"I hereby declare that I have read through this report entitled "**Design and Development of Hand-Glove Controlled Robot Arm System**" and found that it has complied with the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering.

Signature : .....

Supervisor's Name : DR. FARIZ BIN ALI@IBRAHIM

Date : .....

DESIGN AND DEVELOPMENT OF HAND-GLOVE CONTROLLED ROBOT ARM SYSTEM

CHAM KAH YI

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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I declare that this report entitled "**Design and Development of Hand-Glove Controlled Robot Arm System**" 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 : CHAM KAH YI

Date : .....

To my beloved mother and father

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ABSTRACT

In this modern technology era, robotic arms are widely used in automation industry, medicine, and military. Most of these industrial robotic arm system are controlled by using teach pendant. However, this control method is still a tedious task. Therefore, this project is about to make an improvement for the control method of robotic arm. The objective of this project is to develop a wireless hand-glove controlled of robotic arm system. This allows user to control the robotic arm in an intuitive way. A robotic arm consists of 3 degree of freedom is developed. A wireless hand glove controller is designed and developed to control the robotic arm motion wirelessly. Flex sensor and MPU 6050 sensor are used to sense the finger motion and the wrist motion of human hands. Arduino Uno is used as the controllers of the system. Zigbee module is used for wireless communication because it has a wider range of data transmission. Few experiments were conducted to analyse the accuracy and repeatability for the angle rotation and pick and place motion. The average accuracy for each motion is around 0.990 to 0.998 while the standard deviation for each motion is very low which are around 0 to 1.90. Hence, each motion shows a high accuracy and repeatability in angle rotation. For the pick and place motion, all the accuracy for each trial is around 0.988 to 1. The standard deviation for the experiment is very small which is only 0.1339. Therefore, the system has a high accuracy and repeatability in pick and place motion. In conclusion, the wireless hand glove controlled robotic arm has a high performance in terms of accuracy and repeatability.

ABSTRAK

Dalam modern era ini, lengan robot sering digunakan dalam industri automasi, perubatan, dan pertahanan. Kebanyakan sistem tersebut dikawal dengan menggunakan "teach pendant". Akan tetapi, kaedah kawalan ini masih tidak effisien. Oleh itu, projek ini adalah untuk membuat penambahbaikan kaedah kawalan tangan robotik. Objektif projek ini adalah untuk menghasilkan pengawalan lengan robot tanpa wayar menggunakan pengawal sarung tangan. Ini membolehkan pengguna mengawal lengan robot secara intuitif. Lengan robot yang terdiri daripada 3 darjah kebebasan telah dihasilkan. Satu sarung tangan pengawal telah dibuat untuk mengawal lengan robot tanpa wayar. Flex Sensor dan MPU 6050 sensor digunakan untuk mengesan gerakan jari dan pergerakan pergelangan tangan. Arduino UNO telah digunakan sebagai pengawal sistem. ZigBee modul digunakan untuk komunikasi jarak yang sangat jauh. Beberapa eksperimen telah dijalankan untuk menganalisis ketepatan dan kebolehulangan bagi putaran sudut dan gerakan mengambil dan meletakkan objek. Ketepatan purata bagi setiap gerakan adalah dari 0.990 higga 0.998 manakala sisihan piawai bagi setiap gerakan adalah sangat rendah iaitu dari 0 hingga 1.90. Jadi, setiap gerakan menunjukkan ketepatan yang tinggi dan kebolehulangan dalam putaran sudut. Bagi gerakan mengambil dan meletak objek, semua ketepatan bagi setiap percubaan adalah dari 0.988 ke 1. Sisihan piawai untuk percubaan adalah sangat kecil iaitu hanya 0.1339. Jadi, sistem ini mempunyai ketepatan yang tinggi dan kebolehulangan dalam gerakan mengambil dan meletak. Kesimpulannya, pengawalan lengan robot tanpa wayar menggunakan pengawal sarung tangan mempunyai prestasi yang tinggi dari segi ketepatan dan kebolehulangan.

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LIST OF ABBREVIATIONS

ADC	-	Analog-to-digital Converter
DC	-	Direct Current
EEPORM	-	Electrically Erasable Programmable Read-Only Memory
GND	-	Ground
PWM	-	Pulse Width Modulation
RAM	-	Random Access Memory
ROM	-	Read-only Memory
UART	-	Universal Asynchronous Receiver/Transmitter
USB	-	Universal Serial Bus
Vcc	-	Voltage at common collector

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CHAPTER 1

INTRODUCTION

This chapter presents the motivation, problem statement, project objectives and also the scope of this project.

