

**DESIGN OF A PRECISION MOTION CONTROL FOR AN UPPER LIMB OF
ROBOTIC ARM**

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**A report submitted in partial fulfillment of the requirements for the Bachelor Degree
of Mechatronics Engineering**

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I declare that this report entitle “Design of a Precision Motion Control for An Upper Limb of Robotic Arm” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Signature :
Supervisor’s Name :
Date :

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ABSTRACT

The objective of this project is to design a controller which is able to control the output angle for an upper limb of robotic arm. A model of robotic arm of 1 degree of freedom is designed and fabricated. Comparison between few types of motor is carried out and DC geared motor is chosen as the motor to be used in this project. Study is carried out based on previous research to investigate which type of controller is suitable to be used in this project. PID controller and fuzzy logic controller are chosen and compared in terms of their performance such as the steady-state error, settling time, rise time and overshoot. The experimental setup is carried out. The equipments used are Micro-Box 2000/2000C, Cytron DC geared motor, motor driver circuit. Micro-Box module acts as the interface between hardware component and programming software installed in a computer. The software involved in this project is MATLAB R2009a. Open loop simulations are first carried out to obtain the transfer function of motor. It is then substituted into the system for further analysis. Simulation for an uncompensated system is carried out to observe the closed loop system characteristic without using the controllers. After that, closed loop simulations are carried out for compensated systems using PID controller and fuzzy logic controller. Two types of experiments are carried out, namely point to point trajectory control and tracking control experiments. Analysis is made based on the results obtained and the best type of controller is chosen for achieving precise motion control for an upper limb of robot manipulator.

ABSTRAK

Objektif projek ini adalah untuk mereka bentuk pengawal yang sesuai yang mampu mengawal tork keluaran dan kelajuan untuk bahagian lengan atas robot. Model lengan robot 1 darjah kebebasan direka dan dibina. Perbandingan antara beberapa jenis motor dijalankan dan DC motor dipilih sebagai motor yang akan digunakan dalam projek ini. Kajian dibuat berdasarkan penyelidikan untuk menyiasat jenis pengawal yang akan digunakan dalam projek ini. Pengawal PID dan pengawal logik kabur (fuzzy logic) dipilih dan dibandingkan dari segi prestasi mereka seperti keadaan mantap dan masa pengenapan. Eksperimen dijalankan. Peralatan yang digunakan adalah Micro-Box 2000/2000C, Cytron DC motor menjurus, litar pemacu motor. Modul Mikro-Box bertindak antara komponen perkakasan dan perisian pengaturcaraan dipasang dalam komputer. Perisian yang terlibat dalam projek ini adalah Matlab R2009a. Ujian gelung terbuka pertama yang dijalankan untuk mengawal kelajuan dan kawalan tork dalam sistem uncompensated . Selepas ujian gelung terbuka selesai, ujian gelung ditutup akan dilaksanakan untuk sistem pampasan menggunakan pengawal PID dan pengawal logik kabur. Perbandingan akan dibuat dan jenis pengawal yang sesuai akan dipilih untuk mencapai kawalan gerakan tepat untuk bahagian lengan atas robot .

TABLE OF CONTENTS

CHAPTER	TOPIC	PAGE
	PROJECT TITLE	i
	SUPERVISOR DECLARATION	ii
	DECLARATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF FIGURES	ix
	LIST OF TABLES	xi
	LIST OF APPENDICES	xii
1	INTRODUCTION	
	1.1. Motivation	1
	1.2. Problem Statement	1
	1.3. Objectives	2
	1.4. Scope	2
	1.5. Chapter Overview	3

