

Design and Fabrication of Myoelectric Prosthetic ARM

Arjun K¹, Jishnu M K², Rakesh K K³, Mohamad Rashad⁴, Vinay Krishnan U⁵, Dr.Hema P Menon⁶ and Dr. Davidson Devasia⁷

¹⁻⁵Department of Mechanical Engineering, Sreepathy Institute of Management and Technology, Vavanoor, Palakkad, Kerala
Email: arjunkailas0@gmail.com, jishnukdlr37@gmail.com, rakeshkk115@gmail.com, rashadvkt123@gmail.com, vinaykrishnan@simat.ac.in

⁶Department of Computer Science Engineering, Sreepathy Institute of Management and Technology, Vavanoor, Palakkad, Kerala

Email: hemapmenon@simat.ac.in

⁷Dept of Neurology, Aster Medcity, Kochi, Kerala

Email: davidson.devasia@asterhospital.com

Abstract—Myoelectric prosthetic arm design which can be 3D printed is presented. The limb's motion will be actuated and controlled by using muscle contraction of an individual. A fully functioning prosthetic arm will have the ability to grip, grasp, perform precise movements with limited time lag, so as to provide a sense of normal hand. The bionic arm is invented in light of “A working arm for those who lose their arm by amputation”. These modes of innovations do not exist although it is not affordable for ordinary individuals and almost not available to people in developing nations.. Rapid growth and advancement of the 3D printing industry made it much more accessible due to the availability of low cost 3D printers such as XYZprinting da Vinci Mini, lulzBot Mini, RepRap and Fab@Home. The arm is 3D printed, electrically actuated and responds to EMG signals. This study covers a vast range of engineering disciplines. The root cause was identified and implemented a system, an alternative design for a 3D printed artificial arm. Current day circuitry and electronic actuators imitate the device and allow for difficult controls and movements.

Index Terms—3D printing, Prosthetic arm, Myoelectric, EMG signal, Bionic, electrode, sensing, grasping.

I. INTRODUCTION

The most valuable part of every human is their body. Missing a human part, mainly a human limb, is very difficult to live in our society. To produce a functional artificial arm there are many challenges to overcome in its design. The major challenge is to make an artificial arm with reasonable price and good quality. The difficulty of the mechanical and electrical systems find how well the device replaces the human hand and the agility it can give. The design will point to being as physically advanced and diverse as possible. The major aim is to design a 3D printed artificial arm. The user is able to control the arm by the help of electrodes which are placed on the skin. Given figure 1 is a prosthetic arm that has been 3D printed, provides 6 degrees of freedom.

II. BACKGROUND STUDY

Worldwide, there are about 57.7 million people who have faced amputation due to traumatic incidents. Of these

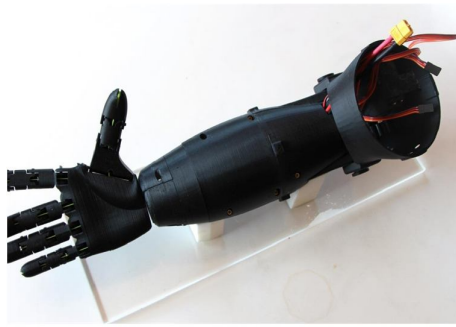


Fig1:: Final 3D printed prosthetic arm
PC: "3D Printed Myoelectric Prosthetic Arm" [1]

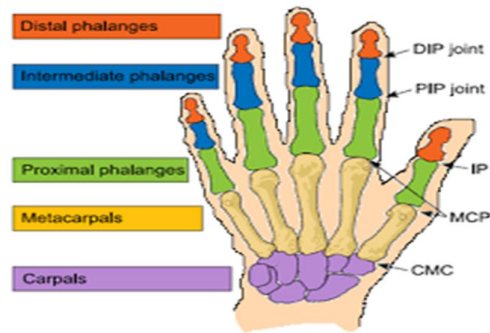


Fig2:Major Bones in a Human hand PC:"Dexmart"[8]

15.7% are due to accidental injuries and approximately 30% from this had to face hand amputation. This is a tragic figure; Prosthetic arm gives a solution for it.

Currently, in the market, there are different kinds of prosthetic arms such as Passive prosthetics, Body Powered prosthetics, and Hybrid prosthetics. ABB Ltd and KUKA are the leading manufacturers. Even though fully functioning prosthetic arms are not much affordable for ordinary people[18].

