Design And Development Of Prosthestic Limbs

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Abstract - *The arm is electronically actuated and controlled by using user muscles. The bionic arm used by a person who born without a limb. Also, we can control this arm by a mobile Application and can save different gestures in it according to need. This type of technologies or product made by using this technology is very expensive and generally not available in developing countries.*

Rapid growth and advancement of industry allows to become a scale manufactures. Some mechanical devices are less complex than myoelectric device. Its limitation has to growth and development in the field will leads to improve over time. This thesis covers a broad range of engineering disciplines. Nowadays, electronic actuators and circuit will animate the device and allow for sophisticated control schemes.

Key Words: bionic arm, gesture, myoelectric device

1.INTRODUCTION

The most valuable thing to any human being is their body. Replacing a mssing human limb, especially a hand which makes one truly appreciate complexity of human body. Prosthetic device have been discovered from ancient civilizations aroung the world which demonstrate the process of prosthetic technology.

The innovation of the wooden leg in ancient time, that was the example of prosthetic device. As time change, designs and material for prosthetic was also improved and started with hinges and pulley systems. As we move further we use the hooks which can open and close the bends of their elbow.

In this century we use the myelectriv prosthetic arm. It's aimed to design the function of human arm as possible and can controlled to some muscular construction.

1.1 Purpose Of Prosthetic

Sometimes it is also known as "Artificial Limb". If any human-being missing his/her leg or arm, or any organ of body which will help you to perform your daily activities such as walking, eating, dressing, handshaking, etc.

1.2 Types of Prosthetic Arm

Generally, there are several categories of prosthetic devices.

1. Passive Prosthetic: The Prosthetic toes have been found attached to ancient Egyptian mummy's. Passive Prosthesis are simple, non-moving devices that aim to restore the cosmetics appearance and basic functionally to amputee. A wooden leg is the example of a passive prosthetic.

2. Body controlled prosthetic: Body power prosthetic can be controlled via ring harness connected to the user. A simple mechanical device known as hook which is linked to the movement of elbow or shoulder. At a time, this device is most popularly and easy to use. This type of devices is very cheaply.

3. Myelectric controlled prosthetic: It measure the electro- myography signals from the contraction of muscles. These signals are measured through electrodes placed on the surface of skin and connected directly to the muscles. These signals are amplified and send to the microcontroller, which gives the information of internal actuators. Nowadays, myoelectric devices are used to control the mechanical devices.

4. Brain controlled interface: Brain-Controlled Interface: The brain-controlled interface integrates electroencephalography (EEG) for recording brain activity and transcranial magnetic stimulation (TMS) for delivering information to the brain. This interface enables humans to engage in brain-to-brain communication, allowing them to solve tasks using their brain signals. Through these communication channels, we can assess the performance of Brain-Net and evaluate its effectiveness in various situations. This form of control is commonly referred to as a direct neural interface or brain-computer interface (BCI).

2. METHODOLOGY

2.1 Ideation/Concept

Our motive is to design a prosthetics arm. Recently, Human Machine Interface (HMI) has become an important part of many technology such as a different bio-signals such as EOG, EMG, and EEG can be deployed to develop a closed-loop control system for physically disabled and elderly people to improve their quality of life. On the other hand, as the road and industrial accidents are increasing in countries, more and more peoples are losing their body parts and are not able to treat their conditions properly due to the financial burden and lack in technology advancement.

We will try to design, implement and test a low cost EMG recording and monitoring system that can detect and process EMG signals from different kinds of muscle contraction. The record signals will interface with the computer through Arduino and then the EMG signals will be analyze at MATLAB platform. We will also develop an algorithm to detect muscle contraction and expansion from raw EMG recordings and then convert it into command signals that will control a robotic arm. Which can be used for those disabled persons who lost their arm. For, Prosthetics arm tactile sensor is also used. This sensor will be used to detect force applied on object and motion of hand is controlled to hold delicate things

In this prosthetics arm, the actuation of finger is done by using the servo motors. There are three types of methods which used for fingers actuation.

- Fingeroperatedwithindividualmotoratelverypoint.
- Closing action of figure is controlled by only one motor using tendon and the return action is controlled by spring.
- Opening and closing both action is controlled by tendon and single motor by using two tendons.

2.2 Mechanism of Actuation of Fingers

There are three mechanism of finger actuation.

1. Finger operated with individual motor at every joint. This require around 23 motors and has to be controlled.
2. Closing action of finger is controlled by only one motor using one tendon and the return action is controlled by spring.
3. Opening and closing both action is controlled by tendon and single motor using two tendons (closing and opening of finger is controlled by clockwise and anticlockwise motion of motor respectively).

