A

Project Report on

IOT BASED MYOELECTRIC PROSTHETIC HAND IN BIOMEDICAL USING ADDITIVE MANUFACTURING.

A Dissertation Submitted in fulfilment of the requirement for the product prototyping certificate

Submitted By

1 Sai Teja.G, Computer Science Engineering

2 Rohith, Mechanical Engineering

3 J.Sri Harshavardhan, Electronics and Communication Engineering

4 K.Pavan Kalyan, Mechanical Engineering

Under the esteemed guidance of

INNOVATIO HUB — POWERED BY ENGINEERS

ROBOTICS RESEARCH CENTER

Initiative by

INNOVATIO DROP PVT LTD.

Under the management of Sreyas Institute of engineering and technology

(Affiliated to JNTU Hyderabad)

NEAR INDU ARANYA, BANDLAGUDA, NAGOLE - 500 068.

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CERTIFICATE

This is to certify that the Dissertation entitled **"IOT BASED MYOELECTRIC PROSTHETIC HAND IN BIOMEDICAL USING ADDITIVE MANUFACTURING"** is a bonafide work done by **SAI TEJA G Regd. No:17VE1A0553, ROHITH Regd. No: 13VE1A0327, J.Sri Harshavardhan Regd. No: 18VE1A04D7, K.Pavan Kalyan Regd. No: 13VE1A0346,** in fulfilment of the requirement for the product prototyping certificate, submitted to the Innovatio Hub - Robotics Research center , initiative of Innovatio Drop pvt ltd. under the management of Sreyas Institute of Engineering & Technology, Hyderabad during the period March 16 2019-Dec 27 2019.

Dr. Suresh akella

Principal
Sreyas institute of engineering and technology

Mr N Vinod Kumar Reddy

Co-Founder
Innovatio Drop pvt ltd

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ABSTRACT

The aim of the project is to develop the Prosthetic robotic hand for Amputees (physically handicapped). This project presents the requirements, design criteria and methodology used to develop the design of a new self-contained prosthetic hand to be used by amputees. In medicine, a prosthesis is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or congenital conditions. The prosthetic hand will resemble the human hand in size and shape and must perform like a human hand. The main concept of research is concerned with finding and deriving the equations for each artificial hand's finger to get matching between the human hand's finger angles. The movement of the fingers is achieved using servo motors connected to each finger individually. To get a real feel of a human hand we are using EMG(electromyogram) sensors that use muscles to control the movement of the bionic hand. Finally, we discuss some of the key areas of research that could lead to vast improvements in bionic hand functionality that may one day be able to fully replicate the biological hand or perhaps even surpass its innate capabilities. Our bionic hand has 6 degrees of freedom(DOF). One degree for each finger and one for wrist movement. To rapidly prototype our research we are using 3D printing technology. It is important for the healthcare community to have an understanding of the development of bionic hands as this area of medicine will expand. This device is designed to help those with full or partial hand loss to retain the functionality and appearance of a regular hand. This project has the potential to positively impact people’s lives.

Keywords—Prosthetic Hand, Prosthesis, Amputees, EMG Sensor, Servo motors,3D printing, Bionic, 4 DOF, and the Medical Field.

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PREREQUISITE

When we start the research we get too many questions

- To Choose an interesting and required topic which would put a smile on people's faces...
- Most professional researchers focus on topics they are genuinely interested in studying...
- Do some preliminary research on your general topic...
- Consider your audience...Start asking questions...

So, if the topic is chosen,

Our aim was the solution to the Amputees. The reasons may be individual specific or generalized. We started asking many questions, major were :What kind of technology is being developed today, and how far have the leading industries gotten in creating the new and improved Prosthesis?And how far can we reach them or try for an improved version?There is an overwhelming amount of research and data within the field of medicine and robotics, but how advanced is the field of bionics?Can we make a 3D printed Myoelectric prosthetic hand using an EMG sensor? (etc.)Every new product is lighter and better, and effort is made to make robotics more realistic looking.A natural way of a prosthetic hand, which involves controlling sensors and actuators which could help with issues like power management and mainly cost.?

This Thesis Document tries to answer the previous question in a short and concise way with literary studies, simulation, and testing, with a focus on the human hand. Literary studies to understand why certain choices have been made. Testing to see how closely we can replicate the biology of the human body with 3D printing technology.

Fig 1.1:PREREQUISITE

CHAPTER II
INTRODUCTION

The human hand is able to perform a complex repertoire of sophisticated movements that enables us to interact with our environment and communicate with one another. To perform the day to day actions, body parts such as hands and legs play a vital role. Amputees who don't have the hand or limbs (etc..) find it difficult in their daily routine. The main motto is to make sure that we help amputees to overcome their everyday issues and they move forward with a great smile. As we know Nothing Beats a Great Smile. The solution found for amputees is Prosthesis.

Prosthetic hands are artificial hands for the amputees so that they can perform their day to day tasks efficiently and easily. These are artificial devices designed for people with upper extremity amputations to provide some functions of natural hands. For an amputee, upper limb loss has many different consequences not only in terms of physically but also socially, economically and psychologically. In order to minimize these consequences and assist the amputee to adapt to normal life, artificial hands and wrists are used to perform daily activities such as dressing, writing and grabbing different objects. 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 differences in their mechanical designs, control signal types and power sources, most of them are extremely expensive at thousands of Rupees.

The process of bidirectional transmission of information from a human brain to the hand cannot be fully implemented between amputees and the prosthetic hand. To solve this problem, a lot of scientific teams have created some alternative approaches. Currently, most of the prosthetic hands can be controlled by means of electromyography surface electrodes(EMG).EMG technology allows detecting electrical activity within muscles of the patient's arm, thereby the amputees could grasp and operate everyday objects via prosthetic hand by processing EMG signals from residual muscles. These can perform almost all movements of a real hand, and even give some gestures which humans feel hard to pose. The prosthetic hand is getting close to the real human hand as shown in fig 1.2.

