Contents

Part I: Theory of Chaos and Synchronization and Applications in Mechanics, Transportation, Communication and Security Related System Concepts

		ion of Two Nonidentical Clocks: What Huygens	
		Observe?	
		lczynski, Przemysaw Perlikowski, Andrzej Stefanski,	
	ısz K apite		
1.1		action	
1.2			
1.3	C	Balance	
	1.3.1	Energy Balance of the Pendulum	
	1.3.2	Energy Balance of the Beam and Whole	
		System (1,2)	
1.4		rical Results	
	1.4.1	From Complete to (Almost) Antiphase	
		Synchronization	
	1.4.2	From Complete Synchronization to Quasiperiodic	
		Oscillations	
	1.4.3	From Antiphase to Almost-Antiphase	
		Synchronization	
	1.4.4	From Antiphase Synchronization to Quasiperiodic	
		Oscillations	
1.5	From (Complete to (Almost) Antiphase Synchronization	
Refe	rences		
	1 - 6 - 1	and the second of the second o	
	-	hronization of 1D and 2D Multi-scroll Chaotic	
		tanhana F. Zamburana Communa O.C. Fálim Poltmán	
		Pacheco, E. Zambrano-Serrano, O.G. Félix-Beltrán,	
		ttle, L.C. Gómez-Pavón, R. Trejo-Guerra,	
		s, C. Sánchez-López	
2.1		action	
2.2		al Aspects for the Amplifiers-Based Design of Chaotic	
	Oscilla	tors	

XIV Contents

	2.3		High-Level Modeling Opamp-Based Circuit Synthesis tonian-Based Synchronization of Multi-directional	23 24
		Multi-9	scroll Chaotic Oscillators	25 27
		2.3.1	Synchronization of 3D-4-Scroll Chaos Generators	29
		2.3.2	Numerical Simulation Results	30
	2.4			
	2.4	2.4.1	n of Chaos-Based Encrypted Communication Schemes	33
			Binary Transmission	34
	2.5	2.4.2	Analog Transmission	35
	2.5		asions	38
	Kerei	ences		38
3			Itering of Chaos for Real Time Applications	41
			h, Z. Lovtchikova	
	3.1		action	41
	3.2		c Modelling of Random Signals	42
		3.2.1	Approximations for PDF of Strange Attractors	43
		3.2.2	Degenerated Cumulant Equations for Two-Moment	
			Cumulants	46
	3.3		ng of Chaotic Signals in Presence of Additive Gaussian	
				49
		3.3.1	Markov Theory of Non-linear Filtering	49
		3.3.2	Approximate Algorithms of Non-linear Filtering of	
			Chaos	51
		3.3.3	Comparative Analysis of Nonlinear Filtering	
			Approach	54
	3.4	"Multi	-moment" Nonlinear Filtering of Chaos	56
	Refer	ences		58
4	Time	-of-Fligh	ht Estimation Using Synchronized Chaotic Systems	61
			Vallinger, Markus Brandner	0.
	4.1		action	61
		4.1.1	Time-of-Flight Measurements	62
		4.1.2	Outline	63
	4.2		onized Chaotic Systems	63
		4.2.1	Convergence	64
		4.2.2	Detection Range	65
		4.2.3	Discretization Algorithms and Numerical Issues	66
		4.2.4	Delay Estimators	69
	4.3		ments	73
		4.3.1	Different Window Lengths	73
		4.3.2	Different Noise Levels	75
		4.3.3	Different Orders of Numerical Solver	75
	4.4		ary and Conclusions	78
		ences		78

