DEVELOPMENT OF CONTROLLER FOR WIRELESS ROBOTICS HAND IN HAZARDOUS ENVIRONMENT

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A report submitted in partial fulfillment of the requirement for the degree of

Bachelor of Mechatronics Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014/2015

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"I hereby declare that I have read through this report entitle "Development of Controller for Wireless Robotics Hand In Hazardous Environment" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering"

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I declare that this report entitle "Development of Controller for Wireless Robotics Hand in Hazardous Environment" 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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To my beloved mother, father and my brother that always giving support in morale and physical.

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ACKNOWLEDGEMENT

As an introduction for this section, I'm feeling honoured because I am able to accomplish this report that was given as my responsibility in order to partially fulfil a part of condition to be awarded Bachelor of Mechatronics Engineering. I'm very honoured and happy on the explanation, teaching and knowledge that didn't even cross my mind before. To be precise, I would like to thank every party that provided me the possibility to complete this project and report.

I would like to thank and show my gratitude to my final year project supervisor, Dr. Mariam Binti Md Ghazaly and Engr. Mohd Rusdy Bin Yaacob who assisted me in handling the necessary paperwork and providing suggestions in order for me to undergo project smoothly.

Lastly, I also would like to show my deepest gratitude to my friends who discussed and even shared their ideas and opinion that was very outstanding and helpful. I will never forget all the helps and the advices by implement fully in any suitable assignments.

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ABSTRACT

Hazardous environments such as in industry sector and high chemical area give high risks to the safety of worker. This risk can be reduced by designing a robotics hand that able to replace the human works. For industry purpose, the robotics hand that developed needs to have a higher performance in accuracy, stability and consistency. However, the current robotics hand in industry is not flexible which mean that it can't be used for different tasks. Therefore, a multi-purpose robotics hand was developed by previous student. But, the performance for current wireless robotics hand is not yet tested and this cause that the performance is not optimized in term of stability and flexibility. Main objective of this project is to design and develop a controller for improving the system performance of wireless robotics hand. However, the current robotics hand is in open loop system. Because of that, the micro servo used need to change to DC geared motor with encoder so that it able to feedback if there not a desired angle. There are three experiments in this project which is controller performance, actuator performance and sensor performance. The flex sensors that mounted on the data glove are used to measure the finger flexion. For sensor performance test, to obtain the accurate flexion of finger, the flex sensors are tested by using ten different values of input voltage which is 0.5V until 5.0V. The values of output voltage for 0°, 30°, 60° and 90° are collected. The data obtained will be plotted by using ORIGIN software. From the graph obtained, it can conclude that a higher value of input voltage which is more than 5.0V is needed so that the time taken to reach the desired angle is shorter. For actuator performance test, it divided into two part which is open loop system and closed loop system. For open loop system, the transfer function is obtained by using Random White Noise method and System Identification Tools. A transfer function is carried out. Closed loop system used to compare the response between the real time systems with the mathematical model. For controller performance test, PID controller is design and tested. The results obtained from PID controller is compared with closed loop system. As a conclusion, it prove that PID controller is suitable to use in robotics hand.

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ABSTRAK

Persekitaran yang berbahaya seperti dalam sektor industri dan kawasan kimia memberi risiko tinggi kepada keselamatan pekerja. Risiko ini boleh dikurangkan dengan mereka bentuk tangan robot yang dapat mengambil alih kerja-kerja manusia. Untuk tujuan industri, tangan robot yang diperlukan dalam sektor industri perlu mempunyai prestasi yang lebih tinggi dari segi ketepatan, kestabilan dan konsisten. Walau bagaimanapun, tangan robot semasa dalam industri tidak fleksibel bermakna bahawa ia tidak boleh digunakan untuk tugas-tugas yang berbeza. Oleh itu, satu tangan robot pelbagai guna telah direkakan oleh pelajar sebelum ini. Tetapi, pelaksanaan untuk arus wayarles tangan robot masih belum diuji dan sebab ini prestasi tidak dioptimumkan dari segi kestabilan dan fleksibiliti. Objektif utama projek ini adalah untuk mereka bentuk pengawal untuk meningkatkan prestasi sistem tangan robot tanpa wayar. Walau bagaimanapun, tangan robot semasa adalah dalam sistem gelung terbuka. Oleh kerana itu, servo mikro digunakan hendaklah diubah ke DC motor menjurus dengan pengekod supaya ia dapat memberi balas jika ada sudut yang tidak dikehendaki. Terdapat tiga eksperimen dalam projek ini iaitu prestasi pengawal, prestasi penggerak dan prestasi penderia. Penderia flex yang dipasang pada sarung tangan digunakan untuk mengukur akhiran jari. Untuk ujian prestasi penderia, penderia flex diuji dengan menggunakan sepuluh nilai voltan masukan yang berbeza iaitu 0.5V sehingga 5.0V. Nilai voltan keluaran untuk 0 °, 30 °, 60 ° dan 90 ° dikumpulkan. Daripada graf yang diperolehi, ia boleh membuat kesimpulan bahawa nilai yang lebih tinggi daripada voltan masukan iaitu lebih daripada 5.0V diperlukan supaya masa yang diambil untuk sampai ke sudut yang dikehendaki lebih pendek. Untuk ujian prestasi penggerak, ia dibahagikan kepada dua bahagian iaitu sistem gelung terbuka dan sistem gelung tertutup. Untuk sistem gelung terbuka, rangkap pindah diperolehi dengan menggunakan kaedah hingar rawak putih dan Alat Pengenalan Sistem. Sistem gelung tertutup digunakan untuk membandingkan tindak balas di antara sistem masa nyata dengan model matematik. Untuk meningkatkan prestasi sistem gelung tertutup, PID pengawal direkakan. Perbandingan antara sistem gelung tertutup dan sistem gelung tertutup dengan PID pengawal dibuatkan. Kesimpulannya, ia menunjukkan bahawa pengawal PID dapat meningkatkan prestasi tangan robot.

