Development of Glove Controlled Prosthetic Hand

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DECLARATION

I hereby declare that this thesis is result of my own effort except for works that have been cited clearly in the reference."

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Date : 12th June 2013

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms scope and quality the award of Bachelor of Electronic Engineering (Computer Engineering) With Honors."

Signature :...............................

Name DR. SOO YEW GUAN

Date : 12th June 2013

DEDICATION

Specially to my beloved parents, siblings and friends for their eternal support, encouragement and inspiration.

ACKNOWLEDGEMENT

First of all, I would like to sincerely thank to my supervisor, Dr. Soo Yew Guan given enthusiasm and guidance throughout the project. Ever since his supervision, I obtained a lot of idea, knowledge and support regarding this project from him.

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ABSTRACT

Prosthetic hands are artificial devices that are utilized to approximate the appearance and function of a natural hand. This thesis proposed a similar sized and light weight prosthetic hand designed and concerned about the possibility of using data glove to control a 5 fingers prosthetic hand. The finger of prosthetic hand which has 3 degree of freedom is designed to make it able to bending like human hand finger. Data glove act as control device to provide the control signal to microcontroller when the prosthetic hand fingers starts bending. The Servo Motor drive is use to drive the sector of each robot hand's finger. Furthermore, the servo motor can only provide a low torque for the finger, so prosthetic hand only can only generate a suitable force for each finger. All then behavior and movement of the robot are process by a single PIC 18F4550 microcontroller. The data glove controller has real time control over the prosthetic hand. So it can emulate a human hand such as grasping object. With further research and development, the robot hand can be used to implement prosthetic arm.

ABSTRAK

Tangan Robot adalah satu bahagian yang sangat penting dalam satu robot kemanusian. Tesis ini berkenaan dengan reka bentuk satu tangan robot yang sama saiz serta ringan dan dapat menggunakan master sarung tangan untuk mengendalikan 5 jari tangan robot. Projek ini adalah membuat satu 5 jari tangan robot yang boleh bergerak seperti tangan manusia. Setiap jari tangan robot mempunyai 3 darjah kebebasan untuk mememulasikan seperti tangan manusia. Sarung data tangan adalah memberikan isyarak untuk mikrpengawal ketika pengguna mengubah posisi tangan. Motor yang Servo drive menggunakan rantai untuk menggerakkan sector setiap jari. Selain daripada itu, servomotor yang hanya dapat mengeluarkan tenaga putaran rendah untuk jari tangan, jadi tangan robot hanya dapat mengeluarkan tenaga yang umum untuk setiap jari. Segala tingkah laku dan pergerakan robot di kawal oleh sebiji mikropengawal jenis PIC18F4550. Sarung data tangan mengawal tangan robot dalam masa nyata. Jadi, tangan robot berupaya mengikut tangan orang untuk memegang dan mengerjung bahan. Dengan lebih pengajian and penyelidkan, tangan robot ini boleh digunakan dalam robot yang kemanusian.

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LIST OF ABBREVIATIONS

PIC	-	Peripheral Interface Controller
PCB	-	Printed Circuit Board
PAMs	-	Pneumatic Artificial Muscles
PWM	-	Pulse-Width Modulation
PC	-	Personal Computer
CAD	-	Computer-aided design

CHAPTER I

INTRODUCTION

1.1 Background of Project

Prosthetic hand is a part of robot arm, and it is important part for a humanoid robot. Typical applications of robot hand include welding, painting, ironing, assembly, pick and place, packaging and testing, all accomplished with high endurance, speed, and precision. It is easy to found a robot hand in now a day industrial for instead of human hand to do the dangerous job and precision job. Industrial robot hands are used in the production process and the transportation process for quality control and carrying the heavy stuff.

Prosthetic hand may be used in place of people demolition bomb to reduce casualties. Astronauts will allow the robot to check out the surrounding areas, to ensure the safety of the space. In addition, the prosthetic hand is also widely used for helping doctor in medical surgery patients. This requires very precise technology to avoid the mistake.

Therefore, this project aims to investigate and development the low cost multipurpose prosthetic hand. The prosthetic hand will be manipulated by using the data glove. The movement of the prosthetic hand should be as close as possible with the human hand.

