## TABLE OF CONTENTS

Chapter	r 1 INTRODUCTION Ali Zilouchian and Mo Jamshidi	1
1.1	Motivation	1
1.2	Neural Networks	3
	1.2.1 Rationale for Using NN in Engineering	3
1.3	Fuzzy Logic Control	4
	1.3.1 Rationale for Using FL in Engineering	\5
1.4	Evolutionary Computation	6
1.5	Hybrid Systems	7
1.6	Organization of the Book References	8
Chapter		17
	Ali Zilouchian	
0.1		17
2.1	Introduction	17
2.2	Basic Structure of a Neuron	18 18
	2.2.1 Model of Biological Neurons	19
	2.2.2 Elements of Neural Networks	19
	2.2.2.1 Weighting Factors 2.2.2.2 Threshold	19
	2.2.2.2 Threshold 2.2.2.3 Activation Function	19
2.2	T 7 7 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	24
2.3	ADALINE	25
2.4	Linear Separable Patterns Single Layer Perceptron	26
2.5	2.5.1 General Architecture	26
	2.5.2 Linear Classification	27
	2.5.3 Perceptron Algorithm	30
2.6	Multi-Layer Perceptron	31
2.0	2.6.1 General Architecture	31
	2.6.2 Input-Output Mapping	32
	2.6.3 XOR Realization	34
2,7	Conclusion	38
7.1	References	38
	References	•
Chapte		39
/ <b>`</b>	Hooman Yousefizadeh and Ali Zilouchian	
		39
3.1	Introduction	25

3.2	NN Classifications	40	
	3.2.1 Feedforward and feedback networks	40	
	3.2.2 Supervised and Unsupervised Learning Networks	_41	
3.3	Back Propagation Algorithm	41.	
	3.3.1 Delta Training Rule	43	
3.4	Radial Basis Function Network (RBFN)	<b>&gt;</b> 51	
3.5	Kohonen Self Organization Network	56	
	3.5.1 Training of the Kohonen Network	58	
	3.5.2 Examples of Self-Organization	59	
3.6	Hopfield Network	62	
3.7	Conclusions	65	
	References	66	
Chapt			
	MEDICINE AND BIOLOGICAL SCIENCES	67	
	Faramarz Valafar		
4.1			
4.1	Introduction	67 67	
4.2.	Terminology and Standard Measures	6/	
4.3 Recent Neural Network Research Activity in Medicine			
	and Biological Sciences 4.3.1 ANNs in Cancer Research	72 72	
	4.3.1 ANN Biosignal Detection and Correction	73	
	4.3.2 ANN Blossgnar Detection and Correction 4.3.3 Decision-making in Medical Treatment Strategies	73 79	
4.4	Summary Summary	88	
7.7	References	88	
	References	00	
Chapt	er 5 APPLICATION OF NEURAL NETWORK IN		
	DESIGN OF DIGITAL FILTERS	93	
	Dali Wang and Ali Zilouchian		
5,1	Introduction	93	
5.2	Problem Approach	94	
	5.2.1 Neural Network for Identification	94	
(5.0	5.2.2 Neural Network Structure	95	
5.3	A Training Algorithm for Filter Design	97	
	5.3/1 Representation	97	
	5,3.2 Training Objective 5.3.3 Weight Adjustment	97	
	5.3.3 Weight Adjustment 5.3.4 The Training Algorithm	98 99	
5.4	Implementation Issues	99	
J. <del>4</del>	5.4.1 Identifying a System in Canonical Form	99	
	5.4.1 Stability, Convergence, Learning Rate and Scaling	100	
	5. 1.2 Sadding, Convergence, Domining Rate and Deaning	100	