1.1 Motivation

In this advanced technology era, robotic arm become an emerging technology for several fields especially for industrial automation sectors. The demand of industrial robotic arm for industrial sector has accelerated significantly from years to years. According to the statistic of world industrial robot by IFR international Federation of Robotics, the sales of industrial robots to all industries rose by 48 % to about 171,000 units between 2010 and 2014 [1]. Todays, several types of remote controlled robotic arm are being developed for the task that is too hazardous and dangerous for human to handle. Hand glove based controlled robotic arm is one of the control method that is able to control the robotic arm remotely from a far distance.

According to the world statistic, there are about 438 nuclear reactor operated by 30 countries around the world for electricity generation [2]. The biggest nuclear power

generating country in the world is United States. The nation generates the most amount of nuclear or radioactive waste which is around 2,800 tons of radioactive waste per year [3]. It is a tremendous harm to handle the waste by the human operator. Therefore, a hand gesture based controlled robotic arm can be used for handling the radioactive waste instead of handling the wastes directly by human hands. Furthermore, nuclear reactor repair work is performed in the highly radioactive environment. Direct access of radioactive work place will expose the human operator to radiation so the task needs to be performed remotely. In the year of 2011, the nuclear power plant in Fukushima, Japan had been damaged by the earthquake and tsunami. An advanced robotic arm is developed by an American technology company in order to fix the leaks in the damaged nuclear reactor in Fukushima. The robotic arm helps to fix the cracks of the reactor without forcing worker direct access to highly radioactive surrounding [4].

Nowadays, antipersonnel landmine is considered as critical issue in the world. Antipersonnel landmines are frequent used illegally and cause injury or death of thousands of people. There are up to 20,000 people are injured or lose their lives every year by these destructive weapons [5]. In Columbia, the government still faces significant challenges in addressing the country's mine problem which has claimed more than 11,000 victims since 1991[6]. Figure 1.1 below shows the number of landmine accidents by department in Colombia from 2010 until 2014.

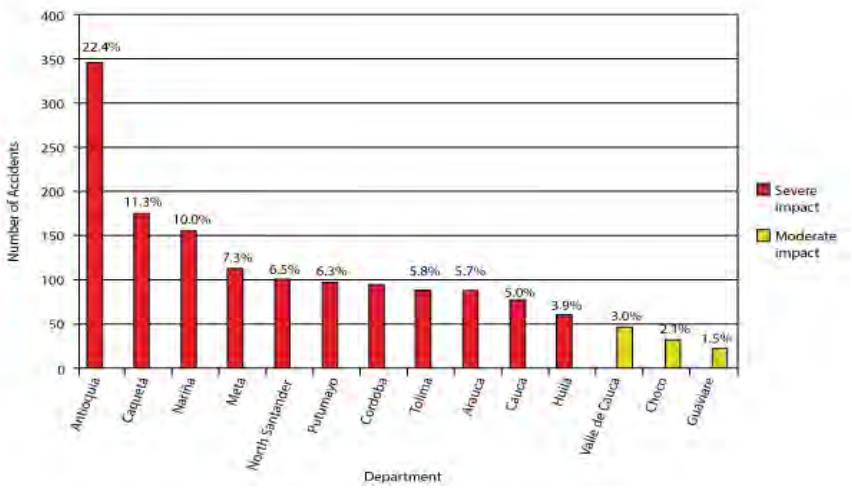

Figure 1.1: Number of Landmine Accidents by Department in Colombia from 2010 until 2014.

Source: http://www.jmu.edu/cisr/journal/19.2/focus/case.shtml

According to the International Campaign to Ban Landmines, there are about 60 countries in the world still contaminated by landmines [6]. A remotely operated vehicle equipped with robotic arm is developed for the demining purpose [7]. Additionally, a gesture controlled robotic arm is developed for defusing bomb by Siddharth Narayanan and C. Ramesh Reddyin in 2015[8].

