Contents

l	Dec	entraliz	ed Fuzzy-Neural Identification and I-Term Adaptive		
	Con	trol of	Distributed Parameter Bioprocess Plant	1	
	Ierol	nam Ba	ruch and Eloy Echeverria Saldierna		
	1.1	Introd	uction	1	
	1.2				
		1.2.1	Description of the RTNN Topology		
			and Its Real-Time BP Learning	3	
		1.2.2	Description of the Real-Time		
			Second-Order Levenberg-Marquardt Learning	7	
	1.3	Descri	iption of the Decentralized Direct I-Term		
		Fuzzy	-Neural Multi-Model Control System	8	
1.4 Description of the Decentralized Indirect (Sliding I		iption of the Decentralized Indirect (Sliding Mode)			
		I-Tern	n Fuzzy-Neural Multi-Model Control System	12	
		1.4.1	Sliding Mode Control Systems Design	14	
	1.5	Analy	tical Model of the Anaerobic Digestion		
		Biopre	ocess Plant	16	
	1.6 Simulation I		ation Results	19	
		1.6.1	Simulation Results of the System Identification	19	
		1.6.2	Simulation Results of the Direct HFNMM Control		
			with and without I-Term	23	
		1.6.3	Simulation Results of the Indirect HFNMM		
			I-Term SMC	27	
	1.7		usion	34	
	Appendix 1: Detailed Derivation of the Recursive				
			Levenberg-Marquardt Optimal Learning		
			Algorithm for the RTNN	35	
	App	Appendix 2			
	Ref	erences		41	
2	Err	or Tole	rant Predictive Control Based on Recurrent		
	Neural Models				
	Peti	Petia Georgieva and Sebastião Feyo de Azevedo			
	2.1				
	2.2	Mode	l Predictive Control Algorithms	47	

xii Contents

	2.3	Neural	Dynamical Process Model	49			
		2.3.1	NN Final Impulse Response (NNFIR) Model	50			
		2.3.2	NN Auto Regressive with eXogenous Input				
			(NNARX) Model	50			
		2.3.3	NN Auto Regressive Moving Average				
			with eXogenous Input (NNARMAX) Model	51			
		2.3.4	NN Output Error (NNOE) Model	51			
	2.4	Identif	ication Experiments	54			
		2.4.1	Classical (one test) Identification Experiment	54			
		2.4.2	Double Test Identification	55			
	2.5	Error 7	Folerant MPC	55			
		2.5.1	Problem Formulation	55			
		2.5.2	Selection of MPC Parameters	57			
		2.5.3	Normalized ETMPC	57			
	2.6	Sugar	Crystallization Case Study	58			
		2.6.1	Process Description	58			
		2.6.2	Crystallization Macro Model	59			
	2.7	Neural	Model Identification	61			
		2.7.1	Identification Experiments	61			
		2.7.2	NN Structure Selection	62			
	2.8		CMPC Control Tests	65			
		2.8.1	Set-Point Tracking	66			
		2.8.2	Computational Time Reduction	68			
		2.8.3	Final Product Quality	69			
	2.9		isions	70			
				71			
	11010	renees .					
3	Adv	ances in	Multiple Models Based Adaptive Switching				
		Control: From Conventional to Intelligent Approaches					
			Sofianos and Yiannis S. Boutalis	,,,			
	3.1		action	73			
	3.2		Model Adaptive Control and Multiple Models				
	3.2	Switching Adaptive Control					
		3.2.1	Adaptive Control Basics	76			
		3.2.2	An Overview of Multiple Models Switching	, 0			
		3.2.2	Control Methods	77			
	3.3	Multin	le Models Switching Control and Neural Networks	87			
	3.3	3.3.1	Multiple Models Adaptive Control for SISO	0/			
		3.3.1	and MIMO Discrete-Time Nonlinear Systems				
				87			
	2.4	N 4 1 & !	Using Neural Networks				
	3.4	-	le Models Switching Control and Fuzzy Systems	90			
		3.4.1	The Role of T-S Fuzzy Systems	91			
		3.4.2	Multiple T-S Fuzzy Models for More Reliable	^-			
			Control Systems	91			