Contents XV

5	Binary Synchronization of Complex Dynamics in Cellular Automata and its Applications in Compressed Sensing and					
		otography	81			
		Dogaru, Ioana Dogaru	٠.			
	5.1	Introduction and Motivation	81			
	5.2	Automata Network Models and the Key Space	84			
	5.3	Characterizing Complex Dynamics in Automata	86			
	5.4	FPGA Implementations of Cellular Automata	89			
	5.5	Applications	90			
	5.5	5.5.1 Compressed Sensing Based on Chaotic Scan	90			
		5.5.2 Efficient Generation of Spreading Sequences	91			
	5.6	Conclusions	92			
		rences	94			
6		Shaping Attractors for Coupled Limit Cycle Oscillators	97			
		Rodriguez, Max-Olivier Hongler, Philippe Blanchard				
	6.1	Introduction	97			
	6.2	Networks of Mixed Canonical-Dissipative (MCD) Systems				
		with Adpating Parameters	99			
		6.2.1 Local Dynamics: L	99			
		6.2.2 Coupling Dynamics: C_k	100			
		6.2.3 Parametric Dynamics: P_k	100			
	6.3	Dynamics of the Network	106			
		6.3.1 Network of Ellipsoidal HOPF Oscillators	108			
	6.4	Numerical Simulations	108			
		6.4.1 Ellipsoidal HOPF Oscillators	109			
		6.4.2 Cassini Oscillators	109			
		6.4.3 MATHEWS-LAKSHMANAN Oscillators	112			
	6.5	Conclusions and Perspectives	114			
	Refer	rences	115			
		Systems' Dynamics Modeling and Simulation with Applications to sical Systems and Phenomena	o			
7	•	•				
′		Switching Behavior in Nonlinear Electronic Circuits:	110			
		ometric Approach	119			
		Thiessen, Sören Plönnigs, Wolfgang Mathis	110			
	7.1	Introduction and Motivation	119			
	7.2	Geometric Approach of Circuits and Fast Switching Behavior	121			
	7 2	7.2.1 Singular Points and Jumps	122			
	7.3	Chart Representation of Circuits and Jump Phenomena	123			
		7.3.1 Jumps in State Space	123			
		7.3.2 Determining the State Space	125			
	7.4	7.3.3 Transient Solution and Hit Point Calculation	126			
	7.4	Adaption of the Geometric Approach to MNA Based System of Equations	127			

XVI Contents

	7.5	7.4.1 Applic 7.5.1 7.5.2	Modification of the System of Equations	127 128 128 132
	7.6		sion	134
				135
8	Dyna	mics of	Liénard Optoelectronic Oscillators	137
	Bruno	Romeir	ra, José Figueiredo, Charles N. Ironside,	
	Julien	Javaloy	ees	
	8.1	Introdu	action	137
	8.2	Resona	ant Tunneling Diode Optoelectronic Oscillators	139
		8.2.1	Resonant Tunneling Diode	140
		8.2.2	RTD Photo-Detector Equivalent Electrical Circuit	142
		8.2.3	Laser Diode Rate Equations	143
		8.2.4	Forced Liénard OEO System with Time Delayed	
			Feedback	145
	8.3	Dynam	nical Regimes of Liénard OEOs	146
		8.3.1	Self-Sustained Oscillations	147
		8.3.2	Injection Locking Dynamics	148
		8.3.3	Quasi-Periodicity and Chaotic Dynamics	152
		8.3.4	Time Delayed Feedback Dynamics	152
	8.4	Conclu	sion and Future Work	155
	Refere	ences		156
9	Appli	cation o	of Coupled Dynamical Systems for Communities	
	Detec	tion in (Complex Networks	159
	Nikolo	ai Nefed	ov	
	9.1	Introdu	action	159
	9.2	Comm	unity Detection	161
		9.2.1	Modularity Maximization	161
		9.2.2	Communities Detection with Random Walk	161
	9.3	Topolo	gy Detection Using Coupled Dynamical Systems	163
		9.3.1	Laplacian Formulation of Network Dynamics	163
		9.3.2	Dynamical Structures with Different Coupling	
			Scenarios	165
	9.4	Overla	pping Communities	168
		9.4.1	Multi-membership	168
		9.4.2	Application of Soft Community Detection for	
			Recommendation Systems	169
	9.5	Metho	ds Testing in Benchmark Networks	171
	7.5	9.5.1	Zachary Karate Club: Communities and Its	
		9.5.1	Zachary Karate Club: Communities and Its Dynamics	171
			Dynamics	171 172
		9.5.1 9.5.2 9.5.3		