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LIST OF ABBREVIATIONS

mW	-	Milliwatt
dBm	-	Decibel-milli
ft	-	Feet
m	-	Metre
Kbps	-	Kilobit per second
GHz	-	Gigahertz
sec	-	Second in Time
V	-	Volt
kg-cm	-	Kilogram centimeters
°	-	Degree
θ	-	Angle
Ω	-	Ohm
K	-	Gain

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CHAPTER 1

INTRODUCTION

This section will explain about the project background/motivation, problem statement, objectives and scope of this project.

1.1 Motivation

Robotics hand is the machine mechanisms that can mimic the motion of human hand. In general, robotics hand plays an important role in the application that requires precision and dexterity. It is very useful to handle the work that unreachable or dangerous to human such as in industry sector and high chemical area.

Nowadays, there are many injured cases in the hazardous environment. In high chemical area, there are more than 13 million workers in the United States are possible exposed to chemicals that can be absorbed through skin. Skin exposure to hazardous chemicals can result in a various kind of occupational diseases and disorders which include occupational skin diseases (OSD) and systemic toxicity. In industrial, the efforts to control workplace exposures to hazardous chemicals are focused on inhalation instead of skin exposures. Besides that, human error also is the one of the reasons that causes the incident happen. In industry sector, Figure 1.1 shows that construction accounted for 774 fatal work injuries in year 2010. From this value of fatal work injuries, it can be seen that construction is more dangerous compare to other industry sector. Due to the risks that facing by worker, this risk can be reduced by design a robotics hand that able to replace the human works.

