

---

## Contents

<b>List of Figures .....</b>	XV
<b>List of Tables .....</b>	XXI
<b>1 Introduction .....</b>	1
1.1 Backgrounds .....	1
1.1.1 Feed-forward Neural Networks .....	1
1.1.2 Recurrent Networks with Saturating Transfer Functions .....	2
1.1.3 Recurrent Networks with Nonsaturating Transfer Functions .....	4
1.2 Scopes .....	5
1.3 Organization .....	6
<b>2 Feedforward Neural Networks and Training Methods .....</b>	9
2.1 Introduction .....	9
2.2 Error Back-propagation Algorithm .....	9
2.3 Optimal Weight Initialization Method .....	12
2.4 The Optimization-Layer-by-Layer Algorithm .....	14
2.4.1 Optimization of the Output Layer .....	15
2.4.2 Optimization of the Hidden Layer .....	16
2.5 Modified Error Back-Propagation Method .....	18
<b>3 New Dynamical Optimal Learning for Linear Multilayer FNN .....</b>	23
3.1 Introduction .....	23
3.2 Preliminaries .....	24
3.3 The Dynamical Optimal Learning .....	25
3.4 Simulation Results .....	28
3.4.1 Function Mapping .....	28
3.4.2 Pattern Recognition .....	30

3.5	Discussions .....	33
3.6	Conclusion .....	33
<b>4</b>	<b>Fundamentals of Dynamic Systems .....</b>	<b>35</b>
4.1	Linear Systems and State Space .....	35
4.1.1	Linear Systems in $\mathbf{R}^2$ .....	35
4.1.2	Linear Systems in $\mathbf{R}^n$ .....	38
4.2	Nonlinear Systems .....	41
4.3	Stability, Convergence and Bounded-ness .....	41
4.4	Analysis of Neuro-dynamics.....	46
4.5	Limit Sets, Attractors and Limit Cycles .....	51
<b>5</b>	<b>Various Computational Models and Applications .....</b>	<b>57</b>
5.1	RNNs as a Linear and Nonlinear Programming Solver .....	57
5.1.1	Recurrent Neural Networks .....	58
5.1.2	Comparison with Genetic Algorithms .....	59
5.2	RNN Models for Extracting Eigenvectors .....	66
5.3	A Discrete-Time Winner-Takes-All Network .....	68
5.4	A Winner-Takes-All Network with LT Neurons .....	70
5.5	Competitive-Layer Model for Feature Binding and Segmentation .....	74
5.6	A Neural Model of Contour Integration .....	76
5.7	Scene Segmentation Based on Temporal Correlation .....	77
<b>6</b>	<b>Convergence Analysis of Discrete Time RNNs for Linear Variational Inequality Problem .....</b>	<b>81</b>
6.1	Introduction .....	81
6.2	Preliminaries.....	82
6.3	Convergence Analysis: $A$ is a Positive Semidefinite Matrix ....	83
6.4	Convergence Analysis: $A$ is a Positive Definite Matrix .....	85
6.5	Discussions and Simulations .....	87
6.6	Conclusions .....	96
<b>7</b>	<b>Parameter Settings of Hopfield Networks Applied to Traveling Salesman Problems .....</b>	<b>99</b>
7.1	Introduction .....	99
7.2	TSP Mapping and CHN Model.....	100
7.3	The Enhanced Lyapunov Function for Mapping TSP .....	102
7.4	Stability Based Analysis for Network's Activities .....	104
7.5	Suppression of Spurious States .....	105
7.6	Setting of Parameters .....	112
7.7	Simulation Results and Discussions .....	112
7.8	Conclusion .....	115

