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Prosthetic Arm for Amputees

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Abstract : *A robotic arm is a Programmable mechanical arm which copies the functions of the human arm. They are widely used in industries. Human robot-controlled interfaces mainly focus on providing rehabilitation to amputees in order to overcome their amputation or disability leading them to live a normal life. The major objective of this project is to develop a movable robotic arm controlled by EMG signals from the muscles of the upper limb. In this system, our main aim is on providing a low 2-dimensional input derived from emg to move the arm. This project involves creating a prosthesis system that allows signals recorded directly from the human body. The arm is mainly divided into 2 parts, control part and moving part. Movable part contains the servo motor which is connected to the Arduino Uno board, and it helps in developing a motion in accordance with the EMG signals acquired from the body. The control part is the part that is controlled by the operation according to the movement of the amputee. Mainly the initiation of the movement for the threshold fixed in the coding. The major aim of the project is to provide an affordable and easily operable device that helps even the poor sections of the amputated society to lead a happier and normal life by mimicking the functions of the human arm in terms of both the physical, structural as well as functional aspects.*

Keywords - *Amputees, Arduino Uno Board, EMG Signals, Human-Robot Controlled Interfaces, Prosthesis System, Servo Motor, Threshold value.*

I. INTRODUCTION

A robotic arm[1] may be defined as a programmable mechanical arm to replicate the human arm function. Its structure is similar to that of a complex robot with a manipulator and an end-effector. The human arm mainly consists of 2 types of movements[2] which are rotational and translational. A bionic arm[3] will be able to produce these movements with a greater efficiency. Here, in this case, the links of the manipulator are connected with joints of amputated patients and thus allowing the latter movements to be made possible. Here, it is the end effector which is used to perform the functions of the human arm.

The design of a prosthetic hand[4] is basically dependent on the functional needs and appearance. It is created by the coordinated work of health care professionals and prosthetics. The design may be achieved manually or with the help of designing software. One can achieve a 3D model[5] with the help of the input parameters that have been fed to the system. It is also possible for us to check the efficiency and performance, without the need for real-time designing, which seems to be cumbersome in nature. The upper extremity prosthesis is classified into several types based on part of the arm that is to be replaced. It is classified as forequarter, shoulder disarticulation, trans-humeral prosthesis, elbow disarticulation, trans-radial prosthesis, wrist disarticulation, full hand, partial hand, finger, and partial finger prosthesis.

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III. METHODOLOGY

We are by an agreeable paradigm of open source hand: InMoov. To begin with, we will link up two 9V batteries in sequence to produce an 18V of power supply for the circuit to work. Manipulation is based on EMG - electrical bustle of muscles which are obtained by the Emg sensor with the sEMG.

We are using a good example of an existing open-source hand: InMoov. First of all, we will connect two 9V batteries in series to produce an 18V power supply to turn the circuit on. Control is based on EMG - electrical activity of muscles which are obtained by the Emg sensor with the sEMG.

The project deals with the introduction of the EMG signal from the body and that signal is responsible for the production of movement in the robotic arm, attached with a servo motor and Arduino Uno. Both the hardware and software tools communicate with one another, in order to make the correct decision whether to move the arm or not, based upon the intention of the subject involved in the process. The project works with an Arduino code that functions whenever an EMG signal arrives. The code has a threshold value that distinguishes between the different EMG values obtained with which the arm is able to produce flexion and extension movements accordingly. Initially, the EMG signal has to be acquired. For this purpose, we have to make use of surface EMG electrodes. Three electrodes are involved in this process. The working electrodes are placed on the mid-muscle and end muscle regions of the biceps respectively. The reference electrode is placed near the bony surface area of the elbow.

Proper positioning of electrodes is necessary for the operation. At the same time, the electrodes that we have chosen should be capable of picking up the desired EMG signals more effectively. Once we have done with this signal acquisition part, the next step is to process the raw EMG signal to get clear results at the end. The stages of EMG signal processing consist of pre-amplification, rectification, smoothening, and post-amplification. In this way, the EMG signal conditioning process is carried out using suitable circuitry constructed on a breadboard. The Arduino Uno works as the brain of the system that commands the robotic arm attached with it, to perform the desired actions. The code is then uploaded on the Arduino Uno, which is connected to a monitor. The Arduino Uno is connected with the external robotic arm through the servo motor. As the code runs, the servo moves the robotic arm to produce the desired movements, with the help of EMG signal values acquired from the body, during flexion and extension processes. Fig.1 shows the block diagram of the project.