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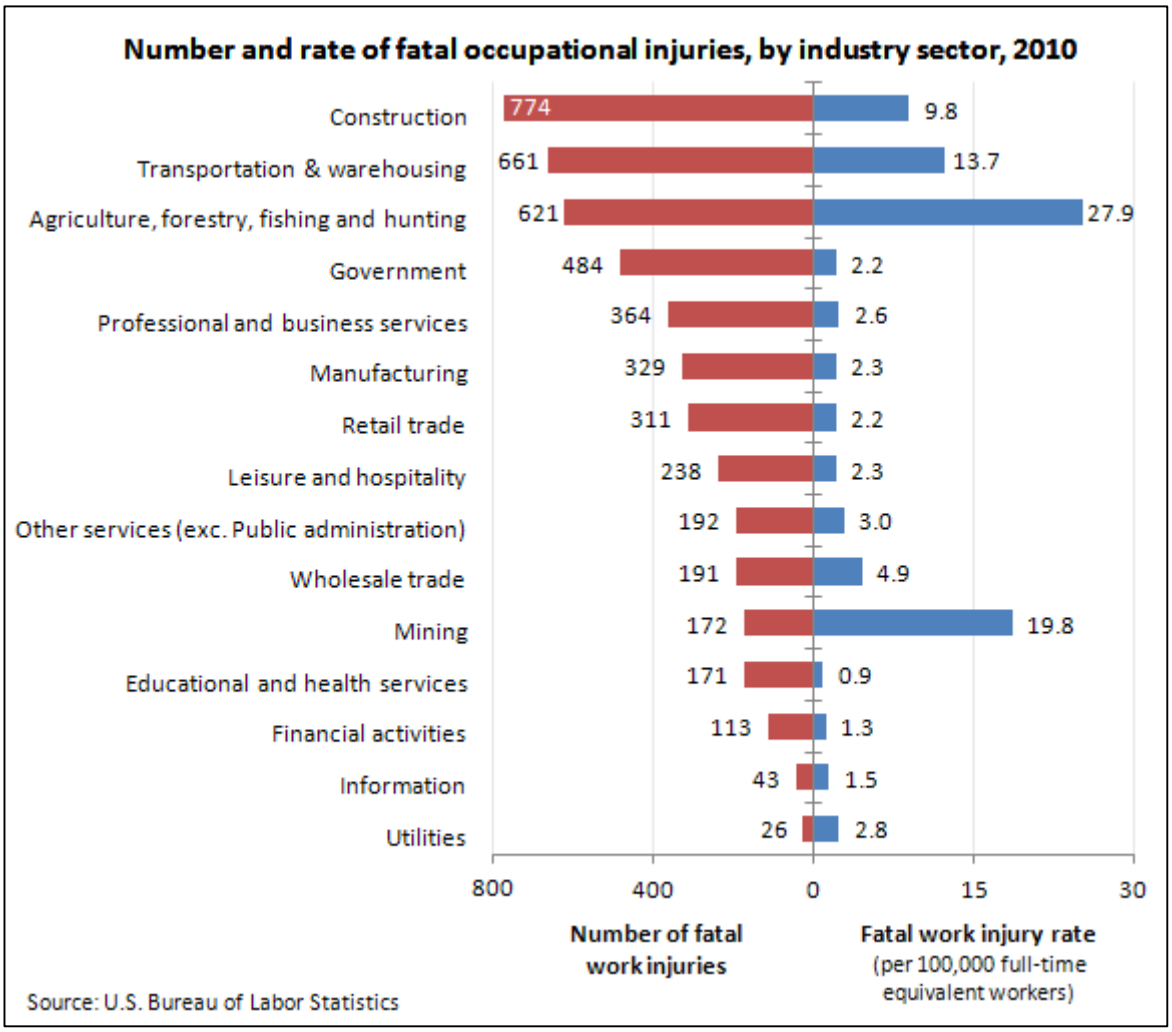

Figure 1.1: Number and rate of fatal occupational injuries by industry sector in 2010

1.2 Problem statement

In this century, robot is commonly used in industry. By using robot, it provides a high implication especially in production line because robots are able to work faster and more accurate compare with human. Moreover, robot is very useful to handle the work that unreachable by human such as work in hazardous environments. In this project, hardware already done by previous student but the robotics hand is in the open loop system. However, current performance of wireless robotics hand is not yet tested, so the performance is not yet optimized in term of stability and flexibility. Other than that, the accuracy of the flex sensor and micro servo also not yet tested. To develop a controller for wireless robotics hand, micro servo that currently used need to be change to DC geared motor with encoder so that it manage to give a feedback to the system. Then, current

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performance of the robotics hand need to be analyze and the accurateness of the robotics hand need to be compared with actual human hand so that it obtain the accuracy grasp.

1.3 Objectives

The objectives of the project are:

1) To design and develop a controller for improving the system performance of wireless robotics hand.
2) To simulate the performance of DC geared motor and flex sensor using MATLAB software.
3) To analyze the system performance of the wireless robotics hand with a controller.

1.4 Project scope

The scope of this project is focused on high hazardous environment but the experiment will be done in normal environment due to safety precaution. The flex sensors are installed to the human hand through glove is used to measure the flexing angle that generated by human fingers and the data is then used to generate motion of the robotics hand. These projects only cover in software development because of the hardware already done by the previous student. Current wireless robotics hand is in open loop system, to develop a controller, micro servo that currently used need to be change to DC geared motor with encoder so that it manage to give a feedback to the system. Because of this, limitation of the projects will only tested for one finger. The controller will be tested in order to analyze the current performance of the system of wireless robotics hand. In order to achieve this target, the hardware specification such as components and sensor used that provided by previous student need to be follow.

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1.5 Chapter Overview

For Chapter 1, it explain about the motivation, problem statement, objectives and scope of the project. Motivation of this project is because of there are many injured cases in the hazardous environment such as in industrial area. The problem statement for this project is that the hardware is done by previous student but it is in open loop system. Due to this problem, micro servo that currently used must be change to DC geared motor with encoder.

In Chapter 2, a review research project on the important elements in development the software and hardware of robotics hand. The first research study is focuses on hardware such as types of motor and robotics hand. Second research study is discusses the types on controller and its system either open loop system or closed loop system. Third research is discusses the MATLAB tools used to analyze the performance of robotics hand.