Contents	XVII
	Ath

	9.7 Refer		sions	178 179
10			orks of Hubs, Spirals, and Zig-Zag Patterns ned Oscillations of a Tunnel Diode and of an	
			d Fiber-ring Laser	181
			uncke, Thorsten Pöschel, Jason A.C. Gallas	101
	10.1		ction	181
	10.1		ow Defined by a Simple Circuit with a Tunnel Diode	183
	10.2			
	10.3		ow-Fast Dynamics of the Circuit with a Tunnel Diode Diagrams	185
			sions and Outlook	187
	10.5			193
			e erbium-doped dual-ring fiber laser	195 196
11			amics of Atmospheric Pollution and Its Association	100
	Siwek	Krzyszte	mental Parameters	199
	11.1		ction	199
	11.2		is of the Pollution Time Series	200
	11.3		lations between the Pollution and the Environmental	
			ters	205
	11.4		rison of the Linear and Nonlinear Prediction Models	207
	11.5		sions	210
	Refer	ences		210
12			mics Modeling of Intelligent Transportation	
	-		an and Social Requirements for the Construction of	
	-		otheses	211
		Mitrea		
	12.1		ction	211
	12.2	Interact	ion and Interactivity in Intelligent Transportation	
			S	212
	12.3		arization: Human and Social Requirements for the	
			Dynamics Modeling of Cooperative Traffic Scenarios	217
		12.3.1	Description of the Pro-active and Co-operative	
			Agency [24]:	220
		12.3.2	The Level of Interpersonal Interaction, Intra-activity	
			(Interaction among Technical Agents) and	
			Interactivity with Human and Social Systems [24]	220
		12.3.3	The "Hybrid Constellations" of Pro-active and	
			Cooperative Agency [24]	221
	12.4	Implica	tions for the Modeling of the User Acceptance	222
	12.5	Conclus	sion	223
	Refer	ences		223

XVIII Contents

13		ow to Handle Societal Complexity			
	13.1	Introduction	227		
	13.2	How Complex Societal Problems Should Be Handled: The Compram Methodology	229		
	12.2	Complex Societal Problems: Problem-Handling Phase 1.1:	227		
	13.3	•	222		
	12.4	Awareness	232		
	13.4	Complex Societal Problems: Problem-Handling Phase 1.2:	222		
	12.5	Mental Idea	233		
	13.5	Complex Societal Problems: Problem-Handling Phase 1.3:	224		
	10.6	Political Agenda	234 234		
	13.6	Handling a Complex Societal Problem			
	13.7	Policymakers: Jump to Conclusions	235		
	13.8	Complex Societal Problems: Uncertainty	236		
	13.9	Are Policymakers Educated for Their Task?	236		
	13.10	- ,	237		
		Creative Problem Solving	237		
		Knowledge Institutes	238		
	13.13	Discussion: Handling Complex Societal Problems to Provide			
		Benefits for All?			
	13.14	Summary	240		
		Electromagnetics Theory, Modeling and Simulation of Real Phygnetic Prototypes	sical		
	ctroma Electi	gnetic Prototypes comagnetics, Systems Theory, Fluid Dynamics, and Some			
Ele	ctroma Electi Funda	comagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics	sical 247		
Ele	ctroma Electi Funda Alfred	comagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics	247		
Ele	Electroma Funda Alfred 14.1	comagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics			
Ele	ctroma Electi Funda Alfred	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics	247 247		
Ele	Electroma Funda Alfred 14.1 14.2	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics	247 247 249		
Ele	Electroma Funda Alfred 14.1 14.2	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics	247 247 249 251		
Ele	Electric Funda Alfred 14.1 14.2 14.3 14.4	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity	247 247 249 251 252		
Ele	Electroma Funda Alfred 14.1 14.2	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations	247 247 249 251 252 254		
Ele	Electric Funda Alfred 14.1 14.2 14.3 14.4	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations	247 247 249 251 252 254 254		
Ele	Electric Funda Alfred 14.1 14.2 14.3 14.4	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field	247 247 249 251 252 254 254 255		
Ele	Electric Fund: Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis	247 247 249 251 252 254 255 257		
Ele	Electr Fund: Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model	247 247 249 251 252 254 254 255 257 259		
Ele	Electric Fund: Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model Towards a Model of an Electron	247 249 251 252 254 255 257 259 261		
Ele	Electr Fund: Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model Towards a Model of an Electron 14.7.1 Purely Electromagnetic Approach	247 247 249 251 252 254 255 257 259 261 261		
Ele	Electroma Electroma Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Fettweis Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model Towards a Model of an Electron 14.7.1 Purely Electromagnetic Approach 14.7.2 Incompleteness of the Original Formulation	247 249 251 252 254 255 257 259 261 261 262		
Ele	Electr Fund: Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model Towards a Model of an Electron 14.7.1 Purely Electromagnetic Approach 14.7.2 Incompleteness of the Original Formulation Travelling Particles	247 247 249 251 252 254 255 257 259 261 261		
Ele	Electroma Electroma Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model Towards a Model of an Electron 14.7.1 Purely Electromagnetic Approach 14.7.2 Incompleteness of the Original Formulation Travelling Particles 14.8.1 Electron-Like Particle Observed in Different	247 249 251 252 254 255 257 259 261 262 264		
Ele	Electroma Electroma Alfred 14.1 14.2 14.3 14.4 14.5	romagnetics, Systems Theory, Fluid Dynamics, and Some amentals in Physics Introduction Electromagentic Field in Vacuum: Maxwell's Equations and Related Results Fluid Dynamics Field Velocity, Rest Field, and Energy Velocity The Flow Equations 14.5.1 General Form of the Flow Equations 14.5.2 Flow Equations of a Basal Electromagnetic Field 14.5.3 Field Rotating around an Axis A Photon Model Towards a Model of an Electron 14.7.1 Purely Electromagnetic Approach 14.7.2 Incompleteness of the Original Formulation Travelling Particles	247 249 251 252 254 255 257 259 261 261 262		

