MYOELECTRIC ARM – FOR THE HALF LIMB AMPUTEE

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Abstract

As the technology around us is attaining a fast pace, we are working towards extending this fast growing technology to help people with half amputation by attempting to make a prototype which will enable the amputees to lead a normal life. Myoelectric Arm is a prosthetic aid which will help the amputee in grasping objects.

A prosthetic is an artificial part of the functional human body which is life less and does not support any mechanical movement. This device will bring this prosthetic into function by using myo-electrical energy as the source. This is done primarily by attaching the servo motor to the prosthetic, and then servo is initiated by the patient's own muscle contractions or by the muscle twitch. The biggest challenge is myo-electric signals. The electric current generated by these muscle contractions is then amplified by means of an E-shield which can support an Arduino microcontroller and with the help of supporting and storage batteries to control the terminal device. Such an arrangement is referred to as a myoelectrical control system.

The main objective of the project is to make a cost effective, sophisticated, miniaturized and an appealing prototype of a myo-electric arm with long duration of time and battery life, which enables amputees to feel completed and use both their limbs normally as they did earlier.

Keywords: *Myoelectric, arduino, servomotor.*

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1. INTRODUCTION

In this technological era where everyone are very much adapted to gadgets and vehicles. People are neglecting the need for safety while seeking thrill and enjoyment which ultimately results in loss of limbs. Coming on to the life of people, as it is improving they are becoming more and more lazy and prone to various health risks like diabetes, cancer, infection, nerve injury (trophic ulceration) etc., ultimately effecting their limbs which need to be amputed to save their lives. The main cause of amputation in developing countries is trauma which usually occurs as a result of motor vehicle accidents, bomb blasts etc. The main causes of upper extremity amputation in percentages are listed in Table1 [7].

Table 1: Causes of amputation in percentages.

Congenital	8.9%
Tumor	8.2%
Disease	5.8%
Trauma	77%

Because of these factors these factors nearly 3 million people are getting amputated every year world-wide and every week about 2,996 people are losing a limb[10] and the most common is partial arm amputation and the next common is one arm amputation. This results in the restriction of working and grasping objects and loss of self-confidence of amputees. They often face overwhelming feeling of losing control and of being dependent due to lack of a functional limb. To overcome all these kind of negative feelings and to make them feel independent and self-confident a myo-electric Arm is developed for the half limb arm amputees, which would help them in restoring few functional movements unlike the life less prosthetics. The main objective is to make a cost effective prototype of a myo-electric arm, which enables the amputee to feel complete and use both their limbs normally as they did earlier. The various steps involved are as follows:

- Designing a mechanical prosthetic arm.
- Making an optimized program in order to initiate the servo motor by the myo signals using the Arduino Duemilanove board and e-health shield over it.
- Collaborating signals and the motor with the least power consumption.
- Testing for the results.

The estimated incidences of arm amputations by different levels are listed percentage vice in Table 2.

Table 2: Different levels of amputations done

Group	Percentage
Below elbow	57
Above elbow and disarticulation	25
Shoulder	8
Hand / Wrist	10

Thus a prosthetic arm can be developed which everyone irrespective of the class and age can afford and use it. And also concentrate on the below elbow amputees since their percentile is more compared to other type of amputees as shown in Table.2. This device helps the amputees gain back lost hope and provide support for the patient.

2. BACKGROUND

The arm amputees were overwhelmed by the introduction of arm prosthetics into the market, the acceptance of these prosthetics have been increased drastically as they felt confident by gaining a replacement for their lost arm. The mental status of the amputees who felt self-pity and who have gone into depression have been feeling better. So this positive result leads to the advancement in the prosthetics.
Initially, the prosthetics were heavy and made of metals which were used to continue in the war that would be provided with a hook to attach the armor shield. Then they were made light in weight for ordinary people using the combination of different materials like metal, wood and leather.

There is a critical problem which the amputees encountered after the replacement with the prosthetics i.e., the functionality. All the above prosthetics are just for the psychological support of the amputees. To overcome this problem, by using the technological advancements the body controlled prosthetics have been developed. The body controlled prostheses are powered and controlled by gross movements of shoulders and upper chest by using a harness that fastens around the user's shoulders or upper body which is attached to a cable that is connected to terminal device [5]. A shoulder harness with a strap buttoned to the trouser passed through a loop to the contra lateral axial and missing limb, with the body movements like shrugging the shoulders will allow the amputee to manipulate the strap tension to open and close a double spring hook, or flex and extend the thumb on a simple prosthetic hand to provide a simple pinch grasp for holding objects. The downside of these types of prostheses is that they require harnessing and straps to work and other part of the body parts are used to activate the grip [3]. The great drawback was the non human looking prosthetics limited the amputees to move in social meetings and events. For example, a split hook hand is easier for the wearer to manipulate but it would not be real looking. They were also noisy, stiff, dirty, and difficult to control [6].

