FAKULTI KEJURUTERAAN ELEKTRIK
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF A POINT-TO-POINT (PTP) POSITIONING CONTROLLER FOR A ROBOTIC HAND

Yeo Chin Kiat

Bachelor of Mechatronics Engineering
2016

" I hereby declare that I have read through this report entitle " Development of a Point-to-Point Positioning Controller for a Robotic Hand" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering "

Signature : ....

Supervisor's Name : ....

Date : ....

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

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

" I declare that this report entitle " Development of a Point-to-Point Positioning Controller for a Robotic Hand" 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	:	....
Name	:	....
Date	:	....

To my beloved mother and father

ACKNOWLEDGEMENT

The work of this thesis represents the concerted efforts of the individual over almost a year. One of the features of training is collaboration and certainly it required many acts of collaboration by the company people in order to come to completion.

When I first started my work , it was quite hard to adapt to the environment but as time passed, I were able to adapt myself to all the condition. After some time, I begin to say that how blessed I felt that the topic and contents of my work was fascinating and enjoyable to me even after many hours of study, processing information, and working. I am also grateful that the knowledge gained through this training is so relevant and useful to my current teaching practices.

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ABSTRACT

The point-to-point (PTP) positioning system of a underactuated hand is a difficult and challenges task in order to control their system performance since the point-to-point positioning for the robotic hands must able to move in high precision with fast response. The underactuated hand is where a robotic hand which the finger of the robotic hand is control via a string or wire with the use of single actuator for each finger. This thesis presents the development of the control system for a 3-DOF for Finger 5 of the robotic hand by using the Micro-Box 2000/2000C interfacing and the Proportional-Integral-Derivative (PID) technique. The characteristic equation of the robotic finger is obtain by using the System Identification Tools which is represented by $G(s) = \frac{-0.9772s+829.9}{s^2+47.48s+0.0728}$. PID controller is designed by using Matlab Simulink to improve the performance of the robotic finger. The PID controller is designed by using Ziegler-Nichols Tuning method and trial and error tuning method. The designed PID controller are implemented and the results for uncompensated closed-loop system are compared with the PID controller. The designed PID controller has the parameters of Proportional gain of 289.8, Integral gain of 0 and Derivative gain of 5. When the input reference of 15° is compared for experimental result, the proposed PID controller shows improvement in rise time from 0.728s to 0.114s, settling time from 1.042s to 0.204s, and steady-state error of 8.111° is eliminated. However, the percentage of overshoot increase from 0% to 0.74% and the overshoot occurred due to the backlash of the mechanical part. Meanwhile, the designed PID controller shows the improvement in simulation result in term of rise time from 2.091s to 0.079s, settling time from 7.246s to 0.200s, steady-state error from 0.023° to 0.0001° and percentage of overshoot remain as 0%. However, the PID controller do not show a good performance in term of controller robustness where the PID controller is hard to track for the reference signal when the angle and frequency is too large. Hence, the designed PID controller shows that the controller has better performance for Point-to-Point Positioning control where the robotic finger can reach the desired position with no error while the PID controller cannot perform well in term of controller's robustness for tracking control.