Lastly, based on the statistical data given above and global issues which are mentioned, it clearly shows that development of hand glove controlled robotic arm is very crucial in today's world in order to help people to deal with the challenging issue especially to perform a hazardous task in inaccessible and highly radioactive environment.

1.2 Problem Statement

Robotic arm has become a crucial technology for automation industries to perform different tasks such as pick and place, welding, and cutting. It provides maximum accuracy with no human error when performing tasks. Dexterous remote control technology allows human to control a robotic arm in an environment where it is unsafe and hazardous. Some of these systems are operated by different kind of variants such as keypad, buttons, joysticks, and teach pendants.

Various types of teach pendants with intuitive user interface have been developed by the robot manufacturers such as a 6D mouse, icon-based programming [9], and a 3D joystick (ABB Robotics). However, there are few issues still occur regarding the control of robotic arm by the teach pendant. Controlling a manipulator in high accuracy and precision is still very difficult to achieve. Each degree movement of robotic arm need a predetermined sequence of button actions and it is very time consuming. Functionality error of robotic arm will occur if the teach pendant is improperly use. Apart from that, the efficiency of robotic arm system controlled by teach pendant is low since it cannot be controlled intuitively. Therefore, robotic arms controlled by teach pedant is still not user-friendly. The process of interaction of hand glove has been shown to be more accurate and natural than normal static keyboard and mouse [10].

In conclusion, a solution is proposed in this project which is to design and develop a hand glove in order to control the robotic arm in more intuitive way and to improve the performance of robotic arm system in term of accuracy and efficiency as well as to reduce the controlling complexity and time consumed.

1.3 Objective and Scope

The objectives need to be achieved are:

1. To design and develop a wireless hand-glove controller for robotic arm system.
2. To analyze the performance of hand glove controlled robotic arm system in terms of accuracy and repeatability.

The scopes of this project are:

1. The robotic arm system has 3 degree of freedom.
2. Develop a wireless hand glove controller for robotic arm system.
3. The hand glove controlled robot arm system can be controlled wirelessly from around 0.5m.
4. 3 Flex sensors are used for sensing finger motion.
5. A Gyro-accelerometer is used for sensing wrist motion of hand.
6. Arduino UNO used as controller of the system.
7. Zigbee Module is used for the wireless communication.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses about the comparison of the microcontroller, sensor, wireless communication module and actuator used in the previous research studies.

2.1 Project Background

Robotic arm is a programmable robot manipulator which has multipurpose usage for human being to perform their task efficiently. For the robotic arm structure, the link of the robotic arm is connected by a joint which allows either linear motion or rotational motion. The end side of the arm is called end effector. The end effectors are normally gripper or tools that used for welding, drilling and spraying. The robot arms can be controlled manually or autonomously. Due to its high accuracy and precision, it can be used to perform a variety of tasks[11].Many research have been done for the robotic arm so that it can be controlled in various ways by using computer terminals, joysticks, as well as through internet.

Nevertheless, programming and control an industrial robotic arm is remain complicated and time-consuming. Additionally, technical expertise is required to control and program the robot. Many researchers have put effort in this field to make it smarter and efficient. Hand movement data acquisition is one of the greatest research technologies and has been widely used in the industrial application. Actually, the development of glove-based system has begun about 20- 30 years ago. According to the journal [12], Sayre glove, Digital Entry Data Glove and LED glove were the first glove prototypes in this world . Thomas de Fanti and Daniel Sandin has developed a glove system called Sayre Glove in 1977. A flexible tube is attached along the finger of glove. A photocell is attached to one end of the tube while source was attached at another end. A camera based system was used for the LED glove to track position. While, in the year of 1983, Gary Grimes developed Digital Entry Data Glove. Various kinds of sensors are embedded on the glove to determine the finger touches. The research in this filed is continued from years to years in order to improve the previous study limitations and build a better performance glove-based system in future.

2.2 Microcontroller

A microcontroller is integrated circuit which is small in size. Generally, a microcontroller consists of a core processor as a brain of the controller, program memory such as RAM and input and output ports. Microcontrollers have been widely used in the devices and system which need to be automatically controlled such as mobile phone, security alarm system and industrial electronic measuring instruments. In this section, there are a few types of types of microcontroller will be discussed which are used as the controller for glove based controlled robotic arm system such as Arduino UNO, P89V51RD2 microcontroller, ATmega16 microcontroller, and Raspberry Pi.