2.1 MOTIVATION

Since childhood, we are very much interested in the field of robotics from seeing movies like Star Wars and Terminator. Designing and building a humanoid robot or human-robotic arm one day was always a dream of most of them. Amputees are strong and capable people, who make do with what they have and are able to overcome adversity. It had been estimated that there are roughly 0.62 amputees in India per thousand population. This translates to close to one million individuals with amputations in the country. So helping them would feel so high. There is room for improvement in all aspects of current prosthetic technology relating to mechanical design, electrical signal processing, and overall system performance. The development of an advanced Human-machine interface is an interesting topic in the field of biomedical as well as real-world engineering. The is most significant in this field is with the help of biomedical signals, such as myoelectric or EMG (electromyography) signals have a key role to play. Controlling the actuators with the help of these sensors was interesting.

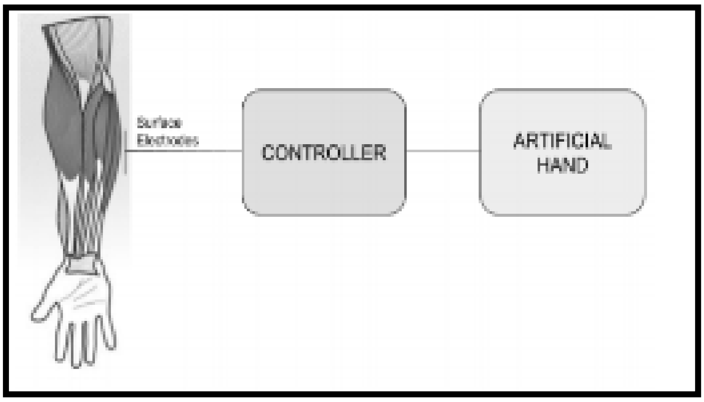


Fig 1.2: Flow diagram of the prosthetic hand process

GOAL

- Hoping that the project will have the potential to positively impact people(Amputees) Life.
- The goal of the thesis is to investigate just how far-fields like medicine, robotics and bionics has progressed in the development of prosthetics and robotics.
- Natures magnificent creation is the human body, we will explore the possibilities of replicating this.

- With a focus on the human hand with its tendons, ligaments and bone structure this thesis will explore existing research on implants, biomaterials, prosthetics, and 3D printing.
- The main goal of this project was to produce a completely mechanical design of a standalone prosthetic hand with 4 degrees of freedom. The hand would be considered a basis for a future product, but the design would also serve as a mechanical investigation into discovering what should be possible with a different design approach. Ideally, a functional prototype could be produced using the design developed in this project. This can be the basis and would help for the process of bidirectional transmission of information from a human brain to the hand.
- Prosthetic hand with the help of an EMG muscle sensor.
- Upon the completion of the thesis, it can prove as both, an element in further research with regards to bionics, and printing on the Object. It can also be valuable in regard to other fields of study within biology, medicine, and engineering.

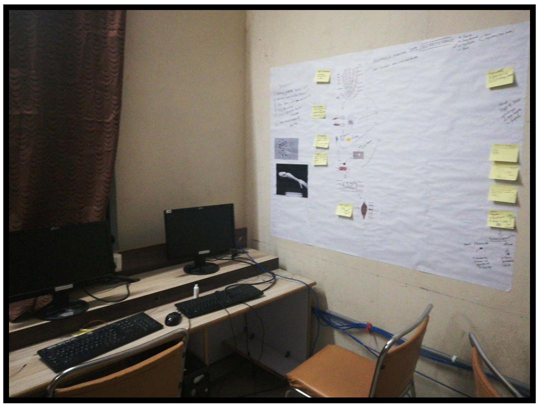


Fig 1. 3: BrainStorming workspace

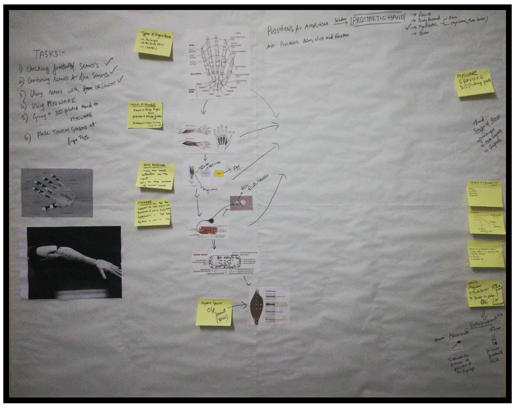


Fig 1. 4: Taking down the overview on the chart

CHAPTER III
LITERATURE SURVEY

Before we choose the problem statement, we had a review of what was essential for people and what features it should consist of.

3.1 What is the product which is essential for people?

We choose the medical field, the problem we wanted to solve was a prosthesis. A prosthesis is nothing but a solution to the amputees. Amputees are people who lost their hands or legs due to some disease. The fascinating thing about them is they do their work with great confidence, they don't find the issue as a reason to procrastinate their work. They are diligent towards their work.

So the main reason is to

- Put a smile on people's faces. ie It would positively impact peoples life
- Helping amputees.

3.2 What are the essential features for the product?

So we found what product was required for the people, now we need to know what features it should have. So we questioned ourselves with few questions and extrapolated some points.

- What kind of technology is being developed today, for creating new and improved Prosthesis?
- How far can we reach them?
- Can we make a 3D printed robotic hand using an emg sensor?
- Cost-Efficient?
- Lightweight?

Based on these, we were focused on quantitative and qualitative research, investigating amputees about their needs and expectations and how they want to use their artificial hand. below is a literature of the research with key points that I found interesting.

3.2.1 What is the user expecting?

- Portable
- Light in weight
- Resembling most of the human hand functionalities

- Firm grip over objects
- Price - not too expensive and bearable by people
- Highly durable

3.2.2 "Must-haves"

- Should be manufactured according to user requirements
- Flexible
- Sufficient degree of freedom.
- Effective

3.2.3 What some people want

- Implementing computer vision and robotic process automation.
- Controlling it with the brain. (Mind-controlled prosthesis).

3.2.4 Opportunities

- Hospitals
- Physical therapy
- Military medical wards
- It is a new innovation in medical science that has been proven to work
- A very important product for amputees who want to live like they use to

3.2.5 Problems

- Could be very expensive
- Should be manufactured according to user requirements
- Too high of a price.
- Motorized prosthetic
- Other companies developing the technology, where customer elasticity is perfectly elastic.

3.2.6 Why they bought a prosthetic hand

- To perform their day to day tasks easily and effectively.
- They require an artificial part to work.