3.1 Methods

3.1.1 Categories of Prosthetic Hand

There are three categories of prosthetic hands such as a cosmetic hand (passive prostheses), a body powered hand, and active prosthetic hand (for example; driven by DC motor) [6]. The cosmetic only emphasizes on the aesthetic look rather than functionality and medical needs Due to their robustness and relatively low cost, it is still one of the popular choices especially in the third world country. The active prosthetic hand is regarded as the modern prosthetic hand. By manipulation of the patient electrical signal (Electromyography), it then translates into prosthetic hand movement. The prosthetic hand studied for this paper is based on the active prosthetic hand category.

3.2 Electromyography Method

3.2.1 Characteristic of sEMG

At present, the process of EMG signals is the most common approach used for controlling active prosthetic hands [7] EMG signals are detected by measuring the electrical signals associated with the activation of the muscle. These electrical signals generally contain raw information on patterns of muscle activity. However, the electrical signals are relatively small and the extraction technique is used to produce consistency [8]. The sEMG is by far the easiest method for active prosthetic hands as shown in table 1. sEMG is a non-invasive method Since there are no surgical requirements it is comparatively short. Patient attaching the sensor electrode to the right muscles. Different muscles are responsible for different types of movement and thus are manipulated and produce a distinguished classification of the movement of the prosthetic arm for prosthetic's control. A typical muscle used is the flexor and extensor muscle. They introduce a non-natural contraction where retraction and contract grasping action of the prosthetic technique that can be used is the forearm to make sure the skin is firm to secure a stab in the sEMG method, influenced by physiological factors [9]. sEMG is a fair signal, with the precision and rectification to be interfered with by many factors without amplification ranging from -5 to 5 mV or 0 to 1.5. Clancy et al. conducted an sEMG signal between the maximum amplitude which was about less than 1mV. Even more, signals which are stochastic make it more difficult to extract[10]. Thus, it highlights the important stage where it is the most important for the accuracy of the prosthetic's accuracy level of the feature extraction method.

Table 1 : selection of sensor

Parameters	**EMG**	**EEG**
Cost	₹1,575	₹24,999
Amplitude	1-10mV	0.001-0.01 mV
Bandwidth	20-2000Hz	0.5-40Hz
Types of hand movements	Precision grip	Power grip
Accuracy	60-80%	77.9%
Types of signals	Surface EMG and Intramuscular EMG	Delta, theta, alpha and beta

3.2.2 Feature Extraction

Feature extraction of sEMG methods which are non-pattern and pattern recognized. The common methods of can be grouped into four categories:

a. Time domain (TD)
b. Time-serial domain (TSD)
c. Frequency or spectral domain
d. Time-scale or time-frequency

The signal-to-noise ratio of sEMG is low and thus makes it difficult to extract sEMG from a strong noise background. Thus extraction of sEMG has to include the factors of temperature, signal to noise ratio, crosstalk.

3.2.3 Block Diagram

Block Diagram illustrates the working mechanism and flow of the inmoov hand. This inmoov hand is controlled through the sensors connected to the remaining muscle of the Patient's arm. Sensors pick up Electromyographic signals which are given to the arduino and converted to movements of the prosthetic arm. Here the servo motors are used to control the individual finger movement of the artificial 3D designed and printed hand.