5.5	2-D Filter Design Using Neural Network	100
0.0	5.5.1 Two-imensional Signal and Digital Filters	100
	5.5.2 Design Techniques	101
	5.5.3 Neural Network Approach	102
5.6	Simulation Results	103
2.0	5.6.1 1-D Filters	103
	5.6.2 2-D Filters	107
5.7	Conclusions	109
5.7	References	110
		1, 7
Chapte	r 6 APPLICATION OF COMPUTER	
•	NETWORKING USING NEURAL NETWORK	113
	Homayoun Yousefizadeh	
6.1	Introduction	/ 113
6.2	Self Similar Packet Traffic	113
	6.2.1 Fractal Properties of Packet Traffic	114
	6.2.2 Impacts of Fractal Nature of Packet Traffic	118
6.3	Neural Network Modeling of Packet Traffic	119
	6.3.1 Perceptron Neural Networks and Back	
	Propagation Algorithm	119
	6.3.2 Modeling Individual Traffic Patterns	122
	6.3.3 Modeling Aggregated Traffic Patterns	126
6.4	Applications of Traffic Modeling	130
	6.4.1 Packet Loss Prevention	130
	6.4.2 Packet Latency Prediction	134
	6.4.3 Experimental Observations	136
6.5	Summary	136
	References	137
Chapte		
	OIL REFINERIES	139
	Ali Zilouchian and Khalid Bawazir	
m 1	The state of the s	139
7.1	Introduction Building the Artificial Neural Network	140
7.2		141
	7.2.1 Range of Input Data 7.2.2 Size of the Training Data Set	141
		142
	<ul><li>7.2.3 Acquiring the Training Data Set</li><li>7.2.4 Validity of the Training Data Set</li></ul>	142
		142
7 7		144
7.3	Data Analysis 7.3.1 Elimination of Bad Lab Values	144
	7.3.1 Elimination of Bad Lab Values	1-4-4

	7.3.2 Process Parameters' Effect on Neural Network Prediction	145
7.4	Implementation Procedure	143
7.4	7.4.1 Identifying the Application	147
	7.4.1 Identifying the Application 7.4.2 Model Inputs Identification	148
	7.4.3 Range of Process Variables	149
7.5	Predictor Model Training	149
7.6	Simulation Results and Discussions	151
7.0	7.6.1 Naphtha 95% Cut Point	152
	7.6.2 Naphtha Reid Vapor Pressure	156
7.7	Conclusions	156
1.1	References	157
	Tesos one of	7
Chapte	r 8 INTRODUCTION TO FUZZY SETS: BASIC	
Chapte	DEFINITIONS AND RELATIONS	159
	Mo Jamshidi and Aly El-Osery	
8.1	Introduction	159
8.2	Classical Sets	160
8.3	Classical Set Operations	160
8.4	Properties of Classical Sets	162
8.5	Fuzzy Sets	163
	8.5.1 Fuzzy Membership Functions	163
8.6	Fuzzy Set Operations	165
8.7	Properties of Fuzzy Sets	166
	8.7.1 Alpha-Cut Fuzzy Sets	168
200	8.7.2 Extension Principle	168
8.8	Classical Relations vs. Fuzzy Relations	170
8.9	Conclusion	173
	References	173
Chanta	r 9 INTRODUCTION TO FUZZY LOGIC	175
Chapte	Mo Jamshidi, Aly El-Osery, and Timothy J. Ross	1/3
	Mo Jamsmai, Aly Bi-Osery, and I morny J. Ross	
9.1	Introduction	175
9.2	Predicate Logic	176
/	9.2.1 Tautologies	179
	9.2.2 Contradictions	180
	9.2.3 Deductive Inferences	180
9.3	Fuzzy Logic	182
9.4	Approximate Reasoning	184
9.5	Conclusion	185
	References	185