2.3 Degrees of Freedom

The which we are going to develop will have 6 to 7 degrees of freedom. For each finger there will be one degree of freedom and, one degree of freedom will be rotation of palm.

2.4 3D Printing

The methodology used in this research was to gather information on the present and future advantages of 3D printing in the medical industry. Currently, 3D Printers are used in a variety of applications throughout the medical industry. The most common uses involve printing dental devices and implants, models of individuals' bodies for pre-surgery practice, and "replacement body parts" (such as prosthetics or replacement segments of bones).

The 3D printers in medical fields, also known as Bio-printers, print cells usually in a liquid or gel. The purpose of these bio-printers is to assemble living tissue. Researchers have been working to create cells layer by layer through a print-head without killing them. In the future, they will be able to make cartilage, bone, skin, blood vessels, small bits of liver, and other tissues by using bio-printers.

2.5 Electrical Design

1. Signal Flow Overview: The signal flow in the system starts with a user flexing, which generates an analog signal. This analog signal is then amplified, rectified, and smoothed by the EMG (Electromyography) sensor board. The microcontroller in the system utilizes this analog signal to generate a pulse width modulated (PWM) signal. The PWM signal is then used to drive servo motors, which in turn tension the tendons responsible for curling up the fingers.
2. Actuation: The actuators employed in this system are standard servo motors capable of rotating to angular positions up to ±90 degrees from their resting position. The precision of each servo motor's angular movement influences the accuracy with which the fingers can be controlled, considering the relatively small movements of the artificial tendons required to open and close each finger.
3. Microprocessor: The central computing component in this system is an 8-bit microprocessor, such as Arduino, which utilizes either the Atmega328 or Atmega2560 microcontroller. It possesses 32 kilobytes of memory and operates at a clock speed of 16 MHz. The microprocessor can be programmed using the Arduino IDE (Integrated Development Environment) on a standard Windows computer through a USB cable.

4. Voltage Regulators: Power Voltage Regulators: In order to regulate the voltage and power supplied to the servos and microcontroller, power regulators are implemented. These regulators serve the purpose of preventing situations where a servo could draw excessive current from the battery, potentially leading to stalling and causing damage to the electronics or even posing a fire hazard.

5. To fulfill this requirement, 5V surface mount regulators have been employed to supply power to the servos, while a 3.3V regulator is used specifically for powering the microcontroller. The selected regulators have a maximum output current of 1A.

   Considering that each servo typically requires access to a minimum of 500mA of current to operate, it is assumed that each 1A power regulator can effectively supply power to two servos. These regulators are designed to maintain a stable output voltage of 5V. However, it is worth noting that operating the servos at 5V instead of the ideal 6.5V may result in slightly reduced performance in terms of speed and torque..

6. Electromyography Sensing: Electromyography Sensing: The system incorporates user-friendly single-channel EMG sensor boards for the purpose of sensing and measuring muscle activity. These sensor boards are equipped with a small printed circuit board (PCB) and three surface electrodes. Two of the electrodes are utilized to measure the voltage potential across a muscle, while the third electrode serves as a ground reference point and is placed on a bony feature.

   The EMG sensor kit is specifically designed to be seamlessly integrated with a microcontroller. It employs an internal amplification system that effectively converts tiny electrical pulses into a rectified and smoothed signal. This signal can then be utilized as an input to the analog-to-digital converter of a microcontroller, allowing for further processing and analysis.

7. Tactile Sensor or Force Sensor: The system incorporates a tactile sensor or force sensor, which is utilized for the detection and measurement of the spatial distribution of force applied perpendicular to a predetermined sensory area. This sensor plays a crucial role in interpreting the spatial information related to force. Its primary purpose is to detect the force applied to an object, enabling the control of hand motion for securely grasping delicate items.

8. Power Supply: Ensuring portability and independence from external power sources is vital for this system. While a wall power supply may be suitable for testing and debugging purposes, a prosthetic arm requires a power source that can be easily carried by an amputee. Considering that servo motors consume a significant amount of current during operation, disposable batteries are not a practical solution as they would be drained too quickly, necessitating frequent replacement.

3.DESIGN AND 3D PRINTING

First of all, we started searching for a design which we can copy or from which we can take help of to start designing our own arm which no one can claim for we referred various project and YouTube videos for that some of them are as follows.

1. Thesis of a Student: The very first we refer was the tesis of one final year BE Mechanical student named Mahadi Elsayed Hussein who had also worked in same domain of making EMG contolled prosthetic arm. We learned a lot from this thesis.

2. InMoovHand: InMoov is one open source website which provides all .stl parts to student or researchers who want to do study on prosthetic arm we referred this website also. Final prototype of this is also attached in
   website of this is www.inmoov.fr.

