"I hereby declare that I have read through this report entitle "Leap Motion – Controlled robotic arm" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Mechatronic Engineering)"

Signature : ....

Supervisor's Name : .... LOI WEI SEN ....

Date : ....

LEAP MOTION – CONTROLLED ROBOTIC ARM

LEE JUN WEI

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

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle "Leap Motion – Controlled 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 : ....

Name : .... LEE JUN WEI ....

Date : ....

To my beloved Mother and Father

Thank you for your incessant support and encouragement. Your sacrifices and loves have helped me to achieve this accomplishment.

Dear Lecturers and Supervisors

Thank you for your continuous support, knowledge and guidance.

Dear Friends

Thank you for all the information, guidance, support and encouragement.

ACKNOWLEDGEMENT

First and foremost, I would like to take this chance to thank my beloved supervisor Mr. Loi Wei Sen for giving the support mentally and physically, by sharing his expertise, knowledge and experience with me. He has always provides me with guidance on how my project should work and gives me new idea to be implemented, as well as solutions for some difficult problems. Never forget the good advices I got from Mr. Lim Wee Teck, Ms. Nur Maisarah binti Mohd Sobran and Ms. Arfah binti Ahmad to do a better report. Nevertheless, as my first panel, Dr. Ahmad Zaki has guided me about my hardware as Dr. Zaki is major in robotics field.

I am highly indebted to pioneers, Tham Yu Jiang and Ali Mutasim who have provided me with the valuable guidance and knowledge which very friendly to share although distance is not allow to meet, and I appreciated it with all of my heart.

Last but not least, a million thanks to all those time, concern and efforts that were given to me during the whole process of completing this project and report. I am thankful to everyone who always inspires me directly and indirectly during my Final Year Project.

ABSTRACT

The robotic arm structure is designed for a purpose, to pick and place an object, controlled by a gesture control mechanism called Leap Motion controller. This is to expose the use of the new way as a controller to control a device or hardware. Furthermore, this is applicable for those tasks that unreachable by human. The robotic arm structure of pick and place is controlled by Arduino as microcontroller to control the angles and displacements of the servo motor precisely. The position and orientation of the fingers and hands send to the Arduino through command prompt. Next, the programming is done by JavaScript language to communicate between Arduino and the Leap Motion controller. Specifically, a detailed 3D drawing is drawn by using SolidWorks and the dimensions for each part drawn needed for the fabrication. The robotic arm hardware then assembled all together. After the platform is done, kinematic and inverse kinematic equation and calculations are programed into JavaScript language for the robotic arm mechanism. The robotic arm followed the hand gesture with the fingers. The position and orientation and the finger are be the same as the robotic arm. Robotic arm then integrate with Leap Motion for pick and place purpose. The movement and accuracy are improved from the experiments and some calculations after the data collected from the experiment. Another test is given to the randomly selected participants to control the robotic arm with a task given. This is to record the participants understanding on the first try on controlling the robotic arm with their hand gestures. Few experiments are carried out to increase the accuracy analyze the precision while improve the overall pick and place performance.

ABSTRAK

Struktur lengan robot direka untuk tujuan, untuk memilih dan meletakkan objek, yang dikawal oleh satu mekanisme kawalan isyarat dipanggil pengawal Leap Motion. Ini adalah untuk memberi pendedahan kepada penggunaan cara baru sebagai pengawal untuk mengawal alat atau perkakasan. Tambahan pula, ini adalah terpakai bagi mereka tugas-tugas yang tidak dapat dicapai oleh manusia. Struktur lengan robot pick dan tempat dikawal oleh Arduino sebagai pengawal mikro untuk mengawal sudut dan anjakan motor servo itu dengan tepat. Kedudukan dan orientasi jari dan tangan hantar ke Arduino melalui arahan segera. Seterusnya, pengaturcaraan dilakukan dengan bahasa JavaScript untuk berkomunikasi antara Arduino dan pengawal Leap Motion. Secara khusus, lukisan 3D terperinci dilukis dengan menggunakan ToT dan dimensi untuk setiap bahagian disediakan diperlukan untuk fabrikasi. Perkakasan lengan robot kemudian dipasang semua bersama-sama. Selepas platform itu dilakukan, persamaan kinematik kinematik dan songsang dan pengiraan diprogramkan ke dalam bahasa JavaScript mekanisme lengan robot ini. Cabang robot diikuti isyarat tangan dengan jari. Kedudukan dan orientasi dan jari adalah sama dengan lengan robot ini. Lengan robot kemudian mengintegrasikan dengan Leap Motion untuk tujuan memilih dan tempat. Pergerakan dan ketepatan dipertingkatkan dari eksperimen dan beberapa pengiraan selepas data yang diperoleh daripada eksperimen. Ujian lagi diberikan kepada peserta yang dipilih secara rawak untuk mengawal lengan robot ini dengan tugas yang diberikan. Ini adalah untuk merekodkan peserta memahami pada percubaan pertama pada mengawal lengan robot dengan isyarat tangan mereka. Beberapa eksperimen yang dijalankan untuk meningkatkan ketepatan menganalisis ketepatan manakala meningkatkan memilih dan tempat prestasi keseluruhan.