1.2 Objectives

The objectives of the project are as follows:

- The aims of this work is to develop a prosthetic hand that is able to:
    - Pick up or handle small to medium sized objects
    - Grasping roll material
    - Perform like a humanoid robot hand
    - Control using data glove controller
    - User able control the prosthetic hand without any training

1.3 Scope of Project

The system consists of a mechanical design, electronic hardware, and software. The works undertaken in the project are limited to the mechanical part, electronic control, and software development.

For the mechanical part: The prosthetic hand includes a finger skeleton design, motor, and caster mounting. String is mounted at the shaft of servo motor to pull the finger. This prosthetic finger is designed to operate in 5 degree of freedom. The data glove design includes the sensor in each the finger by using flex sensor.

Electronic control: Choosing PIC microcontroller as the main brain of the control system. Input and feedback control using same flex sensor. The servo controller can generate the servo pulse from 0.5ms to 2.5ms when it received the signal from the PIC microcontroller.

Software development: A set of C programming code have to be programmed into the device using MPLAB IDE software and modify program based on requirement of prosthetic hand. Software used to draw out the schematic diagram is Proteus.

1.4 Work Contribution

I have developed a five fingers prosthetic hand that has a 15 degree of freedom. Each sector of the finger was tied with a chain system that powered by the servo motor. The prosthetic hand was capable to pick up small to medium size object and sphere shape object. The major contributions of this work are:

- Built a robot index finger which is manipulated by the servo motor.
- Built the prosthetic hand other 5 fingers and successfully manipulated them by the servo motors.
- Combined all the fingers to develop prosthetic hand, which was controlled and manipulated by using a PIC microcontroller.
- I have successfully controlled the prosthetic hand by using a data glove; the output of the data glove is directly proportional to the input for the PIC microcontroller. The microcontroller generated the PWM signals which were used by the servo controller to control the shaft position of the servo motor.
- I have successfully tested our prosthetic hand capability to pick up small and medium size objects and sphere shape objects like ping pong ball.

CHAPTER II

LITERATURE REVIEW

2.1 Prosthesis

In the last thirty years several examples of robotic hands have been developed by research or industry, some designed to mimic the human hand in its manipulation dexterity and functionality, some aimed at achieving better anthropomorphism and cosmetic appearance. Great research effort has been focused on the design of both articulated end-effectors and smart dexterous anthropomorphic hands, for humanoid robotics and prosthetics.

An advanced neuron-controlled prosthetic hand bi-directionally interfaced with a human being should address both functional and cosmetic issues; it should be dexterous enough to allow the execution of Activities of Daily Living (ADLs), and include proprioceptive and exteroceptive sensors for the delivery of consciously perceived sensory feedback. Market available myoelectric hand prostheses are instead similar to rough pincers, having just one (open/close the hand) or two degrees of freedom (DoFs), therefore poor manipulation capabilities. They are controlled by means of electromyographic (EMG) signals picked up from the residual muscles by surface electrodes, amplified and processed to functionally operate the hand. Also the recently commercialized multi-fingered I-Limb prosthesis (Touch EMAS Ltd., Edinburgh, UK) is controlled using a traditional two-input EMG scheme where all fingers open/close simultaneously.

2.2 Actuators

Actuators are the motors responsible for motion in the robot. A mechanism or robot are constructed in such a way that they mimic the animal or human body, so the actuators are perform like a muscles and joints but with a different structure. To achieve the effect motion of the robot, robots normally use mainly rotary actuator. The common actuator is electric, pneumatic, hydraulic, piezoelectric or ultrasonic control.

2.2.1 Pneumatic artificial muscles

Pneumatic artificial muscles (PAMs) are contractile or extensional devices operated by pressurized air. Similarly to human muscles, PAMs are usually grouped in pairs (Figure 2.1) one agonist and one antagonist.