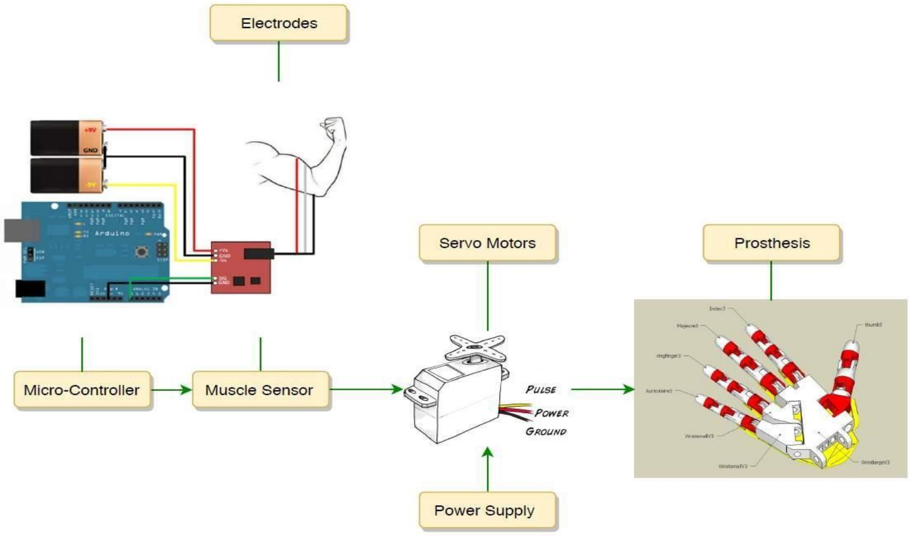


Fig 1: The block diagram of the project

IV. COMPONENTS

The hardware required is,

1. Inmoov 3D printed robotic arm -

3d printed is printed to create real artificial arms and fingers. Advanced functionalities of inmoov robotic arm is fast motor response, forming simple human hand gestures, and integrability as well.

Fig 2: Inmoov 3D printed robotic arm

2. EMG Muscle Sensor And Electrodes -

EMG ie, Electromyography muscle sensor measures, filters, rectifies, and amplifies the electrical activity in response to nerves simulation of the muscles and produces an analog output signal that can be easily read by a microcontroller. And the 3 electrodes are used to capture EMG signals.

First is the reference electrode to be placed on an inactive section of the body, such as the bony portion of the elbow, shin or forearm.The second electrode is to be placed along the mid-length of the muscle. And the last electrode is used to be placed at the end of the muscle.

Fig 3: EMG muscle sensor and Electrodes

3. SG90 Servo motors -

For movement of fingers 5 identical servo motors are required.

Fig 4: SG90 servo motors

4. Arduino Uno -

SIG pin and the GND pin of the EMG muscle sensor are connected to the analog input pin and ground pin of the Arduino board respectively.

Fig 5: Arduino Uno

The software will be using an Arduino IDE, which will act as a medium to connect the natural and the robotic arm. For the time being we have used Proteus 8.9 for the simulation results.

