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DEVELOPING PROSTHETIC ARM USING ELECTROMYOGRAPHY (EMG) SYSTEM

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Abstract

Prosthetic limb was very beneficial to amputee patient but statistic shown that most of amputee decline to use the prosthetic limb offered because of higher cost and cause back pain due to heaviness of the prosthetic limb. The first goal for this project was to develop prosthetic arm using Electromyography (EMG) sensor. The second goal is to monitor the muscle activities and performance of the current prosthetic limb. The prosthetic arm is using embedded system that build in together with the EMGsensor and data logging. The main part of this project is the 3D printed prosthetic arm using PLA white color, 200 micron and above material. Other hardware used for this project are Arduino Mega and servo motor. As mention before, EMG sensor with three electrodes are used to detect muscle energy. This project software is using Arduino IDE and PLX-DAQ for codding and data logging process. Each software is able to act as data logging purpose. Arduino Mega will send data of muscle signal that beencollected by EMG sensor to servo motor that attached to prosthetic arm fingers. The result shown the amount of muscle signal produces when muscle is relaxed and contracted. This system provided real-time data to patient. This will make patient able tomonitor the muscle energy used while using the prosthetic arm.

Keywords: Prosthetic Arm; EMG sensor; Arduino MEGA; Muscle;

1.0 INTRODUCTION

There are 3 causes of the physical disabilities of individual in our society that is chronic diseases, accident and birth defect. Prosthetic limb is the replacement for the limb that had been amputates because of accident, disease or birth defect.

There are four type of prosthetic limb, which replace either partial or complete loss of leg or an arm. The types of amputation are below the knee (Transtibial), above the knee (Transfemoral), below the elbow (Transradial), and above elbow (Transhumeral)

An EMG (Electromyogram) is to measure muscle response or electrical activity of the muscle. EMG has widely used in clinical application for example to check the health of nerves and muscle diseases and seizures. Other than that, EMG also can be applied in sport rehabilitation.

Prosthetic arm is made from a durable and strong lightweight material such as carbon fiber covered with foam padding for comfort purpose and flesh-colored plastic [5].

The body powered prosthetic arm, the hand is operated with cables and a harness which is operated with opposite shoulder while myoelectric operated through the use of electrode.

Body-powered prosthetic limbs are controlled by cables connecting them to elsewhere on the body. For example, a prosthetic arm can be controlled through a cable attached with a strap or harness to the opposite, healthy shoulder. The working shoulder is then moved in certain ways to control the prosthetic device this is similar to how to use a hand lever on bike to control the brakes.

The EMG signal strength or amplitude is dependenton two factors that are force and muscle fatigue. During the limb movement, one can identify the EMG signals amplitude, which could be interpreted as an extent of comparative tension or force of the muscle.As the tension of the muscle varies with time, the magnitude of the EMG signal obtained increases the larger force required for a limb motion to occur. Electromyogram is a combine action potential of themuscle cells of muscle tissue [10].

Myoelectric signal been used in various biological application for example prosthetic arm. Myoelectric signal a weak signal which is then subjected to amplification by the amplifier circuits.

Then the amplified signal is filtered to eliminated the motion artifacts. The accurateness of the signal increases and reduce the environment and devices noise [11].

2.0 EXPERIMENTAL

Project Flow Chart

This prototype accordingly followed the flowchart by dividing each parameter element. There is onesensor use that is EMG sensor that will send signal to servo motor.

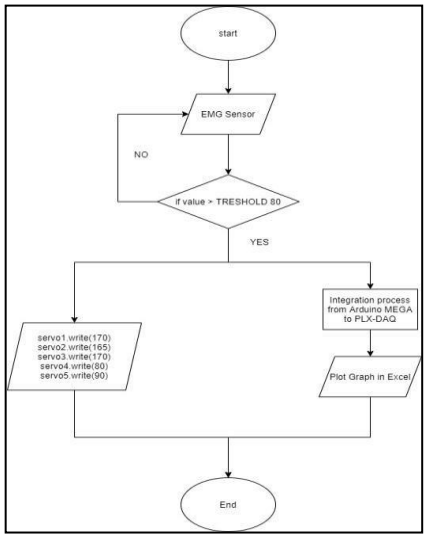


Fig. 1 Project Flow Chart

Base on figure 1, the prototype starts with EMG sensor detect muscle signal from the electrode attach to patient arm. If the EMG sensor detect muscle of electrical signal, the sensor will send the signal to Arduino Mega. If the value of is larger than threshold 80, the servo motor will turn on accordingly with the degree that been set up in codding. At the same time, patient can monitor real-time data collected through PLX-DAQ and can convert the data into graph.