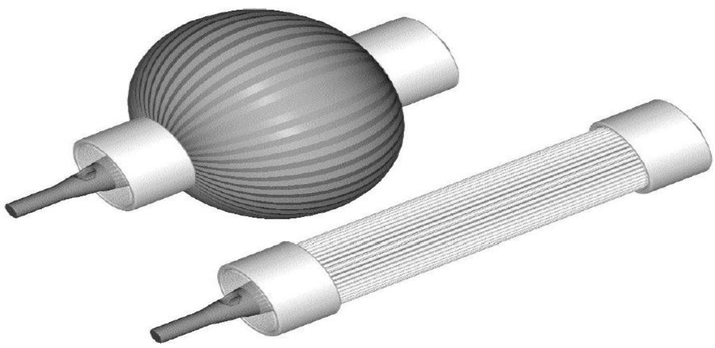

Figure 2.1: Agonist and Antagonist

PAMs are contractile and linear motion engines operated by gas pressure. Their core element is a flexible reinforced closed membrane attached at both ends to fit along each other. The mechanical power is transferred to a load. As the membrane is inflated or gas is sucked out of it, it bulges outward or is squeezed, respectively. Together with this radial expansion or contraction, the membrane contracts axially and thereby exerts a pulling force on its load. The force and motion thus generated by this type of actuator are linear and unidirectional. This contractile operation distinguishes the PAM from bellows, which extend upon inflation.

Although this type of actuator is very suitable to use as the muscle of a humanoid robot, it is hard to find in Malaysia market, so this actuator will not been used in this project.

2.2.2 Sensing

Sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. The sensor is responsive to changes in the quantity to be measured, for example, temperature, position, or chemical concentration. The transducer converts such measurements into electrical signals which usually amplified, can be fed to instruments for the readout, recording, or control of the measured quantities. Sensors and transducers can operate at locations remote from the observer and in environments unsuitable or impractical for humans

Proprioceptive sensors sense the position, the orientation and the speed of the humanoid's body and joints. In human beings inner ears are used to maintain balance and orientation. Humanoid robots use accelerometers to measure the acceleration, from which velocity can be calculated by integration; tilt sensors to measure inclination; position sensors, that indicate the actual position of the robot or even speed sensors. In my project, the position sensor will be mounting at every joint of the finger.

2.2.3 Servo Motor

A servo motor is a generic term used for and automatic control system. The Servo is an automatic device which uses error-sensing feedback to correct the performance of a mechanism. The term correctly applies only to systems where the feedback or error-correction signals help control mechanical position or other parameters. In practical terms, that means a mechanism that you can set and forget, and which adjusts itself during continued operation through feedback.

There are numerous types of servos but they differ in their precision, speed, and strength. The connection of these servos are same, is controlled by three wires (see figure 2.2) which is negative, positive and signal. Roughly 6VDC to power the servo motor and a PWM pulse stream to control position.

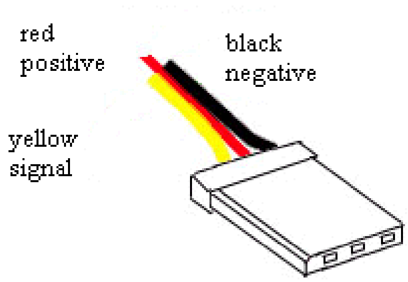

Figure 2.2: Connecter of the servo motor

A servo pulse of 1.5ms width will set the servo to its "neutral" position, or 90°. For example a servo pulse of 1.25ms could set the servo to 0° and a pulse of 1.75ms could set the servo to 180°. The physical limits and timings of the servo hardware varies between brands and models, but a general servo's angular motion will travel somewhere in the range of 180° - 210° and the neutral position is almost at 1.5ms.

2.2.4 Communication

In my project, the communication between microcontroller and microcontroller with the computer is needed and the USB PIC Boot loader will be used. USB PIC Boot loader is a resident boot loader for PIC18 series of Enhanced Flash USB Microcontrollers. It allows user to program application hex into the chip using the standard USB connectivity of your device.

USB PIC Boot loader code is write-protected and cannot be overwritten by firmware. Firmware update or user mode is selected by SW and/or HW switch. Boot loader runs at the boot time (when the processor has just been reset) and is capable of loading a complete application program into a processors memory.