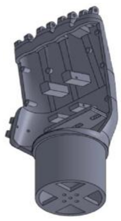
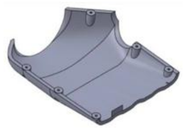
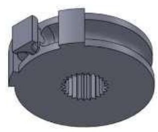
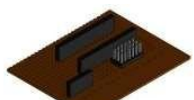
3. DIY Robotic Arm(Will Donaldson): This is YouTube channel who had made a DIY 3D printed robotic arm and he had taken reference from one website is www.instructables.com/id/Robotic-Arm-3D-Printed-DIY-Initial-Prosthetic-Prot. We had referred this prototype also.

4. Adam Jensen Arm by Augmented Future: This is a website where Four companies coming together to bring you the future of prosthetics. OPEN BIONICS, DEUS EX UNIVERSE, RAZER STARGAZER, INTEL REALSENSE from this website we decide to make our design from the pic of Adam Jensen Arm the figure is attached.

3.1 Our Prototype

After studying this we starting we started to make our own design in SolidWorks mostly referring this last image of Adam Jensen Arm with lots of more pics and make our own Design just by visualizing this pictures and referring some other like thesis of Mahdi Elsayed Hussein and InMoov Hand for Dimensions and try to make arm as attractive as Adam Jensen Arm. Below is the list of all component of our Design with Picture of all Parts in Table 3.1

Table -3.1.1: All Components of Prosthetic Arm

ITEM NO.	PART NAME	QTY.	IMAGE
1	Index Finger Bottom	1	
2	Index Finger Middle	1	
3	Index Finger Tip	1	
4	Middle Finger Bottom	1	
5	Middle Finger Middle	1	
6	Middle Finger Tip	1	
7	Pinky Finger Bottom	1	
8	Pinky Finger Middle	1	
9	Pinky Finger Tip	1	
10	Little Finger Bottom	1	
11	Little Finger Middle	1	
12	Little Finger Tip		
13	Thumb Bottom	1	
14	Thumb Middle	1	
15	Thumb Tip	1	
16	Palm		
17	Palm Cover		
18	SG90 - Micro Servo 9g - Tower Pro.1	5	
19	Horn	5	
20	Circuit	1	
21	IS 7485 - M2 x 5 - Z -- 5S	6	

3.2 Complete Design after Assembly

Earlier in Table 3.1, all components are individually shown under this topic like to attach the complete assembly picture of prosthetic are with some special features. The picture of complete assembly is shown in figure 3.2.1.

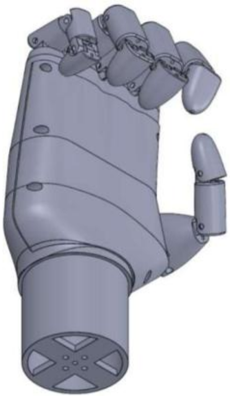


Fig -3.2.1: Complete Assembly

In the figure 3.2.2, the inner view of prosthetic arm is shown how all servo motors and circuit is set in palm is shown for better understanding of scenario.

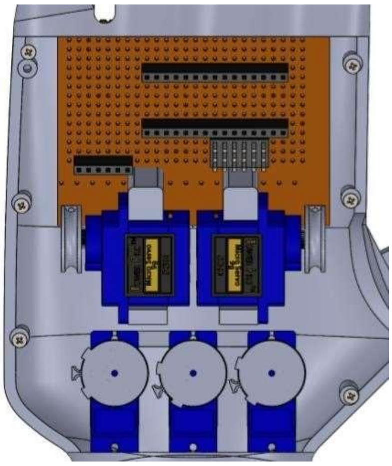


Fig -3.2.2: Innerview of Prosthetic Arm

3.3 Silicing Software and Practical Model

There are lots of slicing software for 3D Printing. For our project we use CURA slicing software via Repetier Host Server.

Repetier-Host is easy to use, even for beginners, but gives you full control of your printer, slicer and printing process if needed. This is the reason why you can print any filament in perfect quality like PLA, ABS, and PETG, chocolate or metal, if your printer hardware supports it.

here, we have put all the data in the Repetier Host and the results are shown in upcoming figures.

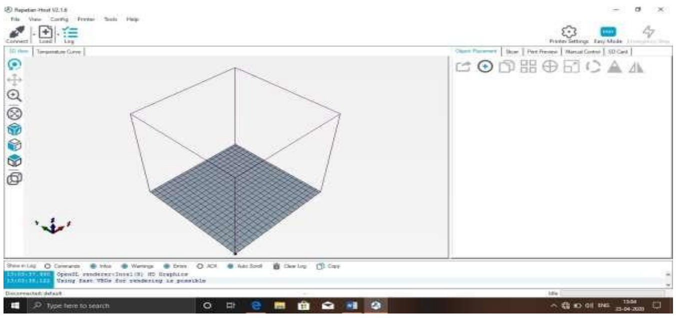


Fig -3.3.1: Interface of Repetier Host

Now, we are inserting some 3D Design as shown in figure 3.3.2.