Contents XIX

	14.9	Quantum Mechanics	267
		14.9.1 Problems with the Conventional Approach	267
		14.9.2 Schrödinger Equation	268
	14.10	Conclusion	270
	Refere	ences	271
15		amentals of Electrodynamics Essential Overview of EM	777
			273
		o Mišković	777
	15.1		273
	15.2		274
	15.3		275
	15.4	- J	277
	15.5		280
	15.6		281
	15.7		282
	15.8		282
	15.9	Differential Equations	283
	15.10	EM Induction	285
	15.11	EM Antinomies	287
	15.12	Structural Models	289
	15.13	Conclusion	291
	Refere	ences	292
	4 7	TALL OF ALL OF ADDRESS OF A MARKET OF	
16		nced Adaptive Algorithms in 2D Finite Element Method of	ากา
		• •	293
		Karban, Ivo Doležel, František Mach, Bohuš Ulrych	303
	16.1		293
	16.2		294
	16.3		296
	16.4		297
		1 (1 1)	298
		1 ,	300
		,	302
	16.5	Conclusion	308
	Refere	ences 3	309
17	SPIC	E Model for Fast Time Domain Simulation of Power	
1,		formers, Exploiting the Ferromagnetic Hysteresis and	
			311
		n Mandache, Dumitru Topan, Mihai Iordache,	<i>)</i> 1 1
		Gabriela Sirbu	
	17.1		311
	17.1		313
	17.2		31 <i>6</i>
	17.5	of ICE implementation) [(

XX Contents

	17.4	Example of Modeling and Simulation of a Single-Phase Power Transformer	318
	17.5	Conclusion	323
		ences	324
	Kelei	circo	327
18		-Coupled Modeling of Induction Shrink Fit of Gas-Turbine	
		e Wheel	325
	Václa	w Kotlan, Pavel Karban, Bohuš Ulrych, Ivo Doležel, Pavel Kůs	
	18.1	Introduction	325
	18.2	Formulation of the Problem and Its Basic Analysis	327
	18.3	Continuous Mathematical Model of the Process of Heating	330
	18.4	Numerical Solution	331
	18.5	Illustrative Example	332
	18.6	Conclusion	338
	Refer	ences	338
Par	t IV:	Theory of Stability and Recent Trends	
19	Stahi	lity Analysis and Limit Cycles of High Order Sigma-Delta	
1/		llators	343
		i Mladenov	3 13
	19.1	Introduction	343
	19.1	Parallel Decomposition of a Sigma Delta Modulator	344
	19.2		348
		Stability of Shifted First Order Sigma-Delta Modulators	350
	19.4	Stability of High Order Sigma-Delta Modulators	330
	19.5	Analysis of Limit Cycles in High Order Sigma-Delta	255
	10.6	Modulators	355
	19.6	Conclusions	364
	Refer	ences	364
20	Stabi	lity Analysis of Vector Equalization Based on Recurrent	
	Neur	al Networks	367
	Moha	mad Mostafa, Werner G. Teich, Jürgen Lindner	
	20.1	Organization of the Chapter	367
	20.2	Vector-Valued Transmission Model	368
	20.3	Recurrent Neural Networks	370
		20.3.1 Discrete-Time RNNs	370
		20.3.2 Continuous-Time RNNs	371
		20.3.3 Stability Analysis Based on Lyapunov Functions	371
	20.4	Stability Analysis of RNNs with Time-Invariant Activation	
	2	Functions	373
	20.5	Analyzing The Optimum Activation Function	375
	-0.0	20.5.1 The Optimum Activation Function	375
		20.5.2 Properties of the Optimum Activation Function	376
		20.5.3 Lyapunov Function vs. Maximum Likelihood	2,0
		Function	378