Chapter 10		FUZZY CONTROL AND STABILITY Mo Jamshidi and Aly El-Osery	187
10.1	Introd	uction	187
10.2	Basic	Definitions	188
	10.2.1	Inference Engine	191
	10.2.2	Defuzzification	193
10.3	Fuzzy	Control Design	194
10.4		sis of Fuzzy Control Systems	195
10.5		ity of Fuzzy Control Systems	199
		Lyapunov Stability	203
	10.5.2		207
10.6	Concl		210
	Refere	ences	210
Chapte	r 11	SOFT COMPUTING APPROACH TO SAFE	/ ^/
		NAVIGATION OF AUTONOMOUS PLANETARY	<b>A</b>
		ROVERS	213
		Edward Tunstel, Homayoun Seraji,	
		and Ayanna Howard	
11.1	Tuetura d	vetice \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	212
11.1	Introd		213
11.2		Practical Issues in Planetary Rover Applications ation System Overview	213 215
11.2	11.2.1		215
11.3		-Logic-Based Rover Health and Safety	217
11.5		Health and Safety Indicators	217
	11.3.1		219
	11.3.3		221
	11.5.5	11.3.3.1 Neuro-Fuzzy Solution	222
11.4	Fuzzy	Terrain-Based Navigation	225
	11.4.1		~-2
	7/	Fuzzy Reasoning	226
		11.4.1.1 Terrain Roughness Extraction	226
		11.4.1.2 Terrain Slope Extraction	228
'/		11.4.1.3 Fuzzy Inference of Terrain Traversability	229
11.5	Strate	gic Fuzzy Navigation Behaviors	229
	11.5.1	Seek-Goal Behavior	230
1	11.5.2	Traverse-Terrain Behavior	231
	11.5.3	Avoid-Obstacle Behavior	232
	11.5.4	/ 3	233
11.6	Rover	Test Bed and Experimental Results	234
	11.6.1	Safe Mobility	235

11.7		nary and Conclusions owledgement	238 239 240 240
Chapte	er 12	AUTONOMOUS UNDERWATER VEHICLE CONTROL USING FUZZY LOGIC Feijun Song and Samuel M. Smith	243
12.1 12.2 12.3 12.4 12.5 12.6 12.7	Slidin Slidin SMFC	round omous Underwater Vehicles (AUVs) g Mode Control g Mode Fuzzy Control (SMFC) Design Examples lines for Online Adjustment Sliding Slope & Effects	243 243 244 245 248 250 255 256
12.8 12.9	At Sea Summ Refere	Experimental Results ary inces	256 256 258 258
Chapte		APPLICATION OF FUZZY LOGIC FOR CONTROL OF HEATING, CHILLING, AND AIR	
		CONDITIONING SYSTEMS Reza Talebi-Daryani	261
13.1 13.2	Introdu Buildin 13.2.1 13.2.2 13.2.3	ng Energy Management System (BEMS) System Requirements	261 262 262 264 264
13.3	Air Co 13.3.1 13.3.2 13.3.3 13.3.4 13.3.5	nditioning System: FLC vs. DDC Process Description Process Control Digital PID Controller Fuzzy Cascade Controller DDC vs. FLC	264 265 265 266 267 268 273
13.4	Fuzzy Compl 13.4.1 13.4.2 13.4.3	Control for the Operation Management of a ex Chilling System Process Description Process Operation with FLC Description of the Different Fuzzy Controllers	274 274 275 276

13.5	13.4.4 System Performance and Optimization with FLC Application of Fuzzy Control for Energy Management of a	279
	Cascade Heating Center	280
	13.5.1 The Heating System	280
	13.5.2 FLC for System Optimization	282
	13.5.3 FLC Description	283
	13.5.4 Temperature Control: Fuzzy vs. Digital	287
13.6	Conclusions	289
	References	290
		1
Chapte		
	INFERENCE SYSTEMS TO ROBOTICS	291
	Ali Zilouchian and David Howard	
1.4.1	Tutus diretion	291
14.1 14.2	Introduction Adaptive Neuro-Fuzzy Inference Systems	292
14.2	Inverse Kinematics	294
14.3	14.3.1 Solution of Inverse Kinematics Using Fuzzy Logic	295
	14.3.2 Solution of Inverse Kinematics Using ANFIS	297
	14.3.3 Simulation Experiments	297
14.4	Controller Design of Microbot	303
1-1	14.4.1 Design of a Conventional Controller	304
	14.4.2 Hierarchical Control	306
	14.4.3 ANFIS Controller for Microbot	307
14.5	Conclusions	313
	References	313
Chapte		
	DESALINATION TECHNOLOGY	317
	Mutaz Jafár and Ali Zilouchian	
//		317
15.1	Introduction General Background on Desalination and Reverse Osmosis	317
15.2	15.2.1 Critical Control Parameters	319
	15.2.1.1 Temperature	319
	15.2.1.2 Pressure	320
	15.2.1.3 Recovery	320
	15.2.1.4 Feed pH	320
	15.2.1.5 Salt Rejection	322
	15.2.1.6 Scaling	322
15.3	Predictive Modeling Using Neural Networks	323
	15.3.1 Redistributed Receptive Fields of RBFN	324
	15.3.1.1 Data Clustering	324