3. MYO-ELECTRIC ARM

The modern externally powered prostheses are more advanced than body-powered prostheses as they have greater grip and contain a power source as a battery with small electric motors that operate the prosthesis [3]. To overcome the drawbacks of the previous systems we introduce the "Myo-electric Arm –For Half Limb Amputee". The main idea of the paper is to acquire the biological functions with the help of electrical signals which would help the amputee live a normal life and perform their mundane activities in more optimized way.

A Myo-electric Arm is a powered artificial arm that detects the electrical changes in the muscle of the amputee's stump and converts into digital signals and they are used to trigger the micro controller which controls the end actuators which activates the prosthetic to achieve the required functionality.

The myo-electrical system comprises the following components which are chosen as the best components while considering the drawbacks of the existing systems and to achieve the target.

The following are the list of components:

- Articulating arm.
- Micro controller Arduino Duemilanova.
- E-Health shield.
- Software.
- Actuator.
- Myo signals.
- Power supply.

3.1 Prosthetic Arm

A body-powered prosthetic arm as shown in Fig.1 which works with a pulley mechanism after making few alterations is used for the prosthetic arm in best way to bring it back to life so that it could perform the biological functions.

Fig.1. Body powered prosthetic arm

Fig.2. Prosthetic arm after alteration

3.2 Actuator

Here the actuator is a servo motor which is very small made of polymer to make it light weight about 9gm and has a stall torque of 1.3kg. The servo motor would be placed in the cavity of the prosthetic arm .The prosthetic arm and the servo motor is connected with the help of a shaft. The servo motor is actually an assembly of four things: a normal DC motor, a gear reduction unit, a position sensing device and a control circuit. The DC motor is connected with a gear mechanism which provides feedback to a position sensor which is mostly a potentiometer. It has a revolution cutoff from 90° to 180° and also few servos have 360°. Their rotation is fixed between the fixed angles. It consists of three wires- a black wire connected to ground; a yellow wire connected to control unit and red wire is connected to power supply. It receives a control signal that represents a desired output position of the servo shaft and applies power to its DC motor until its shaft turns to that position. The Servo Motor generally requires DC supply of 4.8V to 6 V [9].

3.3 Myo Signals

The Myo signals (muscle signals) are used as a trigger to the control unit of the Myoelectrical arm. These muscle signals are the residual of the amputee's stump. The central nervous system in the brain generates the action potentials which stimulates a particular function in the body. The action potentials results from the depolarization of the cell membrane. The muscle action potential lasts for 2-3ms. The action potential releases calcium ions that free up the tropomysin and allow the muscle to contract [4]. For example, if a normal person thinks to hold a bottle with his/her arm, then the action potentials stimulate the arm muscles to grasp the bottle. But if amputee things of holding, then action potentials are delivered to the amputed limb and we are picking up these signals that are transmitted down to the stump to trigger the myo-electric arm. These signals are recorded by using Electromyography (EMG).

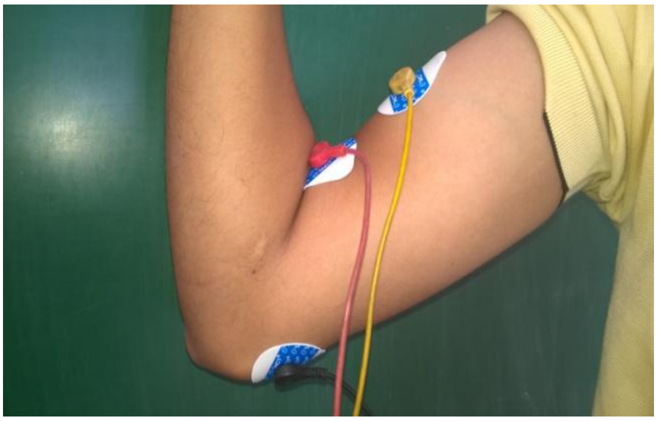

Fig.3. EMG electrodes placement

Electromyography is a technique used to pick up signals produced by the nerves in target skeletal muscles. These signals are captured by electrodes and sensors which make electrical contact with the skin. These electrodes are often times directly connected to the sensor. Two of these electrodes are often placed on the target muscle, while the third is meant to ground the signal and is often attached on or near a bone. For example, to pick up signals from the biceps brachii muscle group, as shown in fig.3 two electrodes would be placed on the upper and lower portions of the muscle, while one electrode is placed near the elbow to ground the electrodes. When action potentials occur in the muscle fibers, the electrodes receive this spiking activity. The EMG is an electrical recording, not mechanical. The strength of muscle contraction corresponds to the size of the signal strength, which in this case corresponds to the amount of voltage output [2]. This voltage output is used to perform the functions of the arm.