Contents XXI

	20.6	Stability	y Analysis of RNNs with Time-Variant Activation	
		Functio	ns	379
		20.6.1	Discrete-Time RNNs with Parallel Update	379
		20.6.2	Discrete-Time RNN with Serial Update	380
		20.6.3	Continuous-Time RNN	382
	20.7	Global	vs. Local Stability for Vector Equalizer Based	
		on RNN	T	382
		20.7.1	Discrete-Time RNN with Parallel Update	383
		20.7.2	Continuous-Time RNN	383
		20.7.3	Discussion	383
	20.8	Conclus	sion	385
	Refere	ences		385
21	Speed	ling Up I	Linear Consensus in Networks	389
	_		gopoulos, Alireza Khadivi, Martin Hasler	
	21.1		ction	389
	21.2		al Application: Forest Fire Localization	390
	21.3		al Application: Distributed Machine Learning	394
	21.4		inear Distributed Average Consensus Algorithm	395
	21.5		zing the Weight Matrix for High Asymptotic	
	21.0	-	gence Rate	397
	21.6		zing the Convergence Rate at Finite Time	399
	21.7		inear Consensus at Finite Time	401
	21.8		sions	404
22	Stabil	lity of I i	near Circuits with Interval Data: A Case Study	407
		-	arczarczyk	107
	$\frac{258m}{22.1}$		ction	407
	22.2		n Statement	408
	22.3		y Of Interval Matrices	409
	22.4		tational Aspects	411
	22.5		cal Experiments	412
	22.6		emarks	413
			cinarks	413
			pplication Area- Optimization, Data Mining, on and Image Processing	
rau	iei ii K	ccoginuo	m and image i focessing	
23			liation and Bias Estimation in	
		_	mization	417
		d Manso		
	23.1		ction	417
	23.2		econciliation	418
		23.2.1	Types of Errors	418
		23.2.2	Brief History	419
		23.2.3	The Benefits of Data Reconciliation	420

XXII Contents

	23.3		Recent Developments and Software Packages Formulation of the Data Reconciliation Problem	420 421 422
	23.4		and the Inclusion of Data Reconciliation and Bias	423
	23.5		iontion to a Continuous Stirred Tank Reactor System	423
	23.6		sion	427
				427
24	Image	e Edge D	Detection and Orientation Selection with Coupled	
			citable Elements	429
			a, Yoshiki Mizukami, Koichi Okada, Makoto Ichikawa	
	24.1		ction	429
	24.2	_	ound	431
		24.2.1	Coupled Nonlinear Elements	431
	242	24.2.2	Edge Detection	432
	24.3	-	gh-Nagumo Elements on a Grid System	433 433
		24.3.1	FitzHugh-Nagumo Element	
	24.4	24.3.2	Coupled Elements	435
	24.4	24.4.1	Edge Detection Algorithm with a Two-Dimensional	450
		24.4.1	Grid System	437
		24.4.2	Algorithm for Edge Detection and Orientation	731
		27.7.2	Selection	438
	24.5	Experin	mental Results and Discussion	
	21.3	24.5.1	Examples of Edge Detection and Orientation	• • •
		2	Selection	440
		24.5.2	Quantitative Performance Evaluation on Edge	
			Detection	443
	24.6	Conclus	sion	446
	Refer	ences		447
25	Cons	ocutive E	Repeating State Cycles Determine Periodic Points in	
23			hine	449
		iel Steph		
	25.1		ction	449
	25.2		Machines & Periodic Configurations	451
	25.3	_	ycles	454
	25.4		Directed Edge Sequences	457
	25.5		Procedure for Periodic Points	461
	25.6	Discuss	sion and Further Work	467
	Refer	ences		468
	Appe	ndix		468
A	than I-	dov		175