		15.3.1.2	Histogram Equalization	325
		15.3.1.3	Widths of Receptive Fields	325
15.4	Case Str	udies		326
	15.4.1	Example	1: Beach Well Seawater Intake	326
		15.4.1.1	Simulation Results	327
	15.4.2	Example 2	2: A Ground Water Intake	329
	15.4.3	Example 3	3: A Direct Seawater Intake	330
		15.4.3.1	Scaling Simulation	330
15.5	Fuzzy L	ogic Contr	ol	334
	15.5.1	Chemical	Dosing Control	337
		15.5.1.1		338
		15.5.1.2	Membership Functions	338
		15.5.1.3	Decision Matrix	338
		15.5.1.4	Results and Discussion	338
	15.5.2	High-Pres	sure Control	341
			Fuzzy Rule Base	34/1
			Decision Matrix	341
		15.5.2.3	Results and Discussion	342
	15.5.3	Flow Rate		342
		15.5.3.1	Fuzzy Rule Base for Flow Control	342
			Decision Matrix	345
		15.5.3.3	Results and Discussion	346
15.6	Applicat	tion of ANI	FIS to RO Parameters	346
	15.6.1	ANFIS Sin	mulation Results	346
15.7	Conclus	ion		346
	Reference	ces		349
Chapter			TIONAL INTELLIGENCE	
			H TO OBJECT RECOGNITION	351
	$\frown$ K	C. Tan, T	H. Lee, and M.L. Wang	
16.1	Introduc			351
16.2	Object I	Recognition	by Neural Feature Extraction and	
		ombination		352
$V_{j}$	16.2.1		ttraction by Neural Network	354
			e Dependent Modulation	355
	16.2.3		on of Features Extracted from	
/	/		ources with Fuzzy Reasoning	356
16.3			Application	358
16.4	Conclus			362
	Reference	ces		363

Chapte	r 17	AN INTRODUCTION TO EVOLUTIONARY COMPUTATION Gerry Dozier, Abdollah Homaifar, Edward Tunstel, and Darryl Battle	365
17.1	Introd	uction	365
17.2		verview of Genetic Search	365/
	17.2.1	The Genetic Representation of Candidate Solutions	366
	17.2.2		367
	17.2.3	Evaluation Function	367
	17.2.4	Genetic Operators	368
		17.2.4.1 Single Point Crossover	368
		17.2.4.2 Uniform Crossover	369
		17.2.4.3 Mutation	370
	17.2.5		370
		17.2.5.1 Proportionate Selection	371
		17.2.5.2 Linear Rank Selection	372
	1000	17.2.5.3 Tournament Selection	372
	17.2.6		372
	17.2.7		373
17.3	17.2.8	Duplicates ic Search	373 373
17.3		ic Programming	376
17.4	17.4.1		376
	17.4.1	•	376
		Fitness Evaluation	377
	17.4.4		377
17.5	Summ	•/	378
		owledgments \	378
	Refere		378
Chapte	r 18	EVOLUTIONARY CONCEPTS FOR IMAGE	
		PROCESSING APPLICATIONS	381
		Madjid Fathi and Lars Hildebrand	
		\.\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	
18.1		uction	381
18.2		ization Techniques	381
		Basic Types of Optimization Methods	381
	18.2.2	/	382
1		18.2.2.1 Minimization in the Direction of the Coordinates	382
		Coordinates 18.2.2.2 Minimization in the Direction of the	382
			382
		Steepest Slope	304