With the USB PIC Boot loader loaded, there are two distinct modes of operation: firmware update mode and Application mode. USB PIC Boot loader uses the EEPROM mark and/or hardware switch to determine which mode to run in.

Firmware Update Mode.

In firmware update mode USB PIC Boot loader utilizes USB connection of Microchip PIC Microcontroller to communicate with PC and load the new application code. Once the programming is done, the USB PIC Boot loader switches to Application mode, the processor is reset and begins running the newly loaded code.

Application mode.

In Application mode USB PIC Boot loader simply remaps reset and interrupts vectors to user mode firmware application.

2.3 Existing Prosthetic Hand

Prosthetic hands have not been widely sold in the market. So this literature is based on the existing prosthetic hand build by individual person or University research. There is one of company got sold the robot hand in this world which is American company Advanced Arm Dynamics. This company manufactured a product name Michelangelo Hand show in Figure 2.3.

2.3.1 Michelangelo Hand

The Michelangelo Hand is robotic hand prosthesis developed by Otto Bock and the American company Advanced Arm Dynamics. The fully articulated hand is the first prosthesis to feature an electronically actuated thumb which mimics natural human hand movements. It can be used for a variety of delicate everyday tasks, and has been in use by military and civilian amputees in the United States and United Kingdom since 2011.

The hand is battery-powered and can be used for up to 20 hours between charges. Constructed of metal and plastic, it is designed with a natural, anthropomorphic aesthetic, and can be custom-fitted for each user. Its motions are controlled by built-in electrodes, which detect the movements of the user's remaining arm muscles and interpret them using electromyography software. The fingers can form numerous naturalistic configurations to hold, grip or pinch objects. The Michelangelo Hand is capable of moving with enough precision to conduct delicate tasks such as cooking, ironing and opening a toothpaste tube, but can also exert enough strength to use a steering wheel. Each unit costs around £47,000 (US$73,800).

Figure 2.3: Michelangelo Hand.[1]

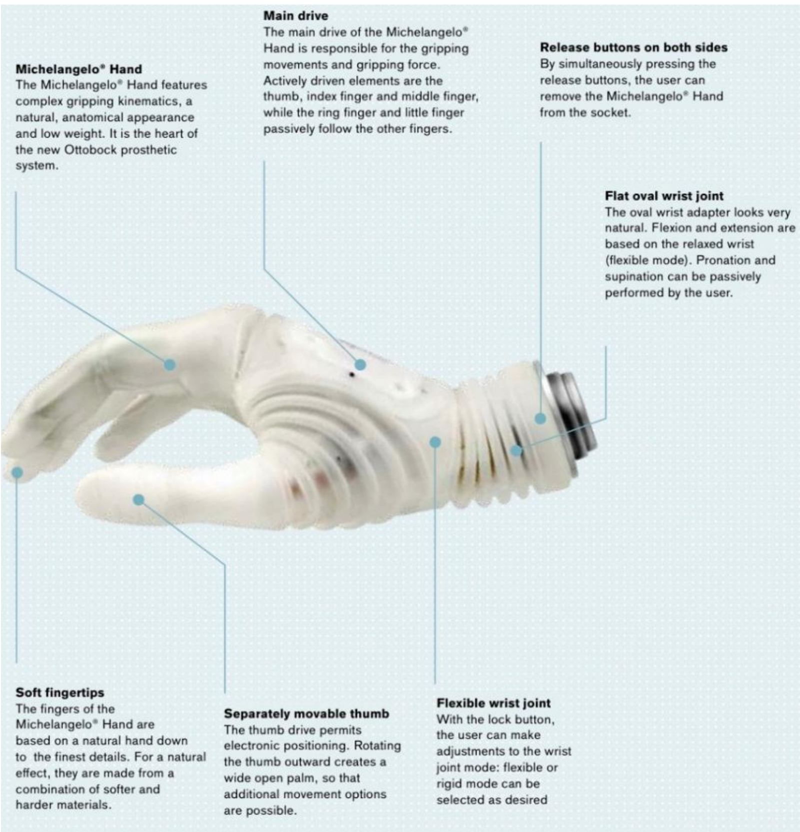

Figure 2.4: Description of Michelangelo Hand.[1]