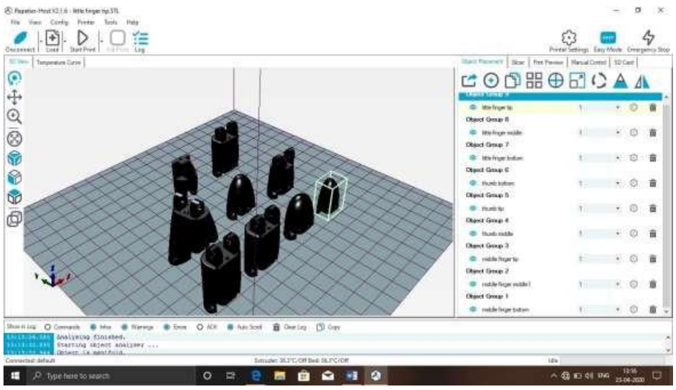


Fig -3.2.2: Some parts of Prosthetic Fingers

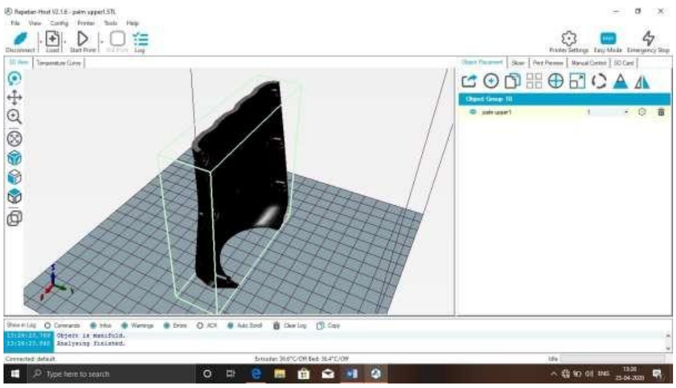


Fig -3.2.3: Upper Portion of Palm

Fig -3.2.4: Analysis of Upper Portion of Palm

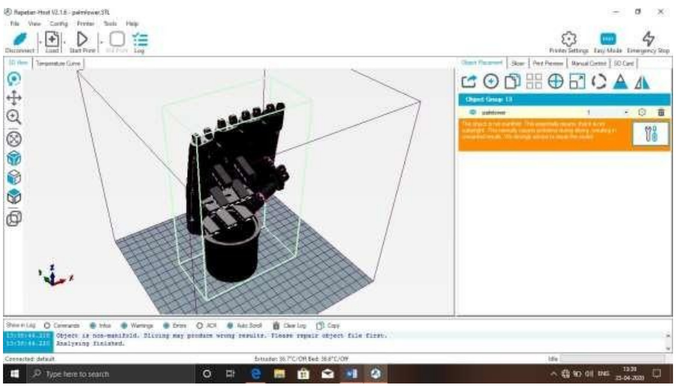


Fig -3.3.5 Lower Portion of Palm

Fig -3.3.6 Analysis of Lower Portion of Palm

3.4 Material

Many different materials can be used for 3D printing, such as ABS plastic, PLA, Polyamide(nylon), glass filled polyamide, stereolithography material (epoxy resins), silver, titaninum, steel, wax, photopolymers and polycarbonate.

Table -3.4.1: Physical Property of PLA + Filament

Extrusion Temperature	205-230 °C
Softening temperature	50 °C
Rockwell hardness	R70-R90
Elongation at failure	3.80%
Flexing strength	55.3 MPa
Tensile breaking strength	57.8 MPa
Modulus of longitudinal elasticity	3.3 GPa
Modulus of elasticity in flexure	2.3 GPa
Glass transition temperature	60-65 °C
Density	1.23-1.25 g/cm^3
Printing accuracy	± 0.1%
Moisture absorption	0.5-50%
Minimum wall thickness	1 mm

Fig -3.4.1 PLA + Filament (white)

4. CONCLUSIONS

In conclusion, the design and development of prosthetic limbs is an important area of research that aims to improve the quality of life for people who have lost a limb. The main aim of this study was to evaluate the current state of prosthetic limb technology and identify areas where further improvements are needed to make them more functional and accessible. The use of advanced materials, sensors, and control systems has enabled the development of prosthetic limbs that can closely mimic the movement of natural limbs. However, there is still a need for further research to improve the integration of prosthetic limbs with the human body and enhance the user's sense of control and feedback. Additionally, the affordability and accessibility of prosthetic devices need to be improved to make them more widely available to those who need them. Overall, continued research in this field has the potential to greatly benefit the lives of millions of people worldwide who have experienced limb loss.

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