According to the data obtained from [8-10] Human hand consists of a minimum 25 bones, above 30 muscles and more than 100 ligaments, nerves and arteries. Human finger has about four degrees of freedom. From these three are rotations of each joint. Thumb produces three degrees of freedom. All together the arm produces 23 degrees of freedom. No Current prosthetics can match the flexibility maneuverability and fluidity of a human hand[7]. The figure shows the major bones in human hand

Based on the controlling method of the arm, there are different kinds of prosthetic devices available in our market.

Passive prosthetics are made in order to restore the cosmetic appearance and to maintain the proper functionality. These kinds are simple and non-moving. When coming to history, Prosthetic toes can be found on Egyptian Mummies [18]. A simple wooden pirate leg is an example of these kinds of artificial limbs.

Mechanical body control prosthetics are controlled with the aid of a harness connected to the user's body. These kinds look like simple devices like a mechanical hook which is connected to elbow/shoulder motions. These kinds of artificial arms are most used nowadays.

Myoelectric controlled prostheses analyse the EMG signals received by the contraction of muscles near the amputee's remaining limb part. Electrodes which are placed on the surface of the skin or connected directly will measure the signal which is received. Then the signal will amplify and will redirect to the microcontrollers. Microcontroller analyses it and controls the internal actuators which are connected. These kinds of artificial arms are more efficient than mechanical devices. Solomon Pereira et.al provided the automated motion in his thesis [20]. The figure shows a be-bionic arm, a fully functioning prosthetic arm that provides 21 ways of motion [11]. The figure 3 shows a be-bionic prosthetic arm.



Fig3: Be-bionic prosthetic arm used for typing



Fig4: a paraplegic woman guiding a prosthetic arm using her thoughts
PC: 3D Printed Myoelectric prosthetic Arm[1]

Direct brain interfacing is used where the most cutting-edge mode of controlling is used. by means of surgery, an array of electrodes are placed on the brain surface that is connected to pedestals installed into the person's skull. When the individual thinks to move, motion signals can be detected on the pedestals installed. This will enable the controlled movement of the robotic arm. This mode of innovation is still in its beginning face. Although it has been established on disabled persons for controlling movements using bionic instruments with their thought alone, which has been proposed by Howdia et.al[4] in her paper presented in Nov 2013. The figure shows a paraplegic woman using her thoughts to guide a robotic arm[1]. The figure 4 shows a direct brain interference

III. FINDINGS AND OBSERVATIONS

Based on the study conducted it can infer that the utilising technology here is much easier to analyse and also reliable to perform. because here we use EMG signals to perform the movement of the arm. EMG signals are less complicated while compared to brain surgical means.

In our market there are several kinds of prosthetic arms available. In these a fully functioning prosthetic arm has minimum of 2.5lac price. when we compare this with our prosthetic arm we could make approximately 5 pieces of fully functioning arm.

IV. DESIGN AND FABRICATION

Signals obtained due to the electrical pulses produced by the contraction of muscles are known as Myoelectric Signals. The electrodes placed on the surface of the skin detect these signals and can be used to control prosthetics. This study was out taken from Cotton et.al [4]

Target Muscle Reinnervation (TMR) is a surgical procedure, taken from Brooker and Graham[5] which takes nerves at the end that residue after amputation and widens them all over the alternative impact muscle array. Which Helped in solving the problem of cross talk between muscle signals.

According to the study proposed by Mane et.al [12] In order to reduce the complexity, expenses and to achieve higher performance Single channel sEMG analysis is more suggested than multi-channel. For better classification and analysing the sEMG Signals aids of Wavelet transformation and artificial neural network (ANN) can be used.

Sudarsan and Dr.chandrasekaran [13] provided advantages of using EMG signals in their paper, i.e; the signals acquired from the patient's body after suitable processing, is used as control input to drive the servos to provide movements to the prosthetic arm.

The main advantage of 3D printing technology is Unlike the subtractive process of manufacturing, 3D printing manufacturing creates its final design by cutting from a large material. Thus it can reduce material wastage and can reduce the cost of production. Moreover, 3D printing is easily customizable. The journal[1,17,21] provides structural support for the following statements.

Mahdi [1] Discusses development of 3D printed prosthetic arm. He successfully implemented and developed a functioning prosthetic arm at an affordable rate using ABS plastic. Later he discussed the wear ability that occurred during testing which should have been replaced with the nylon filament.