Wiring Diagram

The circuit diagram shown this project used 18V battery as power supply for EMG sensor. The main power supply for Arduino Mega is using USB connection to personal laptop. For all five (5) servo motor, it uses the 5V power supply from the Arduino MEGA

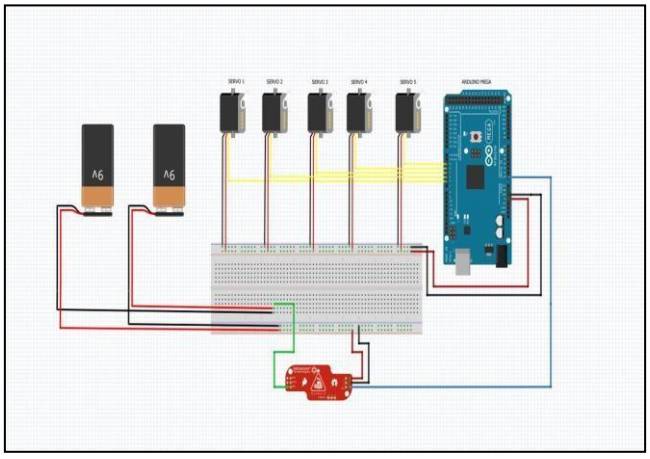
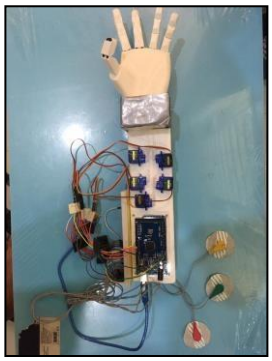


Fig. 2 Circuit Diagram

Prototype Design

To achieve the first objective of this project, a systemhas been developed by completing the project prototype that using EMG sensor. The main part of the prototype is the 3D printed part that was made from Magma PLA Solid Color material. The forearm part is made of polystyrene board and five servo motor are attach to it. The microcontroller and the EMG sensor also attached to the base of the polystyrene board.



(a)

(b)

(c) (d)

Fig. 3 Prototype Design (a)Whole Design (b) 3Dprinted Part front (c) Left view (d) Right view

Software Development

The Arduino IDE was used as the main software forthe Prosthetic Arm with EMG sensor system. Arduino IDE is a system engineering software program for program that require test, measurement and management with fast access to hardware andrecord insight. This software also used to create coding and execute the coding that has been create and upload it into microcontroller, Arduino MEGA.

Parallax Data Acquisition tool (PLX-DAQ) software add-in for Microsoft Excel acquires up to 26 channels of data from any Parallax microcontrollers and drops the numbers into columns as they arrive. PLX-DAQ provides easy spreadsheet analysis of data collected in the field, laboratory analysis of sensors and real-time equipment monitoring.

Figure 4 shown the interface of software PLX-DAQ. Set the port to designated port for USB port connection. Set Baud to 9600 as per codding Baud.

Fig. 4 PLX-DAQ

This project is focusing on only one parameter that need to be concern, which is the muscle signal data from EMG sensor.

CLOCK	MUSCLE SIGNAL
0:09:25	43.00
0:09:25	41.00
0:09:25	41.00
0:09:25	40.00
0:09:25	39.00
0:09:25	42.00
0:09:25	39.00
0:09:25	42.00
0:09:25	39.00
0:09:25	41.00
0:09:25	40.00
0:09:25	40.00
0:09:25	39.00
0:09:25	45.00
0:09:25	45.00
0:09:25	42.00
0:09:25	46.00
0:09:25	40.00
0:09:25	40.00
0:09:25	40.00

Table 1 Relax Muscle Signal

Base on table 1, the column A represent the clock of the data store and column B represent muscle signal collected from EMG sensor. This data collected by put three electrodes on patient forearm. Base on table 1, our muscle signal average is 41 during muscle is relax.

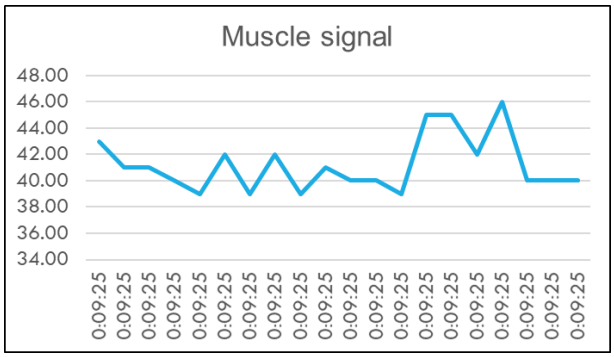


Fig.5 Relax muscle signal graph

As shown in figure 5, the graph shows the muscle signal in relax condition. This signal is collected when patient is open their arm. The average of the signal is 41 with in one minute.