- It is lightweight and cost-efficient because of 3d printing technology.

3.2.7 Behaviors

- Servo movement according to muscle contractions.
- Predefined movements according to the contracted muscle
- 3 degree of freedom for each finger
- One degree of freedom near wrist.

3.2.8 Suggestions

- Using 3d printing material
- Using high torque servo motors
- Using an efficient muscle sensor
- Using sufficient electric current

CHAPTER IV
BACKGROUND RESEARCH

This section is very important because this background study has helped us a lot in the project. So it would be better if u have background research. The purpose of the background study is to help you to prove the relevance of your thesis question and further develop your Project. we conducted preliminary research in the beginning stages of the project when many issues are unclear and thoughts need to be solidified.

We all know that the Military is a critical part of a country. Since 2007, the United States military began expressing interest in revolutionizing prosthetic devices to give wounded soldiers replacement limbs. Many soldiers were injured on the battlefield from improvised explosive devices and landmines. Commonly those soldiers would lose limbs directly. The military had the budget to help wounded soldiers who had given their limbs fighting for their country. It was clear that lower extremity prosthetics were functional and readily available, but upper extremity prosthetics that essentially not advanced since the Civil War. Most people simply made do with what they had when it came to having an arm amputation. Several soldiers however even lost both of their arms and tragedies and it was clear that something needed to be done for them.so the future scope of this project would also include the reason for soldiers as well as amputees.

In this project, when we had the background study we found that two criteria were important for the thesis and project. The first one was about the Anatomy of hand (biological importance) and the history Behind the Prosthetic Hand and Prosthesis.

4.1 ANATOMY OF THE HAND AND FOREARM

This part describes the background theory which is used to implant engineered components into the body or to replace existing ones. It will also explore the technologies that already have biology as inspiration and the materials needed for bioengineering. This section contains many parts that we referred so that it helps in implementing the 3d printed hand very close to the human hand. It explains the theory that forms the backbone of the thesis and gives short examples to better understand the separate fields.

In order to create appropriate physical design and functionality, it is important to know about the human hand. Anatomy is the study of structure and functionality. Though the natural hand is a Perfect instrument that has various degrees of freedom and functionality. We cannot create such with the current technology but with the knowledge of anatomy we can reach up to an extent. However, it is possible to compromise from such ideal specifications and to design a realistic hand prosthesis. The main purpose of this part is to analyze the function ability of natural hand and to determine the hand's most common grasping patterns from an infinite variety of patterns.

4.1.1 COMPOSITION

The hand is composed of many different bones, muscles, and ligaments that allow for a large amount of movement and dexterity. The hand consists of five digits: thumb, index finger, middle finger, ring finger, and little finger. The hand's anatomy consists of 27 bones and over 20 joints, and it involves the use of over 33 different muscles. Bones are responsible for rigidity within a segment of a hand, joints provided that freedom of movement and muscles serve to move rigid segments on each other. Since a great part of hand, prosthesis design is associated with the motion of the human hand and the range of motion of a human hand is restricted by the freedom of joints rather than the activity of musculature, the study of bone and joint movement will help to determine the basic grasping patterns of the natural hand. The forearm contains two long bones, the radius, and the ulna, forming the radioulnar joint. The forearm contains many muscles, including the flexors and extensors of the digits, a flexor of the elbow (brachioradialis), and pronators and supinators that turn the hand to face down or upwards, respectively.

4.1.2 BONES

The bones in the hand are connected to each other by ligaments and are moved by tendons connected to muscles in the forearm and smaller muscles inside the hand. Bone is a type of dense connective tissue, which connects and supports other organs (bones). The bones are also what constitutes most of the toughness of the hand.

There are 3 major types of bones in the hand itself, including:

- Phalanges: The 14 bones that are found in the fingers of each hand and also in the toes of each foot. Each finger has 3 phalanges (the distal, middle, and proximal); the thumb only has 2.

- Metacarpal bones: The 5 bones that compose the middle part of the hand.
- Carpal bones: The 8 bones that create the wrist. The 2 rows of carpal bones are connected to 2 bones of the arm--the ulna bone and the radius bone.

The wrist is formed where the two bones of the forearm – the radius (the larger bone on the thumb side of the arm) and the ulna (the smaller bone on the pinky side) – meet the carpus. Rather than a single joint, the wrist is actually made up of multiple joints where the bones of the arm and hand meet to allow movement. The carpus is formed from eight small bones collectively referred to as the carpal bones. The carpal bones are bound in two groups of four bones:

- the pisiform, triquetrum, lunate and scaphoid on the upper end of the wrist
- the hamate, capitate, trapezoid and trapezium on the lower side of the hand.

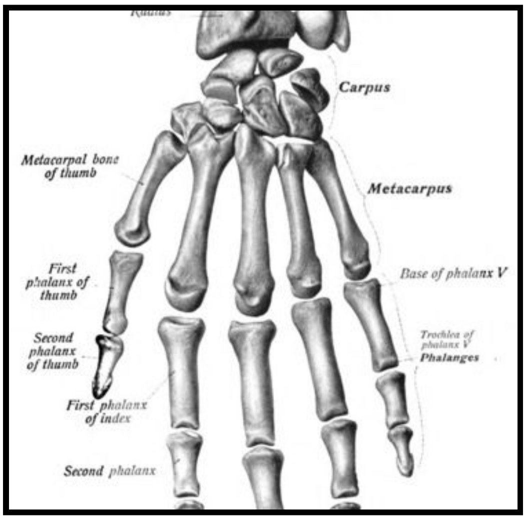


Fig 1.5: **Different types of bones in palm**

4.1.3 MUSCLES

The muscles of the arm and hand are specifically designed to meet the body's diverse needs of strength, speed, and precision while completing many complex daily tasks. The muscles of the hand are the skeletal muscles responsible for the movement of the hand and fingers.

The muscles of the hand can be subdivided into two groups: the extrinsic and intrinsic muscle groups. The extrinsic muscle groups are the long flexors and extensors. They are called extrinsic because the muscle belly is located on the forearm. The intrinsic group is the smaller muscles located within the hand itself. The muscles of the hand are innervated by the radial, median, and ulnar nerves from the brachial plexus.

