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3D Printed Multifunctional Arm

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***Abstract*—Continuous increase in industrialization and lack of safety parameters instances of amputations are growing. The loss of a limb significantly limits the functional activities of daily living. It is required for the amputees to get safer, simpler and automatic artificial limbs. But it is inconvenient for the amputees to get the proper treatment and to buy or use the artificial limbs which are available in the market because of their financial conditions. A huge emphasis is placed on the manipulation, shape, weight and comfort of prosthesis to enable its use as an inherent body part. Continuous efforts were made to design superior artificial arms but the high cost of artificial limbs is a steep economic barrier for patients. This project uses three dimensional printing which is a promising avenue for reducing the cost of bionic limbs. This artificial hand will be able to do various basic actions which are required in our day to day life. Autonomy of the device is achieved through the employment of a unique system which takes input from muscular contradiction with the assistance of sensors embedded within the hand to produce the grip strength and also the ability to lift object and supply good quality of the grip.**

I. INTRODUCTION

The purpose of this project is to build 3D printed multifunctional arm which can be controlled by an EMG signal from the forearm. For an amputee, upper limbs loss has many different consequences not only in terms of physically but also socially, economically and psychologically. The device aims to help the patients who have lost their hand due to accidents, diseases or birth defects with daily activities [1]. The device will be attached to the patient's forearm to replace the lost hand.

Nowadays, several commercial prosthetics devices are available. These devices range varies from passive cosmetic hands to body harness power split-hooks, myoelectric hooks and hands. Despite all the different in their mechanical designs, control signal types and power sources, most of them are extremely expensive at thousands of Rupees. Even cosmoses, artificial limbs made only for aesthetics, although less expensive, are still expensive. Therefore, only very few amputees own a replacement for their limbs not only because there are price, but also due to distribution and maintenance problems. Hence, one of the main purposes of this project is to develop a low-cost 3D printed artificial hand for patients.

Prototype of this artificial arm was created which has basic hand functionality. These artificial arm have integrated DC and PWM motors, force sensors and myoelectric sensors. Three electrodes read the EMG signal will be attached in forearm to control the hand [1]. There are three separate DC motors to control fingers and one servo motor to control the rotation of the wrist. With help of myoelectric sensor, motor driver IC, Arduino we will be able to estimate pressure that the prosthetic grip applies on the holding object. There will be a feedback loop for continues process. The final outcome is a complete artificial arm that met the initial design requirements and can perform basic hand functionality.

II. METHEDOLOGY

A. System Design

This project describes a muscle-based control that releases a user of artificial hands from the continuous attention usually required in opening and closing actions of fingers. Autonomy of the device is achieved through the use of a unique control system which takes input from muscle contraction with the help of sensors embedded in the hand to provide grip strength and the ability to lift any intended object and provide good quality of grip.

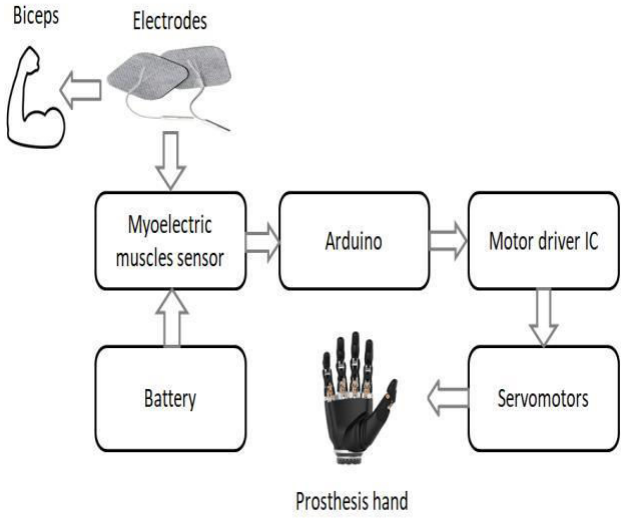

Fig. 1. Block Diagram of System

The bionic arm will consist of servo motors which help for the movement of fingers of the amputee. With the help of servos the gripping action can be controlled. The EMG muscle sensor consists of electrodes which are attached to the muscle site of the amputee. The signals generated by the contraction of the muscles are being read by the electrodes and are passed on to the EMG muscle sensor. The signals generated inside the human body are just a few millivolts which are not sufficient to drive the required conditions so there is a need to intensify these signals. The EMG muscle sensor is utilized for this reason; it enhances the signals which are nourished to them by the electrodes [3]. This enhanced signal is then sent to the Arduino board. EMG sensors are often the best choice because they are convenient and usually require less training. A threshold value is calibrated which can be used to decide the holding and relax action of the prosthetic arm. An analog input from the muscles which is read by sensor and the sensor compares this value against the threshold value which has been set before. When the sensor value is in particular range of value then accordingly operation are performed. The program is allowed to stay in loop as long as an input signal is get by the muscles.

B. 3D Printing

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced cross-section of the object. 3D printing is the opposite of subtractive manufacturing which is cutting out or hollowing out a piece of metal or plastic with for instance a milling machine. 3D printing enables you to produce complex shapes using less material than traditional manufacturing methods.

