

Contents

Preface	iii
Acknowledgements	ix
1 Chaos and Communications	1
1.1 Historical Account	2
1.2 Chaos.....	5
1.3 Quantifying Chaotic Behavior	5
1.3.1 Lyapunov Exponents for Continuous-Time Nonlinear Systems.....	6
1.3.2 Lyapunov Exponent for Discrete-Time Systems	8
1.3.3 Kolmogorov Entropy.....	8
1.3.4 Attractor Dimension.....	10
1.4 Properties of Chaos	12
1.5 Chaos-Based Communications	14
1.5.1 Conventional Spread Spectrum	14
1.5.2 Spread Spectrum with Chaos	16
1.5.3 Chaotic Synchronization	16
1.6 Communications Using Chaos as Carriers.....	19
1.6.1 Chaotic Masking Modulation.....	19
1.6.2 Dynamical Feedback Modulation	20
1.6.3 Inverse System Modulation.....	21
1.6.4 Chaotic Modulation.....	22
1.6.5 Chaos Shift Keying	22
1.6.6 Differential Chaos Shift Keying Modulation	24
1.7 Remarks on Chaos-Based Communications	25

1.7.1	Security Issues.....	25
1.7.2	Engineering Challenges.....	25
2	Reconstruction of Signals	27
2.1	Reconstruction of System Dynamics	28
2.1.1	Topological Embeddings.....	29
2.1.2	Delay Coordinates	30
2.2	Differentiable Embeddings	33
2.3	Phase Space Reconstruction—Example	34
2.4	Problems and Research Approaches	39
3	Fundamentals of Neural Networks	41
3.1	Motivation.....	41
3.2	Benefits of Neural Networks.....	43
3.3	Radial Basis Function Neural Networks	46
3.3.1	Background Theory.....	46
3.3.2	Research Progress in Radial Basis Function Networks.....	49
3.4	Recurrent Neural Networks	56
3.4.1	Introduction.....	56
3.4.2	Topology of the Recurrent Networks.....	57
3.4.3	Learning Algorithms	58
4	Signal Reconstruction in Noise-free and Distortionless Channels.....	60
4.1	Reconstruction of Attractor for Continuous Time-Varying Systems	60
4.2	Reconstruction and Observability	62
4.3	Communications Based on Reconstruction Approach.....	63
4.3.1	Parameter Estimations.....	64
4.3.2	Information Retrievals.....	66
4.4	Reconstruction of Attractor for Discrete Time-Varying Systems	69
4.5	Summary.....	71

5	Signal Reconstruction from a Filtering Viewpoint: Theory	72
5.1	The Kalman Filter and Extended Kalman Filter	72
5.1.1	The Kalman Filter	72
5.1.2	Extended Kalman Filter	76
5.2	The Unscented Kalman Filter	77
5.2.1	The Unscented Kalman Filtering Algorithm	78
5.2.2	Convergence Analysis for the UKF Algorithm	82
5.2.3	Computer Simulations	86
5.3	Summary	89
6	Signal Reconstruction from a Filtering Viewpoint: Application	91
6.1	Introduction	91
6.2	Filtering of Noisy Chaotic Signals	92
6.2.1	Filtering Algorithm	92
6.2.2	Computer Simulation	94
6.3	Blind Equalization for Fading Channels	101
6.3.1	Modeling of Wireless Communication Channels	101
6.3.2	Blind Equalization of Fading Channels with Fixed Channel Coefficients	103
6.3.3	Blind Equalization for Time-Varying Fading Channels	106
6.4	Summary	109
7	Signal Reconstruction in Noisy Channels	110
7.1	Review of Chaotic Modulation	110
7.2	Formulation of Chaotic Modulation and Demodulation	112
7.3	On-Line Adaptive Learning Algorithm and Demodulation	116
7.3.1	Description of the Network	116
7.3.2	Network Growth	118
7.3.3	Network Update with Extended Kalman Filter	119
7.3.4	Pruning of Hidden Units	121
7.3.5	Summary of the Flow of Algorithm	121
7.4	Computer Simulation and Evaluation	123
7.5	Application to Non-coherent Detection in Chaos-Based Communication	131

7.6	Summary	139
8	Signal Reconstruction in Noisy Distorted Channels.....	140
8.1	Preliminaries	141
8.1.1	Conventional Equalizers	142
8.1.2	Reconstruction of Chaotic Signals and Equalization	143
8.1.3	Recurrent Neural Network and Equalization	144
8.2	Training Algorithm	148
8.3	Simulation Study	151
8.3.1	Chaotic Signal Transmission.....	151
8.3.2	Filtering Effect of Communication Channels.....	152
8.3.3	Results	156
8.4	Comparisons and Discussions.....	161
8.5	Summary	164
9	Chaotic Network Synchronization and Its Applications in Communications.....	165
9.1	Chaotic Network Synchronization	166
9.1.1	Network Synchronization.....	167
9.1.2	Chaos Control.....	168
9.1.3	Implementation of the Synchronization Scheme.....	172
9.2	Implementation of Spread-Spectrum Communications	175
9.2.1	Encoding and Decoding	175
9.2.2	Test Results for Communications	178
9.3	Summary.....	181
10	Conclusions.....	183
10.1	Summary of Methods.....	183
10.2	Further Research	185
	Bibliography.....	188
	Index.....	214