The superficial layer of the posterior forearm consists of seven muscles (Figure 6): Brachioradialis, Extensor carpi radialis longus, and brevis, extensor digitorum, extensor digit minimi, extensor carpi ulnaris, and anconeus. The anterior forearm superficial layer has four different muscles (Figure 6) Flexor carpi ulnaris, palmaris longus, flexor carpi radialis, and pronator teres.

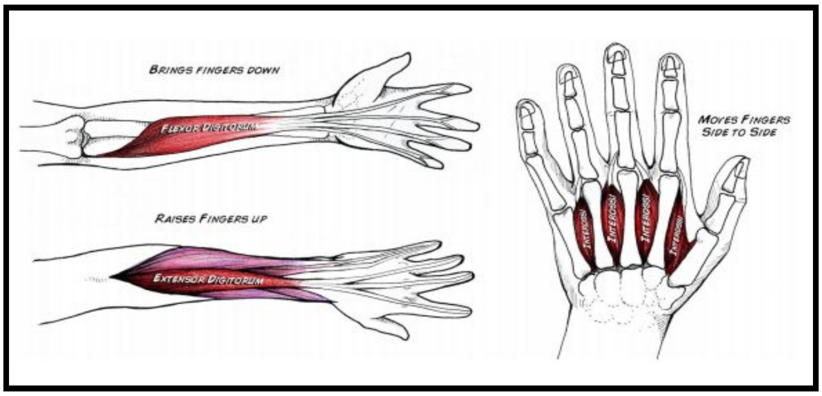


Fig 1.6: Muscles responsible for movement

4.1.4 LIGAMENTS

A ligament is a tissue that binds bone to bone, Ligaments are similar to tendons as they are both made of connective tissue but ligaments can stretch more since it contains more elastic fibers. The ligaments in the fingers stabilize the joints during movement and also determine how much the joints can move a certain way. Normally several ligaments work together in defining the range of motion for a particular joint. People without 100% effective ligaments usually suffer from impeded movement or joint dislocation.

4.1.5 TENDONS

Tendons are bands of connective tissue that usually connects muscle to bone, Figure 2.3 and Figure 2.4. The control and movement of bones are achieved by flexing and relaxing the muscles in the forearm so as to transform the force to tendons connected to the bone. Tendons are tough but still stretch a small amount. This is so sudden stretching of the tendon does not damage or rupture it.

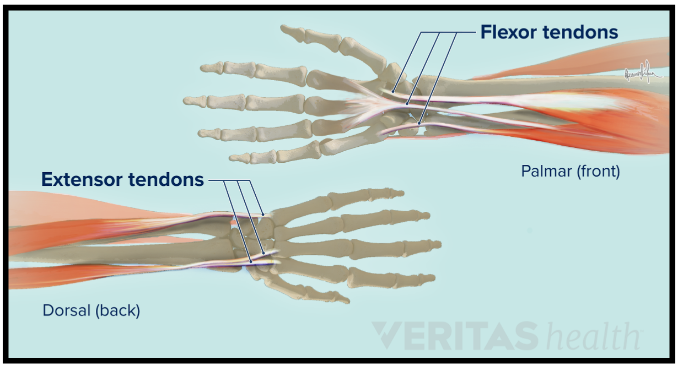


Fig 1.7: Tendons responsible for the connection

4.1.6 TO UNDERSTAND:

When we try to connect the above things with the 3d designing of the hand, we can observe many things.

- The bones in the fingers(Carpels, Metacarpals, Phalanges)represent the different parts of the 3D print of a finger and their DOF.
- The joints also play a crucial role in representing the movement of the artificial hand.
- The Tendons, Ligaments, and Muscles help in wiring the fingers from the hand to the forearm, fixing to the actuators.
- There are many other things which we can understand, these were the major ones.

4.2 HISTORY OF PROSTHETICS

In medicine, a prosthesis or prosthetic implant is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or a condition present at birth. Prostheses are intended to restore the normal functions of the missing body part. The medical world has come a long, long way in terms of the evolution of prostheses (or prosthetic limbs) - for instance, we now have technology advanced enough to give us access to robotic limbs! It hasn't always been this way, though, and in the past, it was much more difficult for people to adjust to life after losing a limb or other body part due to amputation than it is today.

4.2.1 EARLY STAGES

Prosthetics originates from the ancient Near East circa 3000 BC, with the earliest evidence of prosthetics appearing in ancient Egypt and Iran. Early pioneers of the idea of prosthetics were the Egyptians. The first confirmed the use of a prosthetic device was confirmed in 2000 when research pathologists discovered an Egyptian mummy who had a prosthetic toe made of wood and leather. The Greeks also left evidence of using wooden feet after instances where their own were amputated or lost to trauma. Additionally, there are stories of a Roman general who had an iron handcrafted for him so that he could hold his shield and return to battle after his hand had been cut off.

During the Renaissance, prostheses were commonly made with iron, steel, copper, and wood. Returning to the medical discoveries of the Greeks and Romans, the Renaissance helped usher in a rebirth in the history of prostheses, as well as art and philosophy.

The Civil War saw a huge rise in the number of amputations, which meant that the necessity for prosthesis and prosthetic limbs skyrocketed. James Hanger, one of the first amputee of the Civil War, developed the “Hanger Limb” from barrel staves.

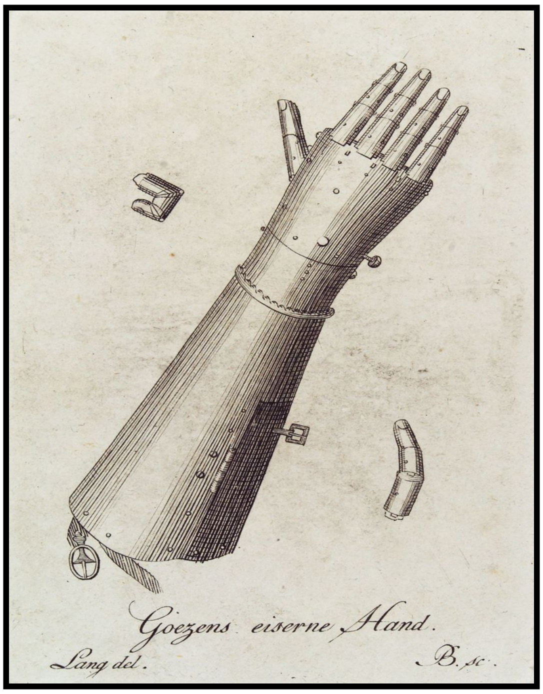


Fig 1.8: Iron prosthetic hand of German knight Götz von Berlichingen, 18th-century engraving.