PARTIAL IMPLEMENTATION

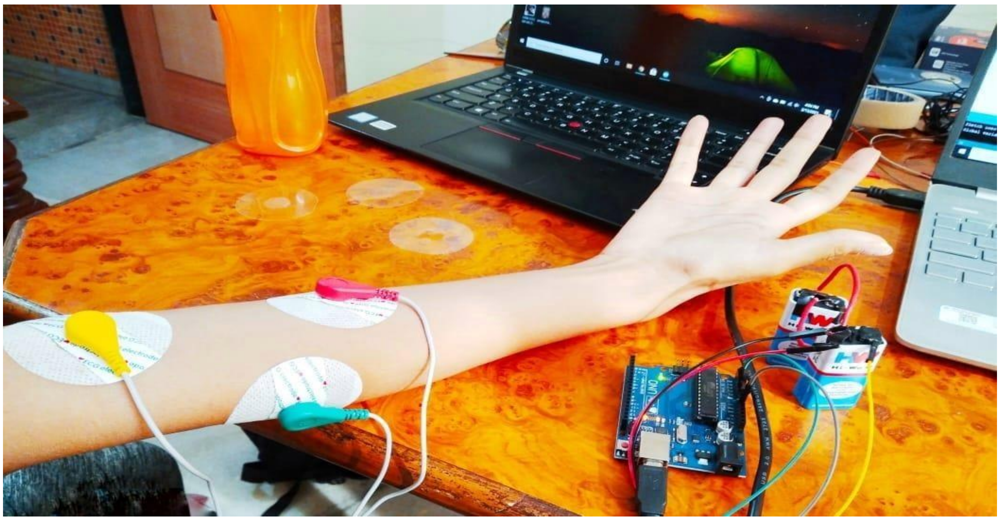


Fig 6: Extended arm with electrodes

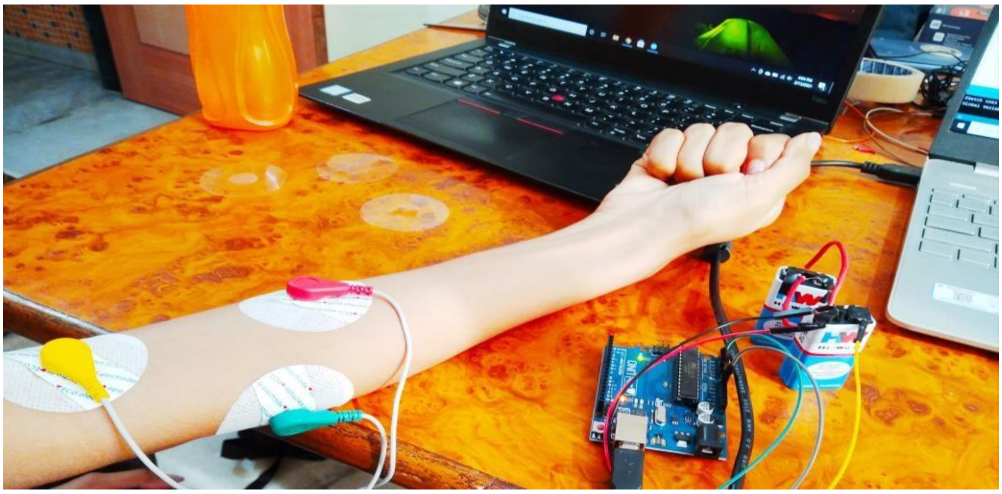
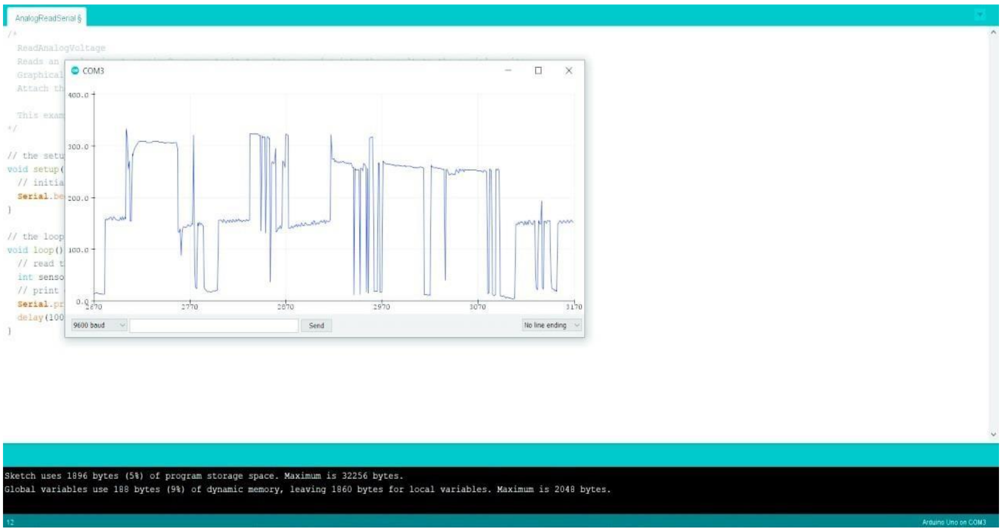


Fig 7: Flexion of the arm with electrodes



```
/*
  ReadAnalogVoltage
  Reads an
  Graphical
  Attach th

  This exam
*/

// the setu
void setup(
  // initia
  Serial.be
}

// the loop
void loop()
  // read t
  int senso
  // print
  Serial.pr
  delay(100
}
```

```
Sketch uses 1896 bytes (5%) of program storage space. Maximum is 32256 bytes.
Global variables use 188 bytes (9%) of dynamic memory, leaving 1860 bytes for local variables. Maximum is 2048 bytes.
```

Fig 8: Serial plotter result on the extension of arm

As seen in the figure, we can observe that as we extend the arm, the graph values are high and as soon as we flex the arm, the graph values are low.

V. CONCLUSION

In this project, we would be implementing a robotic arm that would be controlled by the EMG sensor. We have seen that we would be requiring the Arduino and Arduino IDE platform to control the movement of the servo and the signal to the Arduino will be given by the EMG Sensor that will extract the signals from the muscle.

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