2	LITERATURE REVIEW	4
	2.1. Introduction	4
	2.2. Robotics	4
	2.3. Robotic Arm	5
	2.4. Motor	6
	2.5. Case Study of Controller	8
	2.5. Summary	16
3	METHODOLOGY	18
	3.1. Introduction	18
	3.2. Research Methodology	18
	3.2.1 Project Methodology	18
	3.2.2 Experiment Methodology	19
	3.3. Structure of Robotic Arm	19
	3.4. Hardware Implementation	20
	3.4.1 Cytron 12V DC Geared Motor with Hall Effect Encoder	21
	3.4.2 Micro-Box 2000/2000C (xPC Target Machine)	22
	3.4.3 Motor Driver Circuit	22
	3.5. System Overview	24
	3.6. Mathematical Modeling	26
	3.6.1 Modeling of a DC Geared Motor	26
	3.6.2 Torque	30
	3.6.3 Moment of Inertia	31
	3.6.4 Calculation of Moment of Inertia	32
	3.7. Open Loop Control	33
	3.8. Controller Design	34
	3.8.1 PID Controller	34
	3.8.2 Tuning Methods	36
	3.8.2.1 Trial and Error Method	36
	3.8.2.2 Ziegler-Nichols Method	37
	3.8.3 Fuzzy Logic Controller (FLC)	38
	3.8.3.1 Fuzzification Interface	39
	3.8.3.2 Knowledge Base/ Rule-Based System	41

	3.8.3.3 Inference Engine	41
	3.8.3.4 Defuzzification Interface	41
	3.9. Performance Characteristic (Time Domain)	42
	3.10. Output Angle Measurement	44
	3.11. Uncertainty and Reliability	45
4	RESULTS AND DISCUSSION	46
	4.1. Introduction	46
	4.2. Open Loop Simulation	47
	4.2.1 Transfer Function of Motor	54
	4.2.2 Linearity of the System	54
	4.3. Uncompensated System	55
	4.3.1 Point to Point Trajectory Control for Uncompensated System	55
	4.3.2 Tracking Control for Uncompensated System	58
	4.4. Compensated System with PID Controller	61
	4.4.1 Point to Point Trajectory Control with PID Controller	61
	4.4.2 Tracking Control with PID Controller	78
	4.4.3 Summary for PID Controller	88
	4.5. Compensated System with Fuzzy Logic Controller	89
	4.5.1 Point to Point Trajectory Control with Fuzzy Logic Controller	89
	4.5.2 Tracking Control with Fuzzy Logic Controller	93
	4.5.3 Summary for Fuzzy Logic Controller	95
5	CONCLUSION AND RECOMMENDATION	96
	5.1. Conclusion	96
	5.2. Recommendations	97

	10
REFERENCES	98
APPENDICES	100

LIST OF TABLES

NO.	TITLE	PAGE
2.1	Classification and characteristics of robotic arms	5
2.2	Comparison between the functions of motors	7
2.3	Summary of research papers	17
3.1	Specifications of Cytron 12V DC geared motor	21
3.2	Specifications of Micro-Box 2000/2000C	22
3.3	Parameters in the armature circuit of DC geared motor	27
3.4	Parameters relative to the torque of DC geared motor	30
3.5	Parameters relative to the moment of inertia of robotic arm	31
3.6	Mass of components of robotic arm	32
3.7	Parameters of the open loop simulation	34
3.8	Parameters related to PID controller	35
3.9	Parameters of transient response and the effects caused by manipulating K_p , K_i and K_d values	37
3.10	Controller parameters of Ziegler-Nichols step response method	37
3.11	Components of fuzzy logic controller	38
3.12	Rule base system for fuzzy logic controller	41