ABSTRAK

Sistem Point-to-Point (PTP) Positioning bagi tangan underactuated adalah sukar dan merupakan tugas yang mencabar untuk mengawal sistem prestasi memandangkan Point-to-Point Positioning bagi tangan robotik mestilah boleh berfungsi dengan ketepatan yang tinggi dan mempunyai tindak balas yang cepat. Tangan underactuated adalah tangan robotik di mana jari robotik adalah dikawal dengan menggunakan tali untuk setiap jari robotik. Tesis ini menyampaikan pembangunan sistem kawalan untuk Jari 5 yang mempunyai 3-DOF dengan menggunakan Micro-Box 2000/2000C dan Proportional-Integral-Derivative (PID) controller. Ciri persamaan bagi jari robotik adalah memperoleh dengan menggunakan System Identification Tools di mana mewakili $G(s) = \frac{-0.9772s+829.9}{s^2+47.48s+0.0728}$. PID controller adalah direka dengan menggunakan Matlab Simulink bagi menambah baik sistem prestasi jari robotik. Selain itu, PID controller adalah direka dengan menggunakan dua care iaitu Ziegler-Nichols Tuning Method dan Trial and Error Tuning Method. Kemudiannya, PID controller yang direka sistem prestasinya akan dibandingkan dengan uncompensated closed-loop sistem. Parameter bagi PID controller adalah 289.8 bagi Proportional gain, 0 bagi Integral gain dan 5 bagi Derivative gain. Apabila rujukan input 15 ° dibandingkan untuk keputusan eksperimen, PID controller yang dicadangkan menunjukkan peningkatan dalam rise time dari 0.728s untuk 0.114s,settling time dari 1.042s untuk 0.204s dan steady-state error daripada 8,111 ° dihapuskan. Walau bagaimanapun, percentage of overshoot naik dari 0% hingga 0.74% dan overshoot itu berlaku disebabkan oleh tindak balas bahagian mekanikal. Sementara itu, pengawal PID yang direka menunjukkan peningkatan dalam hasil simulasi dalam tempoh rise time dari 2.091s untuk 0.079s, settling time dari 7.246s untuk 0.200s, steady-stae error daripada 0,023 ° ke 0.0001 ° dan percentage of overshoot kekal sebagai 0 %. Walau bagaimanapun, PID controller tidak dapat menunjukkan prestasi yang baik dalam controller robustness kerana controller yang direka sukar nutuk mengesan isyarat rujukan. Kesimpulannya, PID controller yang direka dapat menunjukkan sistem prestasi yang baik dalam kawalan Point-to-Point Positioning kerana jari robotic dapat bergerak ke posisi yang diingini tetapi PID controller tidak dapat menunjukkan prestasi yang baik semasa tracking control dijalankan.

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LIST OF SYMBOLS

V	**-**	**Voltage**
º	**-**	**Degree**
θ	**-**	**Angle**
e	**-**	**error**
s	**-**	**second**
T	**-**	**Torque**

LIST OF ABBREVIATIONS

DOF	**-**	**Degree of Freedom**
SISO	**-**	**Single-Input-Single-Output**
PID	**-**	**Proportional-Integral-Derivative**
PTP	**-**	**Point-to-Point**
DC	**-**	**Direct Current**
PWM	**-**	**Pulse Width Modulation**
NCTF	**-**	**Nominal Characteristic Trajectory Following**
NCT	**-**	**Nominal Characteristic Trajectory**
FLC	**-**	**Fuzzy Logic Controller**
GUI	**-**	**Graphical User Interface**
3D	**-**	**Three Dimensional**

CHAPTER 1

INTRODUCTION

1.1 General Overview

Robotic hand is a kind of mechanical hand that had similar functions as a human hands which using either an actuator or string mechanism to obtain the force to provide the motion, action and position. Nowadays, most of the robotic design are depend heavily on the automatic control system to control and monitor the operation of the robots. The using of the automatic control system on the robotic designs and robotic hands will reduce the humans workload due to their repeatability, high accuracy and able to operate continuously without humans control. Furthermore, the robotic hands also can be useful where the robotic hands can replace human hands in the dangerous working situation or as a auxiliary for delicate work such as a surgical operation.

Generally, the simplest robotic hands having two degree of freedom (2-DOF) and for the most complex robotic hands can be more than over 30-DOF when high accuracy and precision of the position is needed. A degree of freedom will be formed when there is a joint occurred. In order to design a finger for robotic hands, each finger should had three degree of freedom (3-DOF) so that the finger of the robotic hands had the minimum requirement to mimic the ability and motion of the human hands. Then, the angle and position of the finger will be change by increasing or decreasing the output voltage to the actuator.