Contents

xiii

		3.4.3	Problem Statement and Single Identification Model	92		
		3.4.4	Architecture	93		
		3.4.5	Switching Rule and Cost Criterion	94		
		3.4.6	T-S Identification Models, Controller Design			
			and Next Best Controller Logic	95		
		3.4.7	Stability, Adaptive Law, Convergence			
			and Computational Cost	98		
		3.4.8	Another Approach with Hybrid T-S Multiple Models	101		
	3.5	Nume	rical Example	102		
	3.6	Concl	usions	105		
	Refe	rences		105		
4			ational Intelligence Approach to Software			
			t Repository Management	109		
			no and V. V. S. Sarma			
	4.1		uction	110		
	4.2		mputational Intelligence Based Approach Using Rough			
			uzzy Sets to Model the Component Retrieval Problem	112		
	4.3		1 Sets	113		
	4.4		Sets	113		
	4.5		1-Fuzzy Sets	114		
	4.6		-Rough Sets	115		
	4.7		se Study of the Design and Development of Air Warfare			
		Simul	ation Systems	115		
		4.7.1	Use of Rough-Fuzzy Sets	117		
		4.7.2	Use of Fuzzy-Rough Sets	127		
	4.8	Concl	usions	130		
	Refe	References				
5	A S	oft Con	nputing Approach to Model Human Factors			
J			fare Simulation System	133		
			ao and Dana Balas-Timar	100		
	5.1		luction	134		
	5.2		gent-Based Architecture to Design Military	151		
	5.2		ing Operations	134		
	5.3		ematical Modelling of Pilot Behavior	136		
	5.4		uro-Fuzzy Hybridization Approach to Model the Pilot	150		
	3.4		t in AWSS	141		
		5.4.1		141		
		5.4.1	Modeling the Human Factors and Situation Awareness	141		
		3.4.2	of Pilot Agent	143		
	5 5	Dosia	n of Conflict Situations and Discussion of Results	143		
	5.5 5.6	•				
		CONC		151		
	rc ← T/					

xiv Contents

6	Application of Gaussian Processes to the Modelling					
	and Control in Process Engineering					
	Juš Kocijan and Alexandra Grancharova					
	6.1	Introd	uction	156		
	6.2	Syster	ns Modelling with Gaussian Processes	156		
	6.3	Contro	ol Algorithms Based on Gaussian Process Models	160		
		6.3.1	Inverse Dynamics Control	160		
		6.3.2	Model-Based Predictive Control	163		
		6.3.3	Adaptive Control	173		
	6.4	Design	n of Explicit GP-NMPC of a Gas-Liquid Separator	176		
		6.4.1	The Gas-Liquid Separator	176		
		6.4.2	Gaussian Process Model of the Gas-Liquid Separator	179		
		6.4.3	Design and Performance of Explicit GP-NMPC	182		
	6.5	Concl	usions	187		
	Refe	rences		187		
7	Com	putatio	onal Intelligence Techniques for Chemical			
			ntrol	191		
			v, M. Oprea, M. Cărbureanu and M. Olteanu			
	7.1		tives and Conventional Automatic Control			
			emical Processes	191		
		7.1.1	Objectives of Chemical Processes	192		
		7.1.2	Conventional Automatic Control of Fractionating			
			Processes	196		
		7.1.3	Conventional Automatic Control of Heat Transfer			
			Processes	201		
		7.1.4	Conventional Automatic Control			
			of Chemical Reactors	204		
	7.2	Comp	outational Intelligence Techniques for Process Control	206		
		7.2.1	Computational Intelligence Techniques	207		
		7.2.2	Applications of Computational Intelligence			
		7.2.2	in Chemical Process Control	211		
	7.3	Case	study: The Wastewater pH Neutralisation Process			
			Vastewater Treatment Plant	213		
		7.3.1	The Process Mathematical Model Development	215		
		7.3.2	The R-ANFIS Controller Development	217		
		7.3.3	pHACS Implementing in Matlab/Simulink	219		
	7.4		usion	223		
				224		
	IXC10			~4 ⁻¹		
8	Δnn	lication	n of Swarm Intelligence in Fuzzy Entropy			
9			ge Segmentation	227		
			Priya, C. Thangaraj, C. Kesavadas and S. Kannan	221		
	8.1		luction	228		
	U. I	muvu	WVLVII	0		

Contents

χv

8.2	Background					
	8.2.1	Image as a Fuzzy Event	229			
	8.2.2	Probability Partition Based Maximum Fuzzy Entropy	230			
	8.2.3	Fuzzy Membership Functions for Dark				
		and Bright Classes	231			
	8.2.4	Modified Particle Swarm Optimization Algorithm	233			
8.3	8.3 Methodology					
	8.3.1	Fuzzy Parameter Optimization Using MPSO	235			
8.4	4 Experimental Results					
	8.4.1	Convergence Test	242			
8.5	Concl	usion	244			
References			244			
hout t	he Edi	tors	24			