Nylon can be used effectively in recycling processes due to its biodegradability property. It can also be used as filaments in various extrusion process with different kind of dimension [14]

A set of dynamic stimulation has been performed by Rostro-Gonzalez [15] to identify the functionality of the prototype which is made with the aid of 3D printing technology and to reduce the cost of actuators.

An anthropomorphic robotic hand is the most appropriate method to identify the shape of an object and the most relevant method for grabbing an object was designed by Sean Casley.

In order to make our arm we have to consider different aspects like receiving signals, analysing it, converting these into mechanical signals and performing it. For these we need different kinds of materials. they are:

Servo motors can be used widely on the control system in order to acquire proper motion more accurately and precisely. Thus it can be used for the motion of fingers and palm.

According to Nakshtra Popli[16], Lithium ion batteries provide a long time working when it is fully recharged. It can be fully worked up to 12 hours after fully recharging.

To provide a proper prosthesis it is needed to receive EMG signals and properly process it to control and actuate servos. The EMG sensor kit has electrodes, which collect data for further processing. Arduino EMG sensor kits provide much better data.

As per the study proposed by Dr Scott Day[6] The EMG electrode needs a clean and good connection to the user's skin to surface, because the sweating makes a displacement in the electrodes.

Based on the survey the author proposed designs are shown in figure. Figure 5 shows the final design of the 3D printed prosthetic arm consisting of 35 individual parts using nylon filament. Figure 6 shows the hand drawing model of the hand. Table 1 shows the materials used for designing and development for 3D printed prosthetic arm.

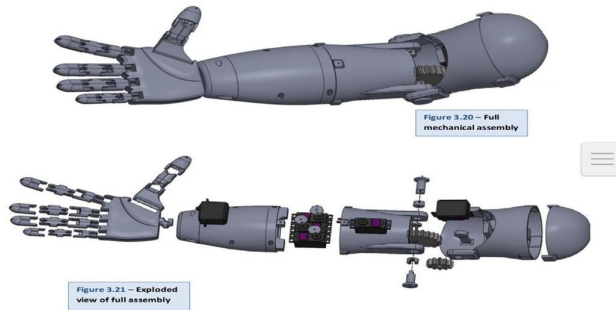


Fig:5 The final design consists of 35 individual 3D printed components printed in Nylon filament

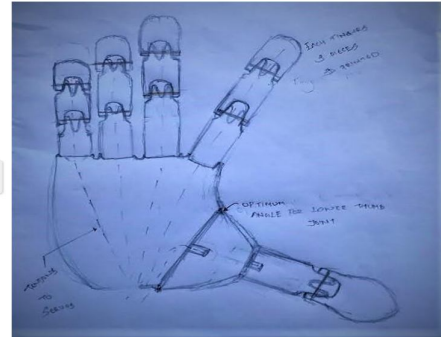


Fig:6 Hand sketch of hand model

TABLE: I MATERIALS USED FOR DESIGN AND DEVELOPMENT OF PROSTHETIC ARM

SYSTEM PROPERTIES	DESCRIPTION
Materials	Nylon Filament
Tendons	Dacron Braid
Power Source	2-Cell 7.4V Lithium polymer rechargeable battery
Microcontroller	PIC16F877A
EMG Sensors	ARDUINO EMG Muscle Sensor kit
Servo Voltage Regulators	AP1117 – 5V output, maximum current 1A
Programmable PCB	Arduino Mega 2560 Rev. 3 Board
Servo Motors	TOWERPRO MG996R
Programmer	PICkit3 programming device

The arm will be made by 3D printing with Nylon filament. The signals from muscle contraction is captured using EMG Sensor Kit. The battery for power storage will be of Lithium Ion battery. The rotary motion will be possible by using servo motors (TOWERPRO MG996R) and Dacron Braid. Microcontrollers (PIC16F877A) and actuators help to control and convert the electrical signals into mechanical functions. In Order to read and write EMG signals into Mechanical signals there will be an programmable Printed Circuit board (Aurdino type).

V. CONCLUSION

Losing an arm by an accident or by birth creates a negative change in a person's outlook. It creates a difference from others which affects mentally and physically to an individual. A difference from one individual to another causes a negative body image Which results in their skills, confidence and motivation .

Myoelectric Prosthetic arm proposes a replacement for an amputee which works by analysing the EMG signals which are received by the muscle contraction. The arm is made by 3D printing with nylon filament. By this it can provide almost accurate replacement of the amputated arm.

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