The list of procedure or analysis methods will be describe in Chapter 3. In this chapter, there consists of system flow chart, development process and experiment conducted. There also describe about theoretical analysis of the method that applies to this project. There are three experiments which is experiment setup and procedures of flex sensor, experiment setup and procedures of robotics hand and PID controller block diagram.

All the results obtained for three experiment will be shown Chapter 4. The results from flex sensor, robotics hand and controller shown is measured and simulated follow the procedure in Chapter 3. Results obtained is tabulated into table and graph is plotted. Based on the results obtained, the performance of flex sensor, performance of DC geared motor and performance of controller is analyzed and discussed.

In Chapter 5, it consists of two parts which is conclusion and recommendation. The conclusion is discussed about the experiment of this project based on the objectives while recommendation is discussed about the suggestion and further development of this project.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this section, a review of previous research project on the important elements in development the software and hardware of wireless robotics hand. The first research study is focuses on hardware such as types of motor and robotics hand. Second research study is discusses the types on controller and its system either open loop system or closed loop system. The third research is discusses the MATLAB tools used to analyze the robotics hand in term of grasping object.

2.2 Types of actuator

Selection of the actuator that used to drive the robotics hand need to be considering some parameter such as efficiency, torque and size of the motor. This section will discuss the types of actuator that commonly used on robotics hand which is servo motor, pneumatics actuator and DC geared motor.

2.2.1 Servo motor

Servo motor can be used in robotics hand. It has a good performance in speed control and torque control [1]. This motor available in smaller size that very suitable if used in the robotics hand. Speed of the movement for robotics finger can be adjusted by controlling the rotational speed of servo motor. Pulse Width Modulation (PWM) is used to adjust and set the values of rotational speed of the servo motor. Servo motor consists of a control period of 0.18μs with the speed and it also has an accuracy error of 0.125%. The performance of servo motor can be tuned by using driver gain in order to grasp an object

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and it will show no overshoot occur. Figure 2.1 shows the relationship between finger joint with the servo driver. In the region of 'moving', the graph shows that the output of joint is more faster than the input of the motor speed but the output torque is smaller than torque for the input.

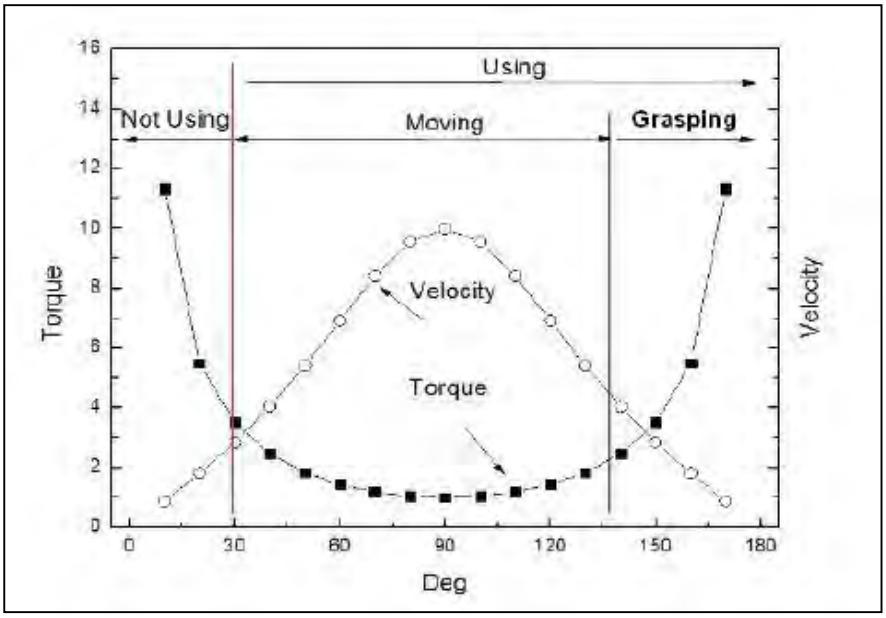

Figure 2.1: Relationship between the motor rotational speed/torque to joint of speed/torque [1]

2.2.2 Pneumatics actuator

Pneumatics actuator normally used in the finger joint which have only one degree of freedom (DOF). By using this actuator, a bigger compressor is needed in order to supply enough air pressured to drive the robot hand [2]. The latest pneumatics actuator had been developed to obtain a better performance compared to the convenient actuator which consists of rubber balloon and a net that covers the rubber balloon. Figure 2.2 shows the schematic diagram of a new design for a pneumatics actuator with basic structure that similar to McKibben type artificial muscle. However, this type of pneumatics actuator had been improved by covering the net with the thickness of 0.21mm of rubber balloon. It more efficiently to shrink when sent the air volume and this will cause the pneumatics actuator to be driven in a low air volume and low air pressure [2]. The range for

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