3.13	Parameters associated with step response of the system	42
4.1	Results of system identification for DC motor speed model (1V)	49
4.2	Results of system identification for DC motor speed model (2V)	50
4.3	Results of system identification for DC motor speed model (3V)	51
4.4	Results of system identification for DC motor speed model (4V)	52
4.5	Results of system identification for DC motor speed model (5V)	53
4.6	Data obtained from open loop simulation	54
4.7	Parameters for point to point trajectory control experiments	55
4.8	Parameters for tracking error experiments	58
4.9	Parameters for point to point experiments using PID controller	61
4.10	Parameters of PID controller obtained from simulation results	75
4.11	Parameters for tracking error experiments for PID-controlled system	78
4.12	Summary of PID-controlled system	88
4.13	Parameters for point to point experiments using fuzzy logic controller	89
4.14	Parameters for tracking error experiments for fuzzy-controlled system	93
4.15	Summary of Fuzzy Logic controlled system	95
5.1	Comparison between the performance of PID controller and fuzzy logic controller	97
6.1	Name and functions of motor pins	33

LIST OF FIGURES

NO.	TITLE	PAGE
2.1	Robotic mechanism	5
2.2	Illustration of a 1-DOF upper limb of robotic arm	6
2.3	Types of control methods for robotic arm	8
2.4	Different arm movements	9
2.5	Comparison of three controllers for RMS error. Bar charts represent mean values for twenty two motions and error bars represent maximum and minimum values	10
2.6	Comparison of three controllers for correlation factors	10
2.7	Comparison of three controllers for mean absolute error	11
2.8	Simulation of a third-order system (demonstrates robustness)	12
2.9	Tracking an ellipse	14
2.10	Experimental results in the upper displacement zone	15
3.1	Design of robotic arm (a) Top view (b) Bottom view (c) Side view (d) Side view	20
3.2	DC geared motor with encoder and its removable cover	21
3.3	Components of Micro-Box module	23

3.4	Motor driver circuit	23
3.5	System concept	24
3.6	Experimental setup of the project	25
3.7	Schematic diagram of the DC geared motor	26
3.8	Block diagram of the DC geared motor	29
3.9	Block diagram of open loop system	33
3.10	Block diagram of a typical PID controller	35
3.11	Block diagram of closed-loop PID control method	36
3.12	Basic structure of fuzzy logic systems	38
3.13	Fuzzy logic control system	39
3.14	The input and output variables of fuzzy logic controller	40
3.15	The surface view of the fuzzy logic controller	40
3.16	The output membership functions	42
3.17	Second order underdamped response specifications	43
3.18	:The experimental set up of robotic arm	44
4.1	Structure of Chapter 4	46
4.2	Graph of input voltage (1V) and output angle against time	49
4.3	Graph of input voltage (2V) and output angle against time	50
4.4	Graph of input voltage (3V) and output angle against time	51
4.5	Graph of input voltage (4V) and output angle against time	52
4.6	Graph of input voltage (5V) and output angle against time	53
4.7	Graph of output angles against input voltages	54
4.8	Results of point to point trajectory control for an uncompensated	56

	system with input angle of 15°	
4.9	Results of point to point trajectory control for an uncompensated system with input angle of 30°	57
4.10	Results of tracking error experiment for an uncompensated system with input angle of 15°	59
4.11	Graph of steady-state error against time for an uncompensated system with input angle of 30°	60
4.12	Results of point to point trajectory control experiment for a PID control system with input angle of 15° and K_p value of 1	63
4.13	Results of point to point trajectory control experiment for a PID control system with input angle of 15° and K_p value of 10	64
4.14	Results of point to point trajectory control experiment for a PID control system with input angle of 15° and K_p value of 14	65
4.15	Results of point to point trajectory control experiment for a PID control system with input angle of 15° and K_p value of 14.6	66
4.16	Results of point to point trajectory control experiment for a PID control system with input angle of 30° and K_p value of 1	67
4.17	Results of point to point trajectory control experiment for a PID control system with input angle of 30° and K_p value of 10	68
4.18	Results of point to point trajectory control experiment for a PID control system with input angle of 30° and K_p value of 14	69
4.19	Results of point to point trajectory control experiment for a PID	70