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x	-	coordinate point of end effector of x-axis
y	-	coordinate point of end effector of y-axis
z	-	coordinate point of end effector of z-axis
θ_i	-	the angle from X_{i-1} to X_i measured about Z_i

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Numerous robots have been developed and used in factories, plants and hazardous environments. They supported human workers and significantly reducing the risk of accidents. In the future, it is expected that robots expanded their work space not only to produce and hazardous environments, but also for the home and office environments to support their daily activities [1]. By combining the advantages of human perception and recognition skills with consistent and accuracy robots, a human-robot collaboration system can enhance target identification rate and reduce the complexity of robotic systems [2, 3].

In many industries, the machines are controlled by complicated control panel, many buttons, joysticks or touchscreen panel. For example of the ABB teach pendant, KUKA teach pendent or even Samsung FARA teach pendent, complicated buttons that confused the operator such as in Figure 1.1 , Figure 1.2, and Figure 1.3 respectively. This Leap Motion controller is a new future to our way of controlling things and the upcoming field that this controller is applicable is in computer technology. ASUS and HP laptops have been applied this controller to their product. In the news, the ASUS will be start shipping their laptop internationally with built in the Leap motion controller. While in October, Leap took a baby step with the HP envy 17 Leap Motion SE. It is the first laptop with embedded Leap Motion controller, and it used a new module that is 70 percent thinner than the on inside Leap's standalone sensor.

Figure 1.1: ABB Teach Pendant

Figure 1.2: KUKA Teach Pendant

Figure 1.3: FARA Teach Pendant

However, there are one device that has movement, voice and gesture recognition that hit the market last year 2010, called Kinect. It is released by Microsoft and is applicable for Windows and Xbox for gaming purposes. However, the price for a piece of Kinect is RM 465 internet price. In contrast, the Leap Motion controller is just cost RM 250 including shipment fee. Moreover, it is easy to use by just using the hand gesture rather than Kinect sensed the body movement to control. Thus, it is cheap and very convenient for the developers to explore. In conclusion, there is a huge potential for developers to expand this future to other audience who are excited to discover the potential of this Leap Motion controller created by the developers. As saying goes, “get your application into millions of hands or even more fingers”.

This project is to design hardware that able to control by Leap Motion controller. The main purpose is to expose the new technology that able to replace the conventional controller. When it comes to a controller for a remote car or a computer game, think of controller with buttons, joysticks or even go further to touchscreen panel. But what if a controller does not has those features, it using human movement instinct for human to control the remote car and the computer games. The conventional controller needed human to observe and get used to it before they master the controller. The natural way our hands move determined the output of a device rather than buttons or joysticks. By using the Leap Motion Controller as the controller and with a wave of a hand or lift of a finger, it replaced all those clicks and taps and drags and drops. The Leap Motion Controller sensed our hands and fingers and also followed every move it make. Our hands and fingers are allowed to move in the wide open space between the controller and the hardware.

The hardware for this project is a Leap Motion controlled robotic arm. The uses of robotic arm can be expanded to greater fields such as for the disabilities, in robotic industries, chemical laboratories, and accomplished tasks where human unable to reach. All this fields needed accuracy and precision to do the tasks, and Leap Motion has very fine system, with the servo actuated robotic arm able to perform such tasks given. Controlling a robotic arm using joysticks or buttons might be difficult, but using the natural and understandable movements and gestures, task is easily performed.

Objective of the Leap Motion is used because it is a new technology of controller able to bring the future in the whole new level of controlling. This will further expand well acceptance usage in robotic fields, despite its small in size, precise and it is a revolutionary way to control an object.

1.2 Problem Statement

In the industries, or in the laboratory which needed to handle stuff with care used robotic arm. The most likely issue that operator of the controller found out difficulties in using those control panels, manual book might be as thick as a textbook. Conventional controller also led to performing task slowly as the confusing buttons and joystick which is not synchronize with the way of the operator could imagine. Moreover, this kind of conventional controller need more time to adapt to the use of the buttons and joysticks to able to do task smoothly.

Several approaches have been developed for sensing hand movements and corresponding by controlling robotic hand. Glove-based techniques well known means to recognize hand gestures. Mechanical utilizes glove is attached sensor that directly measure hand and joint angles of the arm and the spatial position. Although gestural interfaces based glove give more accuracy, if limits freedom because it forces users to use the patch cumbersome devices [4].

1.3 Objective

The main objectives of the project are embarked as below:

1. To develop Leap Motion gesture controlled robotic arm hardware.
2. To construct an algorithm using JavaScript to control the robotic arm.
3. To integrate a Leap Motion controlled robotic arm structure for pick and place purpose.
4. To analyze the accuracy and precision of the robotic arm and to improve its accuracy and pick and place performance.