		18.2.2.3 Simplex Minimization	383
		18.2.3 Probabilistic Optimization Methods	383
	18.3	Evolutionary Strategies	385
		18.3.1 Biological Evolution	385
		18.3.2 Mechanisms of Evolution Strategy	387
		18.3.3 The (1+1) Evolutionary Strategy	394
		18.3.4 The $(\mu+1)$ Evolutionary Strategy	395
		18.3.5 The (μ,λ) Evolutionary Strategy	396
	18.4	Image Processing Applications	397
		18.4.1 Generating Fuzzy Sets for Linguistic Color	
			398
		18.4.1.1 Resistance Spot Welding	398
		18.4.1.2 Linguistic Color Processing	399
			402
			403
			405
	18.5		405
		References	406
	Chapte		409
		Mohammad.R. Akbarzadeh-T. and A.H. Meghdadi	
	19.1	Introduction	409
	19.1		410
	10.0	9-1	410
	19.2	Free Parameters 19.2.1 Competing Conventions	412
	19.3		413
	19.3		414
			414
			415
			417
			417
	10.4		410
	19.4	, , , , , , , , , , , , , , , , , , , ,	418
		The Initial Population	418 422
		The Initial Population 19.4.1 Grandparenting: A Method of Incorporating	422
1	10 5	The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge	422 424
(	19.5	The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge Fitness Function	422 424 427
	19.5 19.6	The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge Fitness Function Speed Regulation of a DC Motor	422 424 427 429
		The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge Fitness Function Speed Regulation of a DC Motor 19.6.1 The Control Architecture	422 424 427 429 431
	19.6	The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge Fitness Function Speed Regulation of a DC Motor 19.6.1 The Control Architecture 19.6.2 Results	422 424 427 429 431 431
	19.6	The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge Fitness Function Speed Regulation of a DC Motor 19.6.1 The Control Architecture 19.6.2 Results Current Problems and Challenges	422 424 427 429 431 431 433
	19.6	The Initial Population 19.4.1 Grandparenting: A Method of Incorporating a priori Expert Knowledge Fitness Function Speed Regulation of a DC Motor 19.6.1 The Control Architecture 19.6.2 Results Current Problems and Challenges	422 424 427 429 431 431

	Ackno Refere	owledgement ences	435 435
Chapter	r 20	GENETIC AND EVOLUTIONARY METHODS FOR MOBILE ROBOT MOTION CONTROL AND PATH PLANNING Abdollah Homaifar, Edward Tunstel, Gerry Dozier, and Darryl Battle	437
20.1	Introd	history	437
20.1		ic Programming for Path Tracking Control	437
20.2	20.2.1		438
	20.2.1		439
	20.2.2	20.2.2.1 Controller Fitness Evaluation	440
20.3	Path T	Fracking Simulation Result	441
	20.3.1	Evolved Controller Robustness	444
20.4	Evolu	tionary Path Planning	445
	20.4.1		446
		20.4.1.1 Environment and Path Representation	446
		20.4.1.2 Visibility-Based Repair of Candidate Paths	446
		20.4.1.3 Path Evaluation, Selection, and	440
20 E	D-41 T	Evolutionary Operators	448 449
20.5	20.5.1	Evolution with Fuzzy Selection Fuzzy Inference System	449
	20.5.1		451
20.6		nary and Conclusions	452
20.0		owledgments	453
	Refere		453
Chapter	21:	PROBLEMS AND MATLAB PROGRAMS	455
// `		Ali Zilouchian and Mo Jamshidi	
21.1	Introd	uction	455
21.2	Neura	l Network Problems	455
21.3		Logic Problems	460
21.4		cations	464
21.5	MATI	LAB Programs	466
Index			469

.