The control system of a three degree of freedom (3-DOF) robotic hands which is used in the project is a single-input-single-output (SISO) system. A Proportional-Integral-Derivative (PID) controller will be developed and then the system performance will be improved by modify the PID controller to a better system such as intelligent PID. All the system performance on the finger of the robotic hands are examined and compare the system performance of the robotic hands.

1.2 Motivation

In recent years, the human like skills robotic hands have attracted the attention from the people around the world for replacing the human hand which require the high precision with fast response. The robotic hand can be used not only for the industrial sector, but it also can be implemented in the medical sector and manufacturing sector. Furthermore, the robotic hand also play an important roles in term of healthcare where the aging population and the people who lost their hand may need the service such prosthetic hand to make their daily life more convenience.

According to the Health and Safety Statistics Annual Report for Great Britain 2013/2014, there are 629,000 injuries happened with 133 fatalities or 44% per 100,000 workers. Figure 1.1 shows the estimated rates of total cases of self-reported work related illness and non-fatal injury in Great Britain. Based on the Figure 1.1, the agriculture, forestry and fishing and construction sector are the two sector which are the first and second highest of the rates of non-fatal injury to be happened.

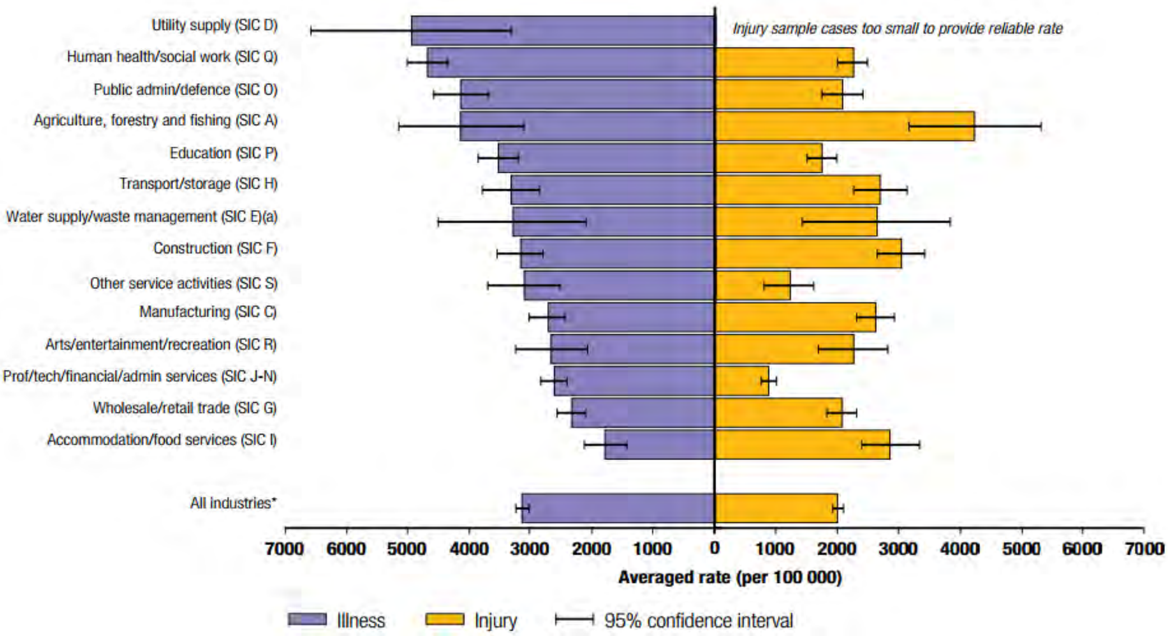

Figure 1.1 : Estimated Rates of Total Cases of Self-Reported Work-Related Illness and Non-Fatal Injury by Industry 2013 in Great Britain [1].

On the other hand, the most injured body parts being reported is back injured with 22% for all types of injured and the closely follow by the hand and fingers with 16.6%. The data shows that hand and fingers also one of the top body parts which are easy to be injured. Table 1.1 shows the most injured body part in Great Britain.