1.4 Scope

The Leap Motion controller is a new technology device that is launched in the mid-year of 2013. To use this device, exploration is needed and learned how to connect to computer. It able to act as a mouse, but the only different is using hand gesture to function like a mouse. An Arduino Uno Rev3 is used as a microcontroller to the robotic arm. Thus the servos are directly connected to the Arduino board. Next, to connect the Leap Motion and the Arduino, both are connected to the same host computer. Appropriate way to connect both Leap Motion controller and Arduino is determined to send data from Leap Motion controller to Arduino. This project covered on the programming in JavaScript language to control the robotic arm by hand gestures sensed by the Leap motion controller. To edit the program, Visual Studio is good software to use. Moreover, this project also constructed the structure of the robotic arm. But before that, a 3D drawing of the robotic arm is drawn by using SolidWorks. The average length of a human arm, which is measured from shoulder to third finger, is approximately 65cm long. Thus the length of robotic arm for this project is shorter than 65cm that is from the base to the gripper of the robotic arm. This project is planned to have a 6 degree of freedoms but the derivation of the formulas take months to get the answer. Thus this robotic arm is limited to maximum 3 degree of freedoms. Another 2 degree of freedom which is for the flexion, extension, supination and pronation wrist movement is included to the robotic arm. This 2 degree of freedoms is independent, thus, no inverse kinematics formulas derivation are needed. Consequently, total of 5 degree of freedoms of robotic arm is built to perform a simple pick and place task. Furthermore, as usual a normal RC servomotor has its error, thus reduce the accuracy.

Therefore, few experiments are carried out to increase the accuracy analyze the precision while improve the overall pick and place performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Figure 1.1 above showed an ABB robotic arm controller. The joystick is the controller the movement of the ABB robotic arm. It is a conventional controller in the market now days. While the Figure 2.2 shows a black glove which is another controller to control a device or a machine. The robot controlling is done by Fusion of Hand Positioning and Arm Gestures using data glove [4]. It is necessary to wear the glove, thus limits it freedom although the precision is high. The weakness is that proper light and camera angle are required for capturing hand gesture correctly. An Electromyographic (EMG) signals are a famous way of collect the data from human arm motion by the movement of muscle in the most research [5]. A technique is needed to handle the light source and viewing angle to capture efficiently hand gesture [4]. But despite having all these available assisting tools, improvement for the aids assisting controller are still much needed.

Figure 2.1: Back glove as controller

2.2 Dark Glove with Colored Cues

The name of the robot is CRS A-460 with three-fingered gripper but is a manipulator graphic model simulator. The real time hand gesture able to guide the robotic arm in gripping gestures in the simulator. This robotic arm has six degree of freedom and it is operated with electric DC servo motors. Furthermore, to control the robotic with hand gestures is to wear a dark glove marked with colored clues on the dark glove. For the tracking the colored cues on the dark glove to capture images in sequence in real time, a single camera is used. The limitation is limited the operator's freedom on need to wear a glove [6].

2.3 Simple Video Camera

3D MATLAB Kinematic model of a PUMA 762 is used for the research. It has six degree of freedom and is operated by electric DC servo motors. The modules on interpretation of hand gestures are in four steps. First are a real time hand gesture formation monitors and gesture capture and then hand feature extraction. Then, pattern matching for gesture capture and last is the command determination corresponding to shown gestures and performing action by robotic system. As computer vision, simple video camera is used to track gestures presentation that has 3 speeds of frames per second. Therefore, real-time technique is used to track the hand when the hand is in the range of vision of the camera. To identify hand, required continuous captured 3 frames to compare the framework to search within which there is movement. 10 different gestures are used for 10 different movements for the robotic arm to gesture commands changed robot specific language to operate the robotic arm. The accuracy is 90% in the right light and low light performance declines. The restriction is placed in the chamber which requires adequate light and camera angle [4].

2.4 A Camera

Camera also has another alternative method to control a robotic arm where consist of four-axis servo motor handmade used for the operation. There are two control modules robotic arm. The first is to compare all the pre-stored data in the database Template Matching Algorithm. Next is to find where the fingertips are and count the number of the same, use the Signature Signal. Both methods have short in the calculation, making it suitable for continuous frame capture sequence. To control the robotic arm gripper, local features used to provide hand gesture while global features hand position is 3D dimension. As for this case, the application of the robot hand control the robotic arm is followed the same path of the human hand. One limitation is that the shoulder position must be configured to the system manually before starting the system.

The experiment is tested under the same conditions light source light is on the left and in the corner at the hands of their fans. This type of source positions always because shadows on the object observed [7].

2.5 Kinect

Virtual robotic arm is used and the task given is to pick a virtual ball and place into a virtual basket. A Kinect sensor is used to track the hand position. The module on controlling the virtual robotic arm is by programming-by-demonstration. It ran VizArtist software with a custom made OSC plugin for accepting Open Sound Control messages and controlling the virtual set. The Kinect sensor tracked the hand position of the operator and delivered the related OSC messages in real-time. Moreover, the implementation of the virtual robotic arm is by spatial mapping to directly control the joint configuration of the robotic arm, based on the user’s left hand position. The limitation for this system is that it involved the operator’s whole body to control [8].