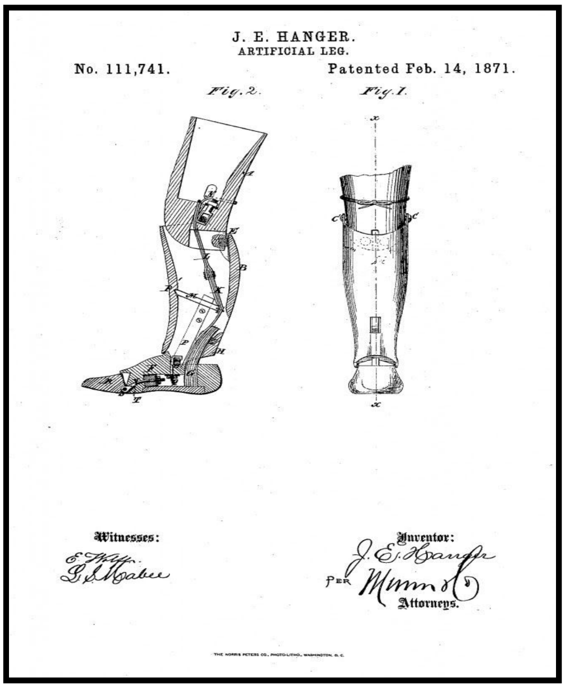


Fig 1.9: During American civil war

4.2.2 TAKING TECHNOLOGICAL LEAPS

- **American Civil War:**

The carnage of the Civil War led to a dramatic increase in the number of amputees, and the field of prosthetics needed to rise to the . James Hdemandanger, a confederate soldier, became the first amputee in the war and went on to invent the ‘Hanger Limb’ a prosthetic leg made from barrel staves and metal, that featured hinged joints at the knee and ankle. The Hanger Limb was the most advanced limb in the history of prosthetics, and the company he founded continues to be a leader in the industry today fig [9].

- **20th Century:**

In spite of the tremendous loss of life and limb in the World Wars, there wasn't a corresponding leap in prosthetic technology like the one seen in the Civil War – at least not until 1946, when researchers at UC Berkeley developed a suction sock for lower-limb amputees. Similar attachment technology is still in use today.

Other major improvements before the modern era:

- Pieter Verduyn – First non-locking below-knee (BK) prosthesis.
- James Potts – Prosthesis made of a wooden shank and socket, a steel knee joint and an articulated foot that was controlled by catgut tendon from the knee to the ankle. Came to be known as "Anglesey Leg" or "Selpho Leg".
- Sir James Syme – A new method of ankle amputation that did not involve amputating at the thigh.
- Benjamin Palmer – Improved upon the Selpho leg. Added an anterior spring and concealed tendons to simulate natural-looking movement.
- Dubois Parmelee – Created prosthetic with a suction socket, polycentric knee, and multi-articulated foot.
- Marcel Desoutter & Charles Desoutter – First aluminum prosthesis.
- Henry Heather Bigg and his son Henry Robert Heather Bigg won the Queen's command to provide "surgical appliances" to wounded soldiers after the Crimea War. They developed arms that allowed a double arm amputee to crochet, and a hand that felt natural to others based on ivory felt and leather

At the end of World War II, the NAS (National Academy of Sciences) began to advocate for better research and development of prosthetics. Through government funding, a research and development program was developed within the Army, Navy, Air Force, and the Veterans Administration.

- **Today and Beyond:**

Today is an exciting moment in the history of prosthetics. It’s a time when great strides are being simultaneously made on both the aesthetic and functional fronts thanks to new technologies and the never-before-seen pace of innovation. Modern materials like carbon fiber are making prosthetics both lighter and stronger. Advancements like 3D printing and biometrics have enhanced the lives of amputees and will continue to do so. The advancement of prosthetic limbs has allowed amputees to return to the life they’re accustomed to, rather than simply providing them with day-to-day functionality**.**

Fig 1.10:3D printed prosthetic hand made by Open Bionics in collaboration with ILM XLab

4.2.3 LIMB PROSTHESIS

A person's prosthesis should be designed and assembled according to the person's appearance and functional needs.

Limb prostheses include both upper- and lower-extremity prostheses.

- Upper-extremity prostheses are used at varying levels of amputation: forequarter, shoulder disarticulation, transhumeral prosthesis, elbow disarticulation, transradial prosthesis, wrist disarticulation, full hand, partial hand, finger, partial finger. A transradial prosthesis is an artificial limb that replaces an arm missing below the elbow.
- Lower-extremity prostheses provide replacements at varying levels of amputation. These include hip disarticulation, transfemoral prosthesis, knee disarticulation, transtibial prosthesis, Syme's amputation, foot, partial foot, and toe. The two main subcategories of lower extremity prosthetic devices are trans-tibial (any amputation transecting the tibia bone or a congenital anomaly resulting in a tibial deficiency) and trans-femoral (any amputation transecting the femur bone or a congenital anomaly resulting in a femoral deficiency).

4.2.4 PROSTHETIC RAW MATERIAL

Prosthetic is made lightweight for better convenience for the amputee. Some of these materials include:

- Plastics:
  - Polyethylene, Polypropylene, Acrylics, Polyurethane
- Wood (early prosthetics)
- Rubber (early prosthetics)
- Lightweight metals:
  - Titanium
  - Aluminum
- Composites:
  - Carbon fiber
- 3d printing Material

ABS Filament, PLA Filament, PET Filament, PETT Filament, Nylon Filament, PVA Filament, Sandstone Filament, Wood Filament.

