Contents

Preface iii

1 Introduction to Neural Networks and *Mathematica* 1

1.1 The Neural-Network Paradigm 2
1.2 Neural-Network Fundamentals 7

2 Training by Error Minimization 39

2.1 Adaline and the Adaptive Linear Combiner 40
2.2 The LMS Learning Rule 42
2.3 Error Minimization in Multilayer Networks 63

3 Backpropagation and Its Variants 67

3.1 The Generalized Delta Rule 68
3.2 BPN Examples 74
3.3 BPN Variations 97
3.4 The Functional Link Network 103

4 Probability and Neural Networks 115

4.1 The Discrete Hopfield Network 116
4.2 Stochastic Methods for Neural Networks 124
4.3 Bayesian Pattern Classification 135
4.4 The Probabilistic Neural Network 144

5 Optimization and Constraint Satisfaction 153

5.1 The Traveling Salesperson Problem (TSP) 154
5.2 Neural Networks and the TSP 156

6 Feedback and Recurrent Networks 177

6.1 The BAM 178
6.2 Recognition of Time Sequences 185

7 Adaptive Resonance Theory 209

7.1 ART1 211
7.2 ART2 243

8 Genetic Algorithms 259

8.1 GA Basics 260
8.2 A Basic Genetic Algorithm (BGA) 266
8.3 A GA for Training Neural Networks 281

Appendix A Code Listings 295

Bibliography 335

Index 337