3.4 Micro Controller

The microcontroller is the heart of the myo-electric arm. It is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

Arduino duemilanove is a microcontroller board based on the ATmega168 or ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller, simply it is connected to a computer with a USB cable or it can be powered with an AC-to-DC adapter battery to get started.

"Duemilanove" means 2009 in Italian and is named after the year of its release. The Duemilanove is the latest in a series of USB Arduino boards.Arduino Duemilanova is selected because it is inexpensive and less hassle microcontroller. It provides a complete, flexible, easy-to-use software and hardware platform [1] and also supports E-health shield which is sandwiched on arduino duemilanove easily when compared to other Arduino products as shown in fig.4. and used to work with the biological signals.

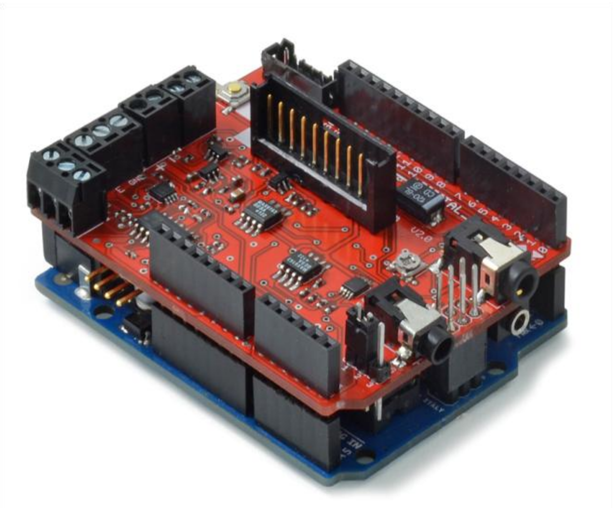

Fig.4. E-health shield on Arduino Duemilanove

3.6 E-Health Shield

The E-health sensor shield allows arduino users to perform biometric and medical applications where body monitoring is needed by using 8 different sensors (see Fig.5.). The sensors supported by E-health shield are SPO2, breathing, body temperature, ECG, GSR sensor, blood pressure sensor, patient position sensor (accelerometer), and EMG sensor.

Fig.5. Applications of E-health shield

The inbuilt EMG sensor from the E-health can sense the impulses from the electrode and be fed to Arduino microcontroller for processing.

3.7 Software

The Arduino Duemilanove can be programmed with the Arduino software."Arduino Diecimila or Duemilanove w/ ATmega168" or "Arduino Duemilanove w/ ATmega328" has to be selected from the Tools > Board menu (according to the microcontroller on your board) E-health library has to be installed into the arduino software to work with biological signals.

4. WORKING

The myo-electric arm consists of small electrical motors at the terminal devices (hand or hook). This terminal device is initiated by the muscle twitch. The muscle twitch is detected by the electrodes placed on the stump as in Fig.3. These signals are acquired by the EMG sensor on the E-health shield and then they are amplified and converted from analog to digital as shown in fig.5. The digital values of the muscle twitch can be observed by a special tool in the arduino software that is serial monitor which are observed in fig.6. The digital values vary depending on the position of the arm and the strength of the twitch.