Fig 1.11: Raw Material

4.2.5 TO UNDERSTAND:

By referring to all this, we had a knowledge of the history of the prosthesis, and types of prosthesis. This can replace any part of the body eg: upper and lower extremity. we came to know about the materials used before and now as the advancement. According to the requirement, we had many choices of designing a prosthetic limb. Different types of prosthetic devices were also observed (eg body-powered, myoelectric). We had made a choice of designing/Prototyping a 3D Printed prosthetic hand and forearm which would demonstrate the functionality of hand, wrist, and forearm. Using 3D printing makes it cost-efficient and lightweight which plays a major role. The material for 3d printing filament chosen was PLA.

CHAPTER V
DIFFERENT TYPES OF PROSTHETIC OPTIONS

The different types of prosthetic options are below

5.1 PASSIVE PROSTHESIS

The passive functional prosthesis does not have any electronic or mechanically moving parts. They closely match skin tone and appearance and provide you with basic, functional capabilities such as pushing, pulling, stabilizing, and supporting.

The passive prosthesis, which is a cosmetic restoration, is another option for upper extremity patients. It is an excellent choice for users who do not require precise hand control or grasp but still seek a cosmetically pleasing prosthesis.

After an amputation, patients have to consider using an artificial hand. A decision needs to be made whether the arm prosthesis will be functional or whether cosmesis is important. They will also support function to an extent by passively supporting in two-handed activities.

Fig 1.12: Passive prosthesis

5.2 CONVENTIONAL OR BODY POWERED PROSTHESIS

The conventional or body-powered prosthesis is a choice many upper extremity users make. This prosthesis is suspended from a harness fastened around the person's shoulder or upper torso. It is controlled by upper body movements that utilize a cable connected to the harness at one end, and a mechanical hand, hook or elbow at the other end. Many people feel this type of prosthesis grants them a wide range of basic functions and control.

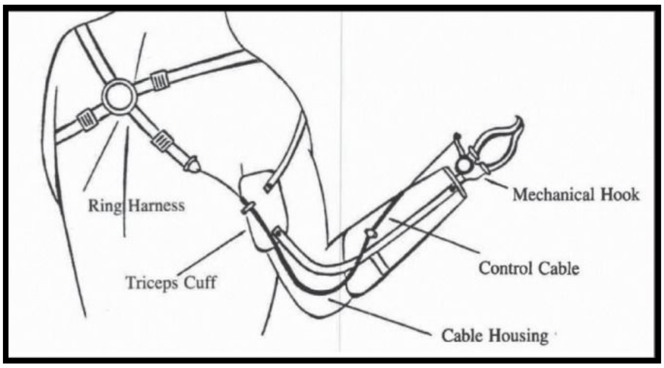


Fig 1.13: Body Powered Prosthesis

5.3 ELECTRIC PROSTHESIS

Another option is the electrically powered prosthesis that utilizes motors to open and close the hand, and can also flex and extend the elbow or rotate the wrist. This option offers many control choices.

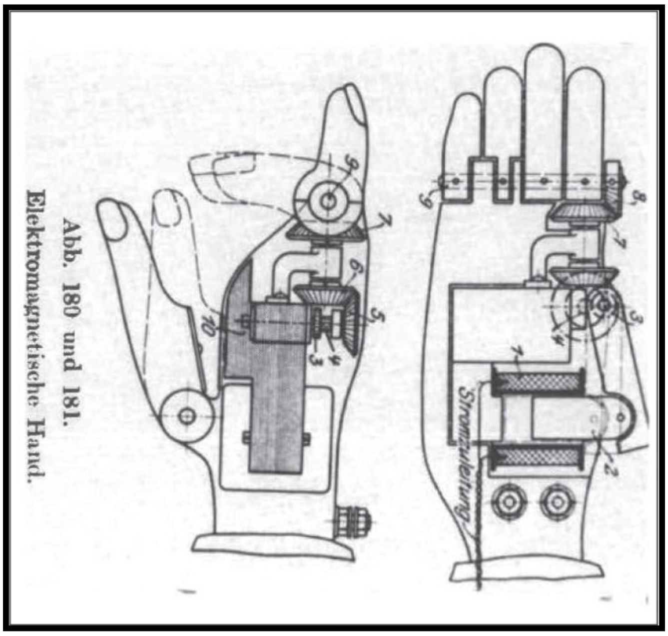


Fig 1.-14: Electric Prosthesis

5.4 MYOELECTRIC PROSTHESIS

One of the most popular is myoelectric control. The user controls the prosthesis by contracting the muscles in the residual limb, generating EMG signals that activate the motor in the elbow, wrist or hand. Some people find that the myoelectric prosthesis allows a greater range of motion, a more natural appearance, and enhanced workability. It is also more comfortable since the harness is either smaller or is eliminated completely.

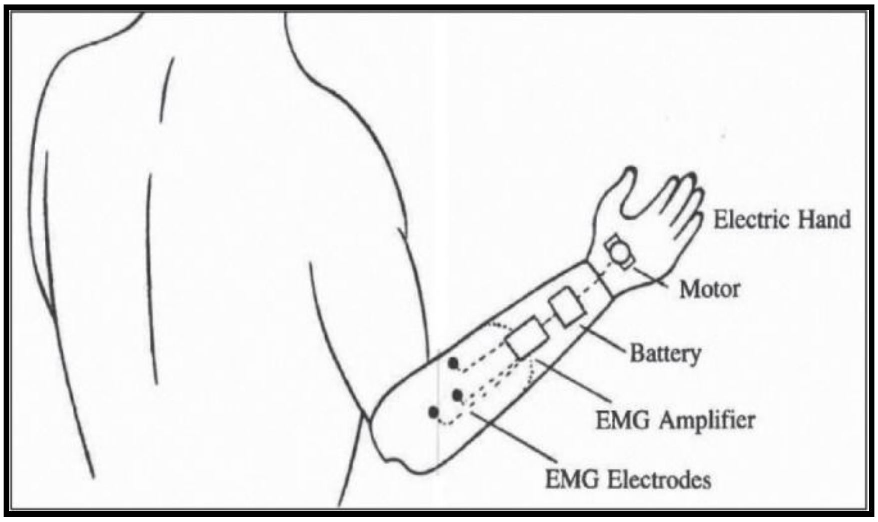


Fig 1.15: MyoElectric Prosthesis

5.5 HYBRID PROSTHESIS

Combining elements of the conventional and the electrically powered prosthesis create another option - the hybrid. A hybrid prosthesis provides the user with the unique ability to operate the elbow and the hand at the same time.