There are many different software tools available for 3D printing from industrial grade to open source. One of them is Tinkercad it is free and works in browser we don't have to install it on our computer. Tinkercad offers beginner lessons and has a built-in feature to export model as a printable file e.g .STL or .OBJ. Once we have a printable file, the next step is to prepare it for 3D printer, this process is called slicing. Slicing basically means slicing up a 3D model into hundreds or thousands of layers and is done with slicing software. When file is sliced, it is ready for 3D printer. Feeding the file to printer can be done via USB, SD or Wi-Fi. This sliced file is now ready to be 3D printed layer by layer [4].

There are many different type of filament used for 3D printing some of them are Engineering PLA, ABS filament , PETG filament , NYLON , a carbon fibre filament composite, PVA, HIPS , Flexible filament (TPU) and Polypropylene. The best 3D printer filament for any project is highly dependent on what the application is because each 3D printing material has its own advantages and disadvantages [7]. In this project we could use PLA or a si or ABS. After considering specific requirement and budget for our project we decided to used ABS plastic which is strong and resists heat well also it is durable. ABS has got a high heat resistant property which is useful for functional prototypes and ABS models do not scratch easily and can last long if stored properly.

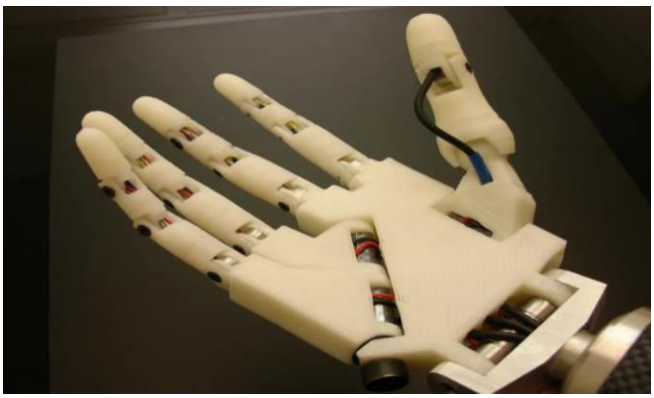

Fig. 2. 3D printed prosthetic hand[5]

Over the past couple of years developing 3D printed bionic limbs has become quite popular. InMoov is an independently run project developing a life like humanoid robot from 3D printing technology. The entire project is open source and provides great mechanical design insight into producing 3D printed robotic body parts. The open source nature of this project allows the public to access computer aided designs and follow step by step guides on how to 3D print and assemble this system [2][5].

III. FLOWCHART

The diagram depicts the flowchart of our project. Initially variables are defined for controlling the motors input and output. The threshold ranges are selected which can be used to decide the particular operation/movements of the artificial arm. The sensor output value is given to Arduino as input. This input value will be compared with threshold ranges set and output operation will be decided accordingly. The program is allowed to stay in loop as long as an input signal is generated by the muscles.

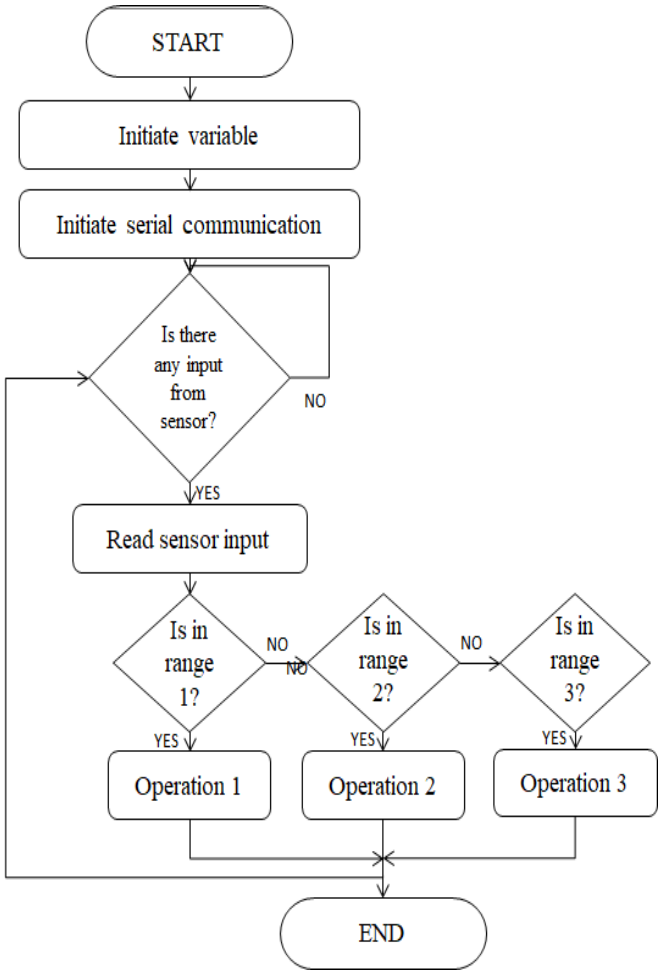

Fig. 3. Flowchart of System

IV. IMPLEMENTATION AND RESULT

At first we have implemented a circuit for interface of body muscles, electrodes and muscle sensor with Arduino. Tested and analyze the signal collected through electrodes which helps us to decide the ranges for threshold. Then we carried out our next task by testing servos. While observing rotation of servos we discover that because of angular

rotation of our servos fingers are not able to move completely. Hence, we have modified our servos to rotate continuously [1].

