TABLE OF CONTENTS

			Pages
A	ckno	owledgment	iii
Thai Abstract		iv	
TC*.		sh Abatmant	
E).	ugus	sh Abstract	vi
Li	st of	f Tables	x
Li	st of	f Illustrations	xi
1	Int	roduction	1
	1.1	Motivation	310
	1.2	Main Contributions	50
2	Res	view and Background	3
_	2.1	Adaptive Control Systems	3
	2.2	Artificial Intelligent Control Systems	4
	2.3	Adaptive Networks	4
	2.0	2.3.1 Typical Adaptive Networks	5
		2.3.2 Neuro-Fuzzy Network	5
		21012 Trout of Table 1,00 Work	
3	Fuz	zy Rules Emulated Network	9
	3.1	Structure of Fuzzy Rules Emulated Network	9
	3.2	FREN, RBF and Mamdani Fuzzy Logic	12
		3.2.1 RBF	13
		3.2.2 Mamdani Fuzzy Logic	13
	3.3	Parameter Adaptation	14
		3.3.1 Adaptation Based on Steeptest Descent Algorithm	14
		3.3.2 Learning Rate Selection	15
4	Dir	ect Adaptive Control System Using FREN	17
	4.1	Structure of FREN Controller	17
		4.1.1 Parameter Adaptation Algorithm	18
		4.1.2 Learning Rate Selection	19
	4.2	Computer Simulation Examples	20
		4.2.1 Single Invert Pendulum System	20

		4.2.2	Water Bath Temperature Control System	25
		4.2.3	HVDC Transmission Control System	29
5	Slid	ing Mo	ode Control and FREN	33
•	5.1	_	tion of Control Effort's Bounds	33
	5.2		with SMC Controller	36
	5.3		ater Simulation Examples	38
	0.0	5.3.1	Robotic Control	38
		5.3.2		43
		5.3.3		55
6	Mul	lti-Innı	it FREN	60
•	6.1		ire of MIFREN	60
	0.1	6.1.1	Mamdani's Fuzzy Inference and MIFREN	61
		6.1.2	MIFREN as Universal Function Approximation	68
	6.2	•	EN with SMC	70
	0.2	6.2.1	Controller Design	715
		6.2.2	Computer Simulation Results	72
	6.3		Learning Algorithm for MIFREN	81
	0.5	6.3.1	Adaptation of LC Parameters	81
		6.3.2	Adaptation of MF Parameters	82
		6.3.3	Nonlinear System Identification Results	83
7	Con	clusion	as and Future Research Directions	88
-	7.1	Conclu	sions	88
	7.2		Research Directions	89
Re	efere	nces		90
Aı	ppen	dix		96
			นแอทมเกแถเตอแต	งขอเทเ
A			Auxiliary Results	97
	A.1	Selection	onoight by Chiang Mai U	Jni ⁹⁷ ersity
Cı	ırric	ulum V	^{ritae} rights rese	e r % e d

LIST OF TABLES

Tab	eles	Pages	
2.1	Examples of neural fuzzy inference systems	8	
4.1	Performance comparisons of controllers for the water bath temperature		
	control system.	26	
5.1	Stable bound of control effort obtained from SMC.	37	
5.2	Comparison of Logistic map control.	51	
5.3	Comparisons of chaotic synchronization control algorithms.	56	

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved

LIST OF ILLUSTRATIONS

Figu	Figures	
2.1	Model-Reference Adaptive Controller (MRAC).	3
2.2	Self-Tuning Controller (STC).	3
2.3	Typical adaptive network architecture.	5
2.4	Structure of SONFIN.	7
2.5	Structure of ANFIS.	8
3.1	Structure of Fren	9
3.2	Example of membership function (MF)	10
3.3	Example of linear consequence (LC)	11
3.4	Example of FREN parameters setting.	12
3.5	Radial basis function network structure.	13
4.1	Control system using FREN	18
4.2	Single invert pendulum	20
4.3	FREN's parameters for the invert pendulum control system.	23
4.4	Responses of the invert pendulum control system using FREN, PID,	and
	neural network controllers.	24
4.5	FREN's parameters for the water bath temperature control system.	27
4.6	Control signal and plant response of the water bath temperature con	trol
	system.	28
4.7	HVDC transmission system	29
4.8	Control system using single FREN	30
4.9	Settings of MF and LC in HVDC transmission.	31
4.10	HVDC simulation results based on PI and FREN controllers.	32
5.1	Control system using FREN and SMC	37
5.2	FREN parameters setting	38
5.3	MF and LC for robotic control system.	1 40 IS
5.4	Initial simulation results of robotic control.	41
5.5	Final simulation results of robotic control.	42
5.6	State trajectory of Hénon map.	43
5.7	MF and LC for Hénon map control.	45
5.8	Initial simulation results of Hénon map control.	46
5.9	Final simulation results of Hénon map control.	47

5.10	Simulation results of Hénon map control when x_d is sine waveform.	48
5.11	Simulation results of Hénon map control when \boldsymbol{x}_d is sine waveform and	
	stable bounds are released.	49
5.12	State trajectory of logistic map.	50
5.13	MF and LC for logistic map control.	52
5.14	Initial simulation results of logistic map control.	53
5.15	Final simulation results of logistic map control.	54
5.16	Generalized Hénon map.	56
5.17	MF and LC of Hénon map synchronization.	57
5.18	Initial and final results of Hénon map synchronization.	58
5.19	State variables and control effort of Hénon map synchronization after	
	learning phase.	59
6.1	Structure of MIFREN	61
6.2	Membership function of (a) X, (b) Y and (c) Z for the two inputs Mamdani	
	fuzzy inference system.	64
6.3	Output-input surface response obtained from Mamdani fuzzy system.	65
6.4	Membership functions of (a) X and (b) Y for MIFREN.	66
6.5	Surface response of MIFREN.	67
6.6	Control system using MIFREN	71
6.7	MF of MIFREN for robotic control.	74
6.8	Simulation results of robotic control using MIFREN.	75
6.9	MF's parameter of Hénon map control	78
6.10	Simulation results of Hénon map control using MIFREN.	79
6.11	Simulation results of Hénon map control using MiFren at $c = \begin{bmatrix} 1 & 4 \end{bmatrix}$.	80
6.12	Two-dimensional sinc function.	83
6.13	Initial and final parameters setting of ANFIS.	84
	Estimated two-dimensional sinc using ANFIS.	85
6.15	MF's parameter of MIFREN for the sinc function identification.	86
6.16	MIFREN result of two-dimensional sinc identification.	87
6.17	RMSE curves of two-dimensional sinc identification.	87ersity