<b>8 Competitive Model for Combinatorial Optimization Problems</b> .....	117
8.1 Introduction .....	117
8.2 Columnar Competitive Model .....	118
8.3 Convergence of Competitive Model and Full Valid Solutions ..	120
8.4 Simulated Annealing Applied to Competitive Model .....	123
8.5 Simulation Results.....	124
8.6 Conclusion .....	128
<b>9 Competitive Neural Networks for Image Segmentation</b> .....	129
9.1 Introduction .....	129
9.2 Neural Networks Based Image Segmentation .....	130
9.3 Competitive Model of Neural Networks.....	131
9.4 Dynamical Stability Analysis .....	132
9.5 Simulated Annealing Applied to Competitive Model .....	134
9.6 Local Minima Escape Algorithm Applied to Competitive Model.....	135
9.7 Simulation Results.....	137
9.7.1 Error-Correcting .....	137
9.7.2 Image Segmentation .....	140
9.8 Conclusion .....	143
<b>10 Columnar Competitive Model for Solving Multi-Travelling Salesman Problem</b> .....	145
10.1 Introduction .....	145
10.2 The MTSP Problem .....	146
10.3 MTSP Mapping and CCM Model .....	148
10.4 Valid Solutions and Convergence Analysis of CCM for MTSP .	151
10.4.1 Parameters Settings for the CCM Applied to MTSP ..	152
10.4.2 Dynamical Stability Analysis .....	153
10.5 Simulation Results.....	156
10.6 Conclusions .....	159
<b>11 Improving Local Minima of Columnar Competitive Model for TSPs</b> .....	161
11.1 Introduction .....	161
11.2 Performance Analysis for CCM .....	162
11.3 An Improving for Columnar Competitive Model .....	165
11.3.1 Some Preliminary Knowledge .....	165
11.3.2 A Modified Neural Representation for CCM .....	167
11.3.3 The Improvement for Columnar Competitive Model ..	168
11.4 Simulation Results.....	171
11.5 Conclusions .....	174

<b>12 A New Algorithm for Finding the Shortest Paths Using PCNN</b> .....	177
12.1 Introduction .....	177
12.2 PCNNs Neuron Model .....	178
12.3 The Multi-Output Model of Pulse Coupled Neural Networks (MPCNNs) .....	180
12.3.1 The Design of MPCNNs.....	180
12.3.2 Performance Analysis of the Travelling of Autowaves in MPCNNs .....	181
12.4 The Algorithm for Solving the Shortest Path Problems using MPCNNs.....	183
12.5 Simulation Results.....	184
12.6 Conclusions .....	188
<b>13 Qualitative Analysis for Neural Networks with LT Transfer Functions</b> .....	191
13.1 Introduction .....	191
13.2 Equilibria and Their Properties .....	192
13.3 Coexistence of Multiple Equilibria .....	197
13.4 Boundedness and Global Attractivity .....	199
13.5 Simulation Examples.....	203
13.6 Conclusion .....	206
<b>14 Analysis of Cyclic Dynamics for Networks of Linear Threshold Neurons</b> .....	211
14.1 Introduction .....	211
14.2 Preliminaries.....	212
14.3 Geometrical Properties of Equilibria .....	213
14.4 Neural States in $D_1$ and $D_2$ .....	214
14.4.1 Phase Analysis for Center Type Equilibrium in $D_1$ .....	214
14.4.2 Phase Analysis in $D_2$ .....	215
14.4.3 Neural States Computed in Temporal Domain .....	217
14.5 Rotated Vector Fields.....	217
14.6 Existence and Boundary of Periodic Orbits .....	219
14.7 Winner-take-all Network .....	226
14.8 Examples and Discussions .....	229
14.8.1 Nondivergence Arising from A Limit Cycle.....	229
14.8.2 An Example of WTA Network .....	229
14.8.3 Periodic Orbits of Center Type.....	229
14.9 Conclusion .....	231
<b>15 LT Network Dynamics and Analog Associative Memory</b> .....	235
15.1 Introduction .....	235
15.2 Linear Threshold Neurons .....	236
15.3 LT Network Dynamics (Revisited) .....	238

15.4	Analog Associative Memory .....	243
15.4.1	Methodology.....	243
15.4.2	Design Method.....	244
15.4.3	Strategies of Measures and Interpretation.....	247
15.5	Simulation Results.....	247
15.5.1	Small-Scale Example.....	248
15.5.2	Single Stored Images.....	249
15.5.3	Multiple Stored Images .....	251
15.6	Discussion .....	252
15.6.1	Performance Metrics .....	252
15.6.2	Competition and Stability .....	252
15.6.3	Sparsity and Nonlinear Dynamics .....	253
15.7	Conclusion .....	255
<b>16</b>	<b>Output Convergence Analysis for Delayed RNN with Time Varying Inputs .....</b>	<b>259</b>
16.1	Introduction .....	259
16.2	Preliminaries.....	261
16.3	Convergence Analysis .....	264
16.4	Simulation Results.....	274
16.5	Conclusion .....	276
<b>17</b>	<b>Background Neural Networks with Uniform Firing Rate and Background Input .....</b>	<b>279</b>
17.1	Introduction .....	279
17.2	Preliminaries.....	280
17.3	Nondivergence and Global Attractivity .....	282
17.4	Complete Stability.....	283
17.5	Discussion .....	285
17.6	Simulation.....	286
17.7	Conclusions .....	286
<b>References .....</b>	<b>289</b>	