Afterwards, we will be printing our artificial hand using 3D printing technology. Then we will assemble our whole prototype together to obtain end result of project. Therefore, we will be able to acquire our intended result which is to make 3D printed multifunctional arm for basic operation of hand which will be helpful for amputees.

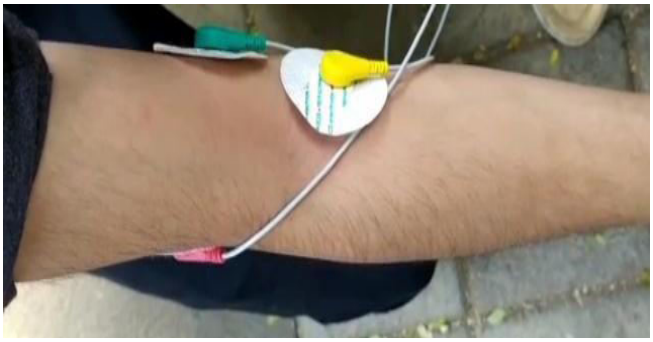

Fig. 4. Electrodes Attached to Body Surface

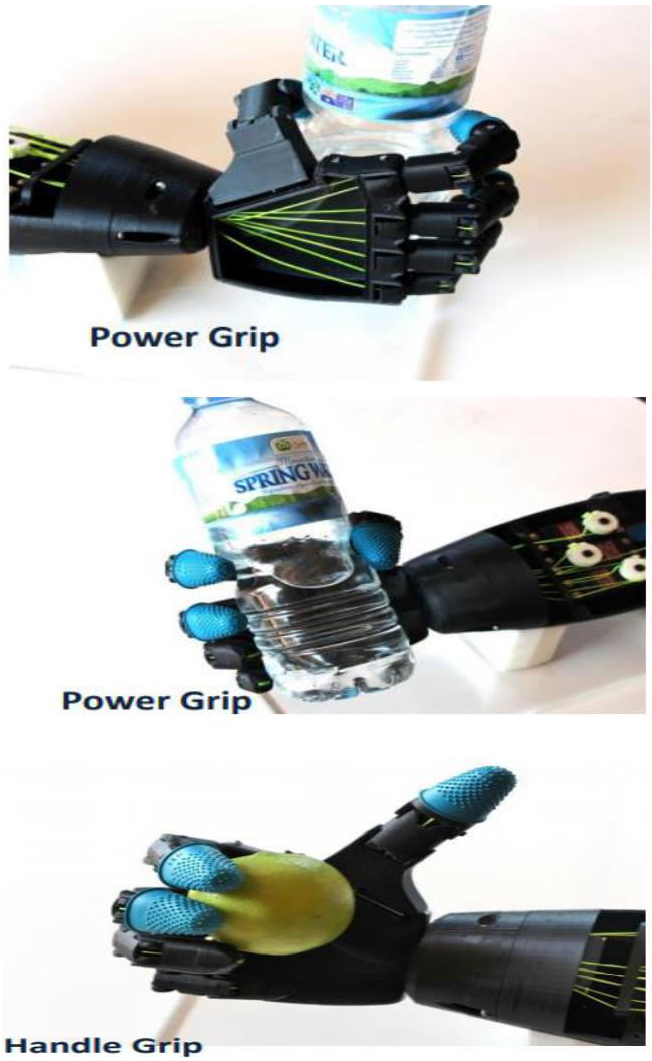

Fig. 5. 3D Printed Multifunctional Arm [6].

3D PRINTED MULTIFUNCTIONAL ARM

V. FUTURE SCOPE

Although this project is complete it can be improvise/optimize. And surely, it has a lot of aspects to be upgraded, but the most important are [2]:

- Adding pressure sensor to control the force of the grab when there is some object.
- Improve the design of the forearm pieces in order to achieve a more natural and real shape.
- Try to add more servos to be able to move each finger with independence.
- Continuous improvements of the program and the signal reading.

VI. CONCLUSION

We are able to acquired EMG signals of finger gripping movements by placing surface electrodes at specific site on wrist. This was done by a myoelectric sensor which also helps in amplification and filtering of the acquired raw EMG signals. Then, we designed 3D printed arm prototype which can make different movements of fingers through DC gear motors. Different finger movements are controlled and driven using microcontroller Arduino uno and motor driver IC L293D respectively. All these processes are done on the bases of acquired and filtered EMG signals of an amputee from electrodes. Hence, one can see a better future for amputees by installing this type of myoelectric arm which is comparatively affordable in price into their handicapped area.

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