5.6 MIND CONTROLLED PROSTHESIS

If electrodes can sense the electricity caused by muscle contractions, why can't they just go to the source of the information and measure the electrical signals carried in the nerves or even the brain? The answer is that they can, but recording from the brain and nerves is more challenging for several reasons. For example, electrical signals in the brain and nerves are very small and hard to access. The field of neural interfacing is dedicated to developing ways to listen and communicate with the brain and nerves.

As an example of neural interfacing technology, scientists can implant micro-scale electrodes in the brain to listen in on brain activity. When the patient mentally tries to move his or her amputated limb, the microelectrodes can intercept motor command signals generated in the brain, and these signals can then be used to control a prosthetic device.

Johnny Matheny is the first person to live with an advanced mind-controlled robotic arm.
Future advances in neural interfacing will allow artificial devices to more effectively stimulate the nerves or brain in order to restore a sense of touch and allow patients to feel their artificial

limbs. This capability will go a long way in closing the gap between prosthetic limbs and the natural limbs they're designed to replace.

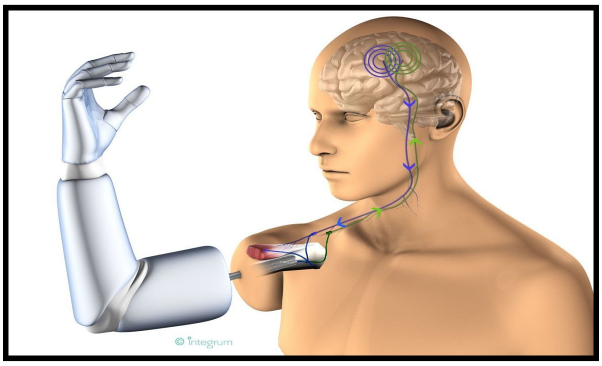


Fig 1.16: Mind-Controlled Prosthesis

5.7 TO UNDERSTAND

The mind-controlled prosthesis shows how the field of prosthetics is constantly advancing. While the challenges are great, remarkable progress has been made over the past few decades, and dedicated researchers around the globe are working each day to make prosthetic limbs as close as possible to the real thing. But we had chosen the Myoelectric prosthesis for prototyping the functionality of a human hand.we had certain reasons for choosing, you can choose based on your requirement and availability.

CHAPTER VI
PROTOTYPES

Whether you have complete information about the project, or not it is important to understand the functionality and use of sensors and actuators. To understand this, we created small models that demonstrate the functionality of the original Prosthetic Hand.We had to use lesser torque actuators and some different sensors to control the movement of fingers. For the model of the hand, we used a cardboard piece that was cut in the form of a hand. The prototypes made were :

- Controlling Servo Motor(Actuators) and Cardboard Model:
- Controlling Servo Motors and Cardboard Model with IR Sensor:
- Controlling Servo Motors and Cardboard Model with FLEX Sensor:

6.1 CONTROLLING SERVO MOTOR (ACTUATORS)AND CARDBOARD MODEL

In this phase of the prototype, we wanted to test the functionality of the actuators. The steps involved were:

- ➔ First, we have taken cardboard and made it in the form of a hand.Attached small pieces of straws to each finger so that it acts as a way for the threads.
- ➔ We have taken small pieces of wire and attached them to fingers through the straws.In the process of attaching them to fingers, we have stapled it according to the DOF of the finger.
- ➔ Next, we have chosen the microcontroller that is Arduino UNO.So, we have taken a product and an actuator. We are controlling the product using the actuator and the microcontroller.

<u>**Connections :**</u>

- **Connect** the black wire from the **servo** to the GND pin on the **Arduino**.
- **Connect** the red wire from the **servo** to the +5V pin on the **Arduino**.
- **Connect** the yellow or white wire from the **servo** to a digital pin on the **Arduino**.

<u>**Code for this phase :**</u>

```
#include <Servo.h>
Servo myservo;
int pos = 0;
```

```
void setup() {
 myservo.attach(10);
}
void loop() {
 for (pos = 0; pos <= 180; pos += 1) {
   myservo.write(pos);
   delay(15);
 for (pos = 180; pos >= 0; pos -= 1) {
   myservo.write(pos);
   delay(15);
 }}
```

Now we understood the controlling of fingers using Servo motor. All we have done is control the servo with the predefined code ie we have predefined the servo movement. Do u think was that enough?

It was not enough, that was the reason the other two phases were also involved to improve the accuracy.

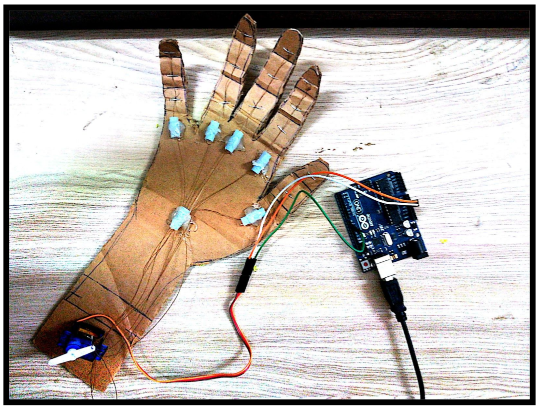


Fig 1.17: Cardboard model with ServoMotor

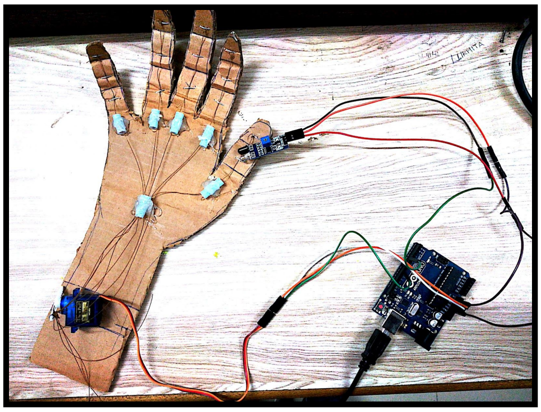


Fig 1.18: Cardboard model with servo and IR

6.2 CONTROLLING SERVO-MOTORS/ CARDBOARD MODEL WITH IR SENSOR

In this phase of the prototype, we wanted to test the functionality of the actuators by an input from a sensor. Here we have not predefined the servo movement it was based on the sensor input.