CLOCK	MUSCLE SIGNAL
0:09:27	40.00
0:09:27	0.00
0:09:27	31.00
0:09:27	75.00
0:09:27	111.00
0:09:27	150.00
0:09:27	179.00
0:09:27	204.00
0:09:27	107.00
0:09:27	200.00
0:09:27	250.00
0:09:27	253.00
0:09:27	220.00
0:09:27	249.00
0:09:27	273.00
0:09:27	292.00
0:09:27	308.00
0:09:27	326.00
0:09:27	337.00
0:09:27	351.00
0:09:27	365.00

Table 2 Contracted muscle signal

Table 2 shown the signal collected during muscle is contracted. The patient is asked to make their hand into a fist for 1 minute. Base on the table, the signal collected are high compare to signal collected when muscle is relaxed.

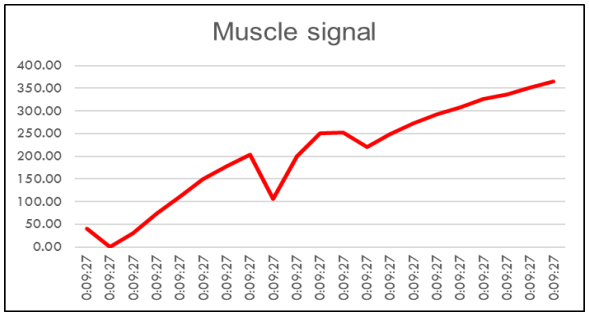


Fig.6 Contracted muscle signal graph

As shown in figure 6, the graph shows the muscle signal in contracted condition. This signal is collected when patient arm makes a fist. The graph increases rapidly when the patient forearm muscle change from relaxed to contracted.

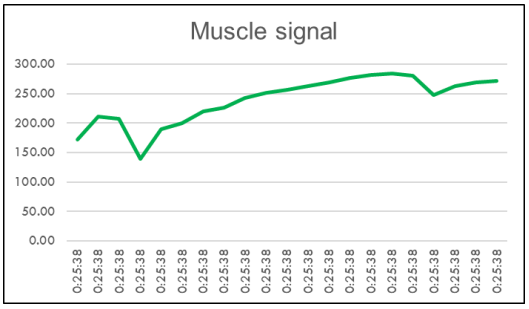


Fig. 7 Contracted muscle signal

Figure 7 shown the muscle remain contracted for 1 minute. The average of muscle signal collected during the muscle contracted is 250. With this data collected, researchers are able to determine the muscle signal of more are that is relaxed and muscle that is contracted. More accurate signal can be obtain by using high end EMG sensor that is more costly.

4.0 CONCLUSION

In conclusion, by conducting the research on prosthetic arm using EMG sensor, the design on prosthetic arm using electromyograph has found useful; knowledge and future understanding. This project been carried out within a year of period. Moreover, All the objective stated in 1.5 are to develop the prosthetic arm using for disable person,to control finger of prosthetic arm using Electromyography (EMG) and to monitor the muscle value using PLX-DAQ application have been achieve. This project concludes that using EMGsensor to gain muscle signal from muscle and applywith the prosthetic arm are achievable. Moreover, with enough budget for the project, the best hardware can be bought in order to gain better data and result gain for the project. There are several problems encounter during the progress to finish this project. The main problem is during the progress of the project, MCO (Movement Control Order) been conduct by our government due to pandemic issue. This make item purchasing harder due to many shopsare close to purchase item for the product. Some item that been order online also effected to the MCO. The main part of the product that is prostheticarm that need to use 3D printing service are not available in my region. Student only available to visit the shop of 3D printing service at Kuala Lumpur after the MCO is lifted by the government.

This project can be improved in the future by using latest EMG sensor. this project using EMG sensor that required 18V power supply. Myoware company has developed the latest muscle sensor that used 5v power supply, this make a huge different between the EMG sensor that been used for this project. The latest EMG sensor may come costly than the current one but this could help researcher get a better EMG signal.

Other than that, as a main microcontroller, new researcher can also use Arduino mega with built-inWi-Fi adapter. The main problem which ESP 8266 had was the ESP 8266 itself was difficult to communicate with mega Arduino. It's because the ESP 8266attaches to Arduino Mega using the adapter. Arduino mega with integrated Wi-Fi adapter has been developed to help users interact with ESP 8266and is similar to node MCU. Next, researcher also canuse AI (artificial Intelligence) for the prosthetic arm movement using neuron network.

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