	control system with input angle of 30 °and Kp value of 14.6	
4.20	Results of point to point trajectory control experiment for a PID control system with input angle of 60 °and Kp value of 1	71
4.21	Results of point to point trajectory control experiment for a PID control system with input angle of 60 °and Kp value of 10	72
4.22	Results of point to point trajectory control experiment for a PID control system with input angle of 60 °and Kp value of 14	73
4.23	Results of point to point trajectory control experiment for a PID control system with input angle of 60 °and Kp value of 14.6	74
4.24	Results of point to point trajectory control experiment for a PID control system with input angle of 15 °and Kp value of 8.76	75
4.25	Results of point to point trajectory control experiment for a PID control system with input angle of 15 °and Kp value of 8.76	76
4.26	Results of tracking error experiment for a PID control system with input angle of 15 °	79
4.27	Results of tracking error experiment for a PID control system with input angle of 30 °	80
4.28	Results of tracking error experiment for a PID control system with input angle of 60 °	81
4.29	Comparison between output angles for a PID control system with different frequencies and input angle of 15 °(Top to bottom: 0.1Hz, 0.5Hz, 1Hz, 5Hz, 10Hz, 10Hz)	82

4.30	Comparison between output angles for a PID control system with different frequencies and input angle of 30° (Top to bottom: 0.1Hz, 0.5Hz, 1Hz, 5Hz, 10Hz, 10Hz)	83
4.31	Comparison between output angles for a PID control system with different frequencies and input angle of 30° (Top to bottom: 0.1Hz, 0.5Hz, 1Hz, 5Hz, 10Hz, 10Hz)	84
4.32	Comparison between steady-state error for a PID control system with different frequencies and input angle of 15° (Top to bottom: 0.1Hz, 0.5Hz, 1Hz, 5Hz, 10Hz, 10Hz)	85
4.33	Comparison between steady-state error for a PID control system with different frequencies and input angle of 30° (Top to bottom: 0.1Hz, 0.5Hz, 1Hz, 5Hz, 10Hz, 10Hz)	86
4.34	Comparison between steady-state error for a PID control system with different frequencies and input angle of 60° (Top to bottom: 0.1Hz, 0.5Hz, 1Hz, 5Hz, 10Hz, 10Hz)	87
4.35	Graph of input voltage, output angle and steady-state error against time for a compensated system with input angle of 15°	90
4.36	Graph of input voltage, output angle and steady-state error against time for a compensated system with input angle of 30°	91
4.37	Graph of input voltage, output angle and steady-state error against time for a compensated system with input angle of 60°	92
4.38	Graph of steady-state error against time for a fuzzy logic control system with an input angle of 15° (Top to bottom: 1Hz, 3Hz, 5Hz)	94

4.39	Graph of steady-state error against time for a fuzzy logic control system with an input angle of 30° (Top to bottom: 1Hz, 3Hz, 5Hz)	94
4.40	Graph of steady-state error against time for a fuzzy logic control system with an input angle of 60° (Top to bottom: 1Hz, 3Hz, 5Hz)	95
6.1	Project research methodology flow chart	101
6.2	Project experiment methodology flow chart	102
6.3	Rear view of the motor with encoder and cover	103
6.4	Block diagram of driver circuit	104
6.5	Open loop Simulink block diagram	105
6.6	Open loop Simulink block diagram with transfer function	105

LIST OF APPENDICES

NO.	TITLE	PAGE
A	Final Year Project Research Gantt Chart	100
B	Project Research Methodology Flow Chart	101
C	Project Experiment Methodology Flow Chart	102
D	Connections of Cytron DC Geared Motor	103
E	Block Diagram of Driver Circuit Board	104
F	Procedure of Open Loop Control System	105
G	Fuzzy Rule-Based System	106

CHAPTER 1

INTRODUCTION

1.1 Motivation

For accurate servo-positioning of mechanical actuators in realistic engineering systems, high precision motion is required to achieve both high speed and high torque. Once an adequate control loop is designed, the system basically has the ability to achieve the required precise positioning as the errors between the reference and the controlled variables because of fluctuations or disturbances can be discovered and minimized correspondingly [1].

