الآيـــــــة

(اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن شَجَرَةٍ مُّبَارَكَةٍ زَيْتُونِةٍ لَّا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُّورٌ عَلَى نُورٍ يَهْدِي اللَّهُ لِنُورِهِ مَن يَشَاء وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ)

صدق الله العظيم

سورة النور

الآية 35

Dedication

To light that enlightens me the path of success, dear father.

To who taught me and suffered difficulties to make me happy, dear mother.

To those who I walked with them and make my own way towards success, friends.

Last but not least, my deepest gratitude goes to all the teachers I learnt from since my childhood, I would not have been here without their guidance, blessing and support.

Acknowledgment

In the name of Allah, the Most Gracious and the Most Merciful Alhamdulillah, all praises to Allah for endowing me with health, patience and knowledge to complete this work.

I am grateful to who helps me to make this requirement possible and for his valued suggestion. I enjoyed his support and patience during the very tough moment of the research work and writing of the thesis, **Dr.Awadalla Taifor Ali**

Abstract

Water flow control is highly important in industrial applications such as boilers in nuclear power plants. This dissertation analyses the effectiveness of water flow using the Proportional Integral Derivative (PID), fuzzy logic and neuro-fuzzy controllers are implemented in MATLAB/SIMULINK to test the behaviour of the system. The response of the fuzzy controller and neuro fuzzy are compared with a conventional PID controller. The results are shown and the effectiveness of the controllers is illustrated.

مستخلص

التحكم في تدفق الماء مهم جداً في التطبيقات الصناعية مثل المراجل في وحدات القدرة النووية.هذا البحث يحلل تأثير تدفق الماء بإستخدام المتحكم التناسبي التكاملي التفاضلي ,المنطق الغامض والمنطق الغامض العصبي التي نفذت في برنامج MATLAB/SIMULINK لإختبار سلوك النظام .إستجابه المتحكم الغامض والمتحكم الغامض العصبي حيث تمت مقارنتها بالمتحكم التقليدي التناسبي التكاملي التفاضلي . النتائج تم عرضها وتأثيرات المتحكمات قد وضِّحت.

TABLE OF CONTENTS

	Page. No
الايه	i
Dedication	ii
Acknowledgment	iii
Abstract	iv
مستخلص	v
Table of Contents	vi
List of Figures	ix
List of Tables	xi
List of Abbreviations	xii
Nomenclature and Abbreviation	xiii
CHAPTER ONE INTRODUCTION	
1.1 General Review	1
1.2 Problem Statement	1
1.3 Objectives	2
1.4 Methodology	2
1.5 Layout	2
CHAPTER TWO LITERATURE REVIEW	
2.1 Flow Control System	3
2.1.1 Fluids characteristic	3
2.1.2 Mechanics of fluids	3
2.1.3 Classification and description of fluid flow	3
2.2 Servo Control System	4
2.2.1 Fundamentals of servo motion control	4
2.2.2 Modelling a simple servo system	5

2.3 The Proportional Integral Derivative Algorithm	6
2.3.1The characteristics of P, I and D controllers	7
2.3.2 Tuning ruled for PID controller	7
2.3.3 Ziegler Nichols rules for tuning PID controllers	8
2.4 Fuzzy Logic Fundamentals	10
2.4.1 Fuzzy sets and fuzzy logic	11
2.4.2 Types of membership functions	12
2.4.3 Linguistic variables	12
2.4.4 Fuzzy logic implementation	12
2.4.5 Fuzzy control systems	13
2.5 Artifical Neural Network	15
2.5.1 Neural networks architectures	15
2.5.2 Training algorithms	16
2.6 Adaptive Neural Fuzzy Inference Systems	20
CHAPTER THREE METHODOLOGY	
3.1 System Description	21
3.1.1 Fundamental control principle of coupled tank system	22
3.1.2 Mathematical modelling of the coupled tank system	23
3.2 PID Controller Design	27
3.3 Fuzzy Controller Design	28
3.3.1 The FIS editor	28
3.3.2 The membership function editor	39
3.3.3 The rule editor	31
3.4 Adaptive Neural Fuzzy Inference Systems Design	33
CHAPTER FOUR RESULTS AND DISCUSSION	
4.1 Simulation Result of Uncontrolled System	35
4.2 Simulation Result of PID Controller	36
4.3 Simulation Result of Fuzzy Logic Controller	38

4.4 Simulation Result of ANFIS Controller	40
CHAPTER FIVE **CONCLUCTION AND RECOMMENDATIONS**	
5.1 Conclusion	42
5.2 Recommendations	42
References	43

LIST OF FIGURES

Figure	Tittle	Page. No
2.1	PID controller	6
2.2	Unit-step response of a plant	8
2.3	S-shaped response curve	9
2.4	Sustained oscillation with period P_{cr}	*10*
2.5	Classical/crisp set and fuzzy set boundary	11
2.6	Types of membership functions	12
2.7	Block diagram of a typical fuzzy logic controller	13
2.8	Membership functions of the output linguistic values	14
2.9	Neural network architectures	16
3.1	Layout of the coupled tanks system	21
3.2	Schematic diagram of coupled tank apparatus	22
3.3	Model of PID controller	28
3.4	Fuzzy FIS Editor	39
3.5	Membership function editor for level	30
3.6	Membership function editor for the rate	30
3.7	Membership function editor for the valve	31
3.8	The Fuzzy rule for fuzzy controller	31
3.9	Model of fuzzy controller	32
3.10	Rule viewer of fuzzy logic	32
3.11	Surface viewer	32
3.12	Model of ANFIS controller	33
3.13	ANFIS model structure with two inputs and one output	33
3.14	ANFIS editor training the rules using back-propagation algorithm	34
4.1	Module of flow system	35
4.2	Result of uncontrolled system	35
4.3	PID response before tuning	36
4.4	values of k_p, k_d and k_i after tuning the PID	37

4.5	PID response	37
4.6	Comparison between PID response and uncontrolled system	38
4.7	The control signal for PID controller	38
4.8	Fuzzy controller response	39
4.9	Control signal for fuzzy controller	39
4.10	The result of ANFIS controller	40
4.11	The response of PID, fuzzy and ANFIS	41

LIST OF TABLES

Table	Title	Page. No
2.1	The effect of P, I and D controller for time response	7
2.2	Ziegler-Nichols tuning rule based on step response of plant	9
2.3	Ziegler-Nichols tuning rule based on critical gain K_{cr} and critical Period p_{cr}	10
3.1	Parameters of the coupled –tank system	23
4.1	Performance of the controllers	41

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ANN	Artificial Neural Networks
ANFIS	Adaptive Neural Fuzzy Inference Systems
EX	Expert Systems
FL	Fuzzy Logic
FLC	Fuzzy Logic Controllers
FFANN	Feed-Forward Artificial Neural Networks
PB	Back Propagation
PID	Proportional Integral Derivative

NOMENCLATURE AND ABBREVIATION

J	Inertial load
f	Friction
U(t)	Input voltage
T(t)	Torque
Y(s)	Output shaft position
U(s)	Motor input
m	Meter
T	Time constant
K	The system gain
k_p	Proportional gain
k_i	Integral gain
k_d	Derivative gain
e(t)	Tracking error
R(t)	Desired input value
K_{cr}	Critical value
W(t)	Neurone weights
Ƞ	Learning-rate constant
∇Err	Error gradient