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

TEO TING HUAN

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

Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka

June 2014

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.

Signature	:
Author’s Name	:
Date	:

I hereby declare I have read through this report entitle “Design of A Precision Motion Control for An Upper Limb of Robotic Arm” and found that it has comply the partial fulfillment for awarding the Bachelor of Mechatronics Engineerinh with Honours.

Signature :
Supervisor’s Name :
Date :

ACKNOWLEDGEMENT

I would like to express my greatest gratitude to the people who have helped and supported me throughout this project. I am grateful to my supervisor, **Dr. Mariam Md Ghazaly,** for her continuous support for the project, from initial advice and contacts in the early stages and through ongoing advice and encouragement all the way. Her willingness to give her time so generously has been very much appreciated.

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

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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.