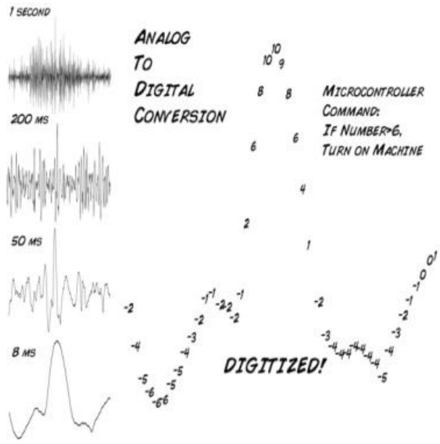

Fig.5. Analog to digital conversion

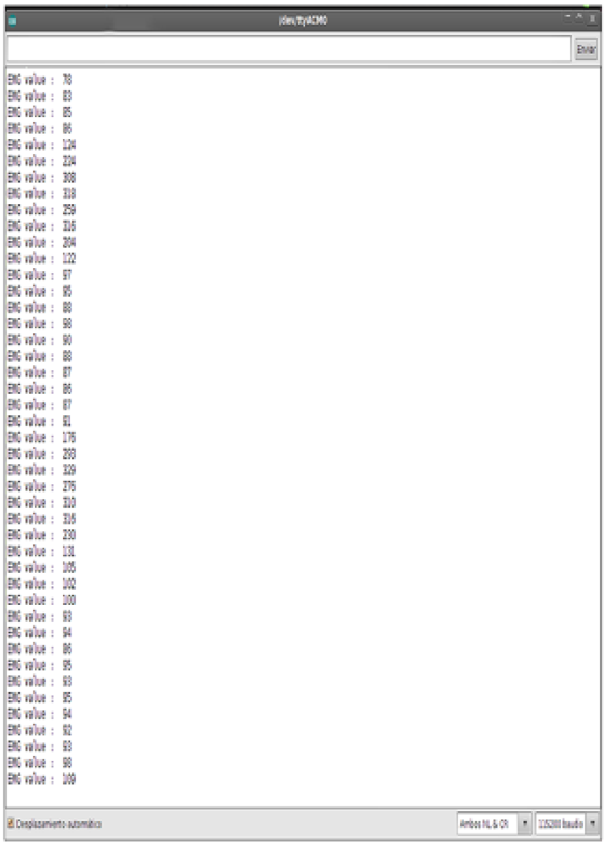

Fig.6. EMG digital values

To acquire these signals we need to write a small program with the header file <ehealth.h> library and by using the statement "EMG=health .getEMG" and "serial.Print(EMG)" by keeping a delay of 100. By using these values we could write another program to activate the servo motor at the terminal point, we require two libraries they are <servo.h> and <ehealth.h> and combine the two programs of the motor and the EMG signals. The final program is verified and uploaded into the arduino duemilanova and executed (see Fig.7. and Fig.8.). Initially the amputee gives a muscle twitch and then when the value reaches the threshold level as mentioned in the program the servo motor gets triggered and as a result the hand opens to hold the things.

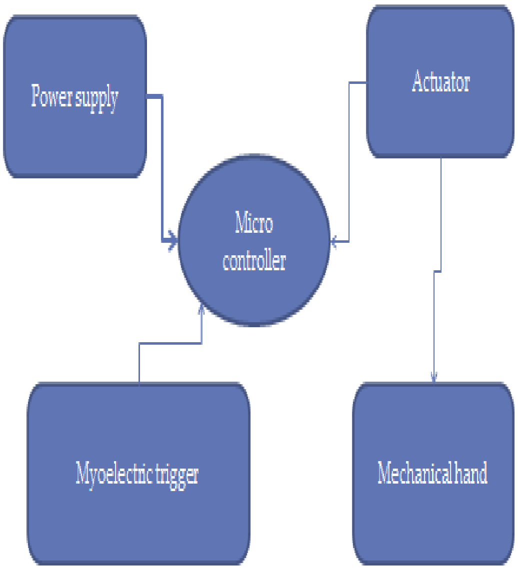

Fig.7. Block diagram

Fig.8. Control unit of the Myo-electric arm

When the amputee triggers the signal the arm opens as shown in Fig.9. as a result of the triggered muscle signal whose value is within the limit of the threshold levels. And when the signal drops down the controller commands the actuator to come back to the rest condition then the closed position of the arm is observed as shown in fig.10. The best part in this is that when the arm is open only then the power is used by the servo or else the servo uses zero power.

5. RESULTS

Fig.9. Open position when triggered by the Myo signal

Fig.10. Close position when in rest position after the trigger is given.

6. CONCLUSION

Developing prostheses, which will duplicate some of the functions of a lost hand and arm, is an enormous challenge. The human hand itself is an extremely complex and challenging terminal device, which moves with a precision and dexterity that has long challenged the minds of researchers in medicine and engineering.

This project is developed keeping in mind of all the amputees irrespective of the age, sex or class. It is purely made to complete the need of the actual arm. It helps them in feeling complete, performs their mundane activities, and is easy to wear. The Servo motors which are now most widely used assemblies in order to grip object and also to work on portable batteries.

The ultimate aim of the project is to help every amputee lead a normal life with this prosthetic arm which is light in weight and also economic. There is an 80% cost reduction compared to the commercially available myo-electric arm which requires surgeries to implant electrodes. This will help in access to the product to a mass population of amputees.

7. FUTURE WORK

This work can be further reviewed and redesigned to use myo-electrical impulses as power source and also to append wrist control, which will help in 2 degrees of freedom as shown in fig.11. This is done primarily by building into the arm prosthesis electrodes that are activated by the patient's own muscle contractions. The electric current generated by these muscle contractions is then amplified by means of electrical components and then stored in batteries to control the wrist movements along with the fingers. Such an arrangement can give even more freedom of movement for the amputees.

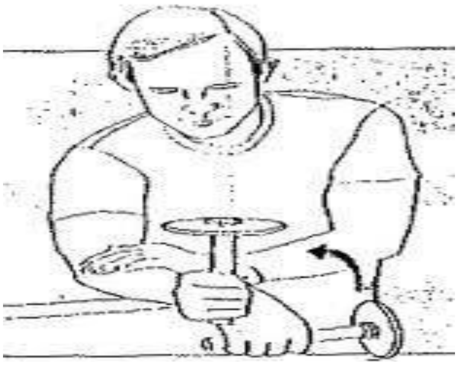

Fig.11. Wrist movements (pronation and supination)

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