challenges	34
1.7	Probabilistic Computing	34
1.8	Hybrid Intelligent Systems	35
1.9	Models of Hybrid Intelligent Systems	36

Part II: Flexible Neural Trees

2	Flexible Neural Tree: Foundations and Applications	39
2.1	Introduction to Flexible Neural Tree	39
2.2	Flexible Neural Tree Algorithms	40
2.2.1	Encoding and Evaluation	40
2.2.2	Flexible Neuron Instructor	40
2.2.3	Fitness Function	42
2.2.4	Structure and Parameter Learning	42
2.2.5	Flexible Neural Tree Applications	44
2.2.6	Exchange Rate Forecasting	64
2.2.7	Face Recognition	69
2.2.8	Microarray-Based Cancer Classification	73
2.2.9	Protein Fold Recognition	76
2.3	Multi Input Multi Output Flexible Neural Tree	79
2.4	Representation and Calculation of the MIMO FNT	80
2.4.1	Hybrid Algorithm for Structure and Parameter Learning	82
2.4.2	Hybrid Algorithm for Flexible Neural Tree Model	84
2.4.3	Illustrative Examples	84
2.5	Ensemble of Flexible Neural Tree	89
2.5.1	The Basic Ensemble Method	90
2.5.2	The Generalized Ensemble Method	90
2.5.3	The LWPR Method	90
2.5.4	Stock Index Forecasting Problem	91
2.6	Stock Index Forecasting Experimental Illustrations	93

Part III: Hierarchical Neural Networks

3	Hierarchical Neural Networks	99
3.1	Hierarchical Radial Basis Function Neural Networks	99
3.1.1	The Radial Basis Function Network	100
3.1.2	Automatic Design of Hierarchical Radial Basis Function Network	101
3.1.3	Tree Structure Optimization by Extended Compact Genetic Programming (ECGP)	102
3.1.4	Parameter Optimization Using Differential Evolution Algorithm	102
3.1.5	Procedure of the General Learning Algorithm	103
3.1.6	Variable Selection in the HRBF Network Paradigms	103
3.1.7	Experimental Illustrations	104
3.1.8	Face Recognition	105

- 3.2 Hierarchical B-Spline Neural Networks 108
 - 3.2.1 The B-Spline Network 108
- 3.3 Automatic Design of HB-Spline Network 109
 - 3.3.1 Encode and Calculation for HB-Spline 109
 - 3.3.2 Tree Structure and Parameter Optimization 110
 - 3.3.3 Procedure of the General Learning Algorithm 111
 - 3.3.4 Variable Selection in the Hierarchical B-Spline
Network Paradigms 111
 - 3.3.5 Experimental Illustrations 111
 - 3.3.6 Wisconsin Breast Cancer Detection 111
 - 3.3.7 Time-Series Forecasting 113
- 3.4 Hierarchical Wavelet Neural Networks 118
 - 3.4.1 Wavelet Neural Network 118
- 3.5 Automatic Design of Hierarchical Wavelet Neural
Network 119
 - 3.5.1 Ant Programming for Evolving the Architecture of
HWNN 119
 - 3.5.2 Parameter Optimization Using Differential
Evolution Algorithm 121
 - 3.5.3 Procedure of the General Learning Algorithm for
HWNN 121
 - 3.5.4 Variable Selection Using HWNN Paradigms..... 122
 - 3.5.5 Experimental Illustrations 122
 - 3.5.6 Application to Jenkins-Box Time-Series 124

Part IV: Hierarchical Fuzzy Systems

- 4 Hierarchical Fuzzy Systems 129**
 - 4.1 Introduction 129
 - 4.2 Takagi-Sugeno Fuzzy Inference System (TS-FS) 131
 - 4.3 Hierarchical TS-FS: Encoding and Evaluation 131
 - 4.3.1 Encoding 132
 - 4.3.2 Evaluation 133
 - 4.3.3 Objective Function 134
 - 4.4 Evolutionary Design of Hierarchical TS-FS 135
 - 4.4.1 Algorithm for Designing Hierarchical
TS-FS Model 135
 - 4.4.2 Feature/Input Selection with Hierarchical TS-FS 136
 - 4.5 Experimental Illustrations 137
 - 4.5.1 Systems Identification 138
 - 4.5.2 Chaotic Time-Series of Mackey-Glass 139
 - 4.5.3 Iris Data Classification 142
 - 4.5.4 Wine Data Classification 144

Part V: Reverse Engineering of Dynamical Systems

5 Reverse Engineering of Dynamic Systems 151

5.1 Introduction 151

5.2 Calculation and Representation of Additive Models 152

5.3 Hybrid Algorithm 153

5.3.1 Tree-Structure Based Evolutionary Algorithm 153

5.3.2 Evolving an Optimal or Near-Optimal Structure of Additive Model 154

5.3.3 Parameter Optimization 156

5.3.4 Summary of General Learning Algorithm 158

5.3.5 Experimental Illustrations 159

5.3.6 Discussions 165

5.4 Inferring a System of Differential Equations 168

5.5 Inference of Differential Equation Models by Multi Expression Programming 169

5.5.1 Structure Optimization by the MEP 169

5.5.2 Parameter Optimization by Particle Swarm Optimization Algorithm 170

5.5.3 Fitness Definition 171

5.5.4 Summary of Algorithm 172

5.6 Modeling Chemical Reactions 172

5.6.1 Simple Chemical Reaction Model 173

5.6.2 Two-Species Lotka-Volterra Model 174

5.6.3 Bimolecular Reaction 175

5.7 Inferring Gene Regulatory Networks 176

5.7.1 The Small Artificial Gene Regulatory Network 178

5.7.2 The Large-Scale Artificial Gene Regulatory Network with Noisy Environment 181

Part VI: Conclusions and Future Research

6 Concluding Remarks and Further Research 185

6.1 Limitations of Conventional Computational Intelligence 185

6.2 Towards Tree-Structure Based Hierarchical Hybrid Computational Intelligence 186

6.2.1 Tree Structure Based Evolutionary Computation Models 186

6.2.2 Hierarchical Hybrid Computational Intelligence Framework 186

6.3 Static and Dynamical Models 190

References 191