The motivation for this project is to improve the motion for an upper limb of robotic arm using positioning control and analyze the performance of the controllers in terms of steady-state error, settling time and rise time. With improved motion control, the robot manipulator can be applied in various fields such as medical fields and semiconductor industry, in which a precise motion using robot manipulator is more preferred rather than human labor.

1.2 Problem Statement

Robotic arm requires precise motion controls which enable it to determine the exact trajectory and the torque needed to achieve a targeted outcome. Currently in robotic assembly cell for small production, there are still some limitations for robots arms. For example, they cannot work efficiently in complicated environments without knowing any environmental information. They often rely on an external sensor system to help with the assembly work [2]. Also, improper motion control results in injuries or fatality. Thus, it is important to improve the capability of robotic manipulator.

With improved motion control, the robotic arm can be used in wider range applications and with increase efficiency. For example, it can be used in semiconductor industry in which a precise motion is required. The problem faced is in deciding and designing an appropriate controller to control the output angle of the upper limb of robotic arm correspondingly.

1.1 Objective

The main objectives of this project are:

1. To design a suitable controller to control the output angle for an upper limb of robotic arm.
2. To run the point to point trajectory control experiment and tracking control experiment.
3. To analyze and compare the performance of the controllers in terms of steady-state error, settling time and rise time.
4. To decide the best type of controller to be used.

1.2 Scope

The scopes covered in this project are

1. Design a controller to control the motion of robotic arm using MATLAB version 2009a.
2. Run the open-loop simulation and obtain the transfer function of motor.
3. Run the closed-loop simulation with uncompensated system.
4. Run the closed-loop simulation with compensated system for PID controller and fuzzy logic controller.
5. Analyze the performance of PID controller and fuzzy logic controller by manipulating the input angle and observe the graphs of output angle.
6. Compare the performance of PID controller and fuzzy logic controller in terms of steady-state error, settling time and rise time.

1.5 Chapter Overview

Chapter 1 introduces the motivation of this project, the overall problem faced by people and how to solve that specific problem. The objectives and scope covered in this project are listed accordingly.

Chapter 2 gives an overview on the current context of this research topic and the relating past studies based on similar topics. Background theory is included in this section. It is divided into topic-related sub-sections and the sections are discussed one by one.

Chapter 3 shows the methodology of project implementation including project implementation flow chart, project experiment flow chart and the overview of the system. The equipments used in this project are introduced, whereas the related equations regarding this project is outlined and derived.

Chapter 4 shows the results and discussion including the open-loop and closed loop simulation results. The results are shown textually and visually. The technique of system identification using Simulink block diagram is used. System transfer function is obtained for further analysis. PID and fuzzy logic controllers are implemented and compared in terms of their performance to decide whether which type of controller is more suitable to control the motion of robotic arm.

Chapter 5 is the conclusion made based on the findings on the previous chapters. Recommendation is made based on the conclusion to get improvement for the future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A human arm motion has been taken into consideration during the set-up designing stage. It was considered that it should allow for the greatest angular displacement possible, and that it should be able to transport the greatest possible mass at the tip. In this section, the structure and components which make up this whole project are investigated. Research is done in selecting the proper type of controllers to be used in the system.

2.2 Robotics

In the manufacturing process, most of the industrial automated tasks are carried out by specialized machines which are designed to carry out predetermined functions. The inflexibility and generally high cost of these machines have led to a public interest in robots which are capable of performing a variety of manufacturing tasks at lower production costs and greater flexibility in works.

A definition used by the Robot Institute of America gives a more precise description of industrial robots: “A robot is a reprogrammable multi-functional manipulator designed to move materials, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks [3].” Figure 2.1 shows the mechanism of robots. It is a closed loop system with feedback path.