The steps involved were:

➔ The first steps were similar to the above phase, we have used the same model instead of creating a new model from the cardboard piece. Let me repeat the steps for u,First, we have taken cardboard and made it in the form of a hand.

➔ Attached small pieces of straws to each finger so that it acts as a way for the threads.We have taken small pieces of wire and attached them to fingers through the straws.In the process of attaching them to fingers, we have stapled it according to the DOF of the finger.

➔ Next, we had to choose a sensor. We taught of IR sensor which was not related to the project but we can understand the methodology of controlling the servo movement according to the sensor input.IR sensor has two kinds of input, we can also use it in the form of analog by using the PWM pins.For the time being, we preferred to use the digital functionality of IR.Based on that input, we had controlled the servo movement by using a microcontroller that is Arduino UNO.

➔ So, we have taken a product and an actuator. We are controlling the product using the actuator and the microcontroller but based on sensor input fig [18].

Connections :

- **Connect** the black wire from the **servo** to the GND pin on the **Arduino**.
- **Connect** the red wire from the **servo** to the +5V pin on the **Arduino**.
- **Connect** the yellow or white wire from the **servo** to a digital pin on the **Arduino**.
- **Connect** the negative wire on the **IR** sensor to GND on the **Arduino**.
- **Connect** the middle of the **IR** sensor which is the VCC to 5V on the **Arduino**.
- **Connect** the signal pin on the **IR** sensor to pin 8 on the **Arduino**.

Code for this phase :

```
#include <Servo.h>
const int analogInPin = A0;
int sensorValue = 0;
int servoPin = 9;
int i = 0;
Servo servo;
void setup() {
servo.attach(servoPin);
```

```
}
void loop() {
  sensorValue = analogRead(analogInPin);
  if(sensorValue < 600){
    for (int i = 0; i<=180; i++){
    servo.write(i);
    delay(10);
   }
  }
  servo.write(i);
}
```

This was quite enough, but we wanted to know the analog functionality of the sensor so that we get accurate movements like a natural hand. So we wanted to use a different sensor that was related to the project. That was done in the next phase of the prototype.

6.3 CONTROLLING SERVO-MOTORS ON CARDBOARD MODEL WITH FLEX SENSOR

In this phase of the prototype, we used the Flex sensor for understanding the functionality. if u have the flex sensor directly u can use this skip the above phase.if u have an ample amount of time then u can follow step by step.

The steps involved were:

- ➔ The first steps were similar to the above phase, we have used the same model instead of creating a new model from the cardboard piece.
- ➔ Let me repeat the steps for u,
- ➔ First, we have taken cardboard and made it in the form of a hand.
- ➔ Attached small pieces of straws to each finger so that it acts as a way for the threads.
- ➔ We have taken small pieces of wire and attached them to fingers through the straws.
- ➔ In the process of attaching them to fingers, we have stapled it according to the DOF of the finger.
- ➔ Next, we had to choose a sensor. We taught of Flex sensor which was related to the project but we can understand the methodology of controlling the servo movement according to the sensor input.

- ➔ The prosthetic hand can also be made from a flex sensor but that wouldn't be so efficient, but it can be used as a basis for the next or future product.
- ➔ Take a glove and attach each flex sensor to the fingers of the glove, so according to the movement of the flex sensor, the fingers are controlled.

Connections

- **Connect** the black wire from the **servo** to the GND pin on the **Arduino**.
- **Connect** the red wire from the **servo** to the +5V pin on the **Arduino**.
- **Connect** the yellow or white wire from the **servo** to a digital pin on the **Arduino**.
- One end of the **flex** sensor is **connected** to GND while the other end is **connected** to Analog Input A0 of **Arduino**. A 10KΩ resistor is **connected** between A0 and +5V. This **connection** means that the **flex** sensor and the 10KΩ resistor for a voltage divider:

Code for this phase

```
#include <Servo.h>
Servo myServo;
const int flexPin = A0;
void setup()
{
  myServo.attach(11);
}
void loop()
{
  int flexValue;
  int servoPosition;
  flexValue = analogRead(flexPin);
  servoPosition = map(flexValue, 800, 900, 0, 180);
  servoPosition = constrain(servoPosition, 0, 180);
  myServo.write(servoPosition);
  delay(20);
}
```

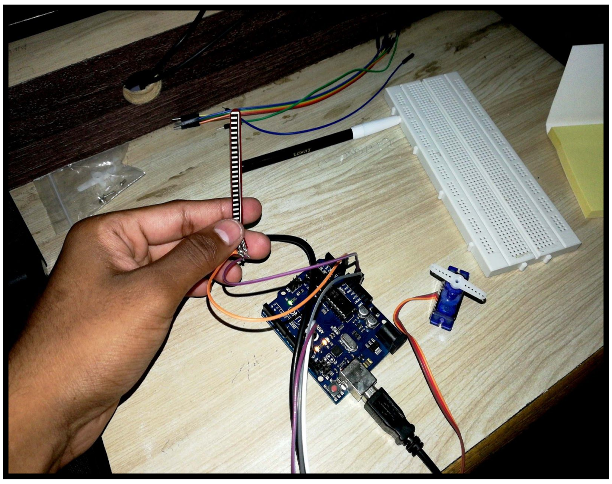


Fig 1.19: Testing of flex sensor and servo

CHAPTER VII

3D PRINTING TECHNOLOGY

The reasons there are different types of 3D printers and printing processes are similar to that of the 2D printers we're so familiar with. It all comes down to the following six considerations:

1. cost
2. quality
3. speed
4. capability
5. Practicality
6. User expectations

Some printers only print text—others text and graphics. The technologies and materials used also vary, and the way the machine extrudes ink to paper. 3D printers are even smarter. And like their 2D counterparts, they also offer a range of options including quality, materials, and price.

7.1 PROCESS INVOLVED IN 3D PRINTING

The 3D printing process is no longer difficult for the home user once you grasp the basic principles. OK, so printers, printing materials, printed objects, and 3D printing software can all vary. Yet despite this, the process from design to end product follows a similar path. We've covered these processes in some detail in another guide, but here's how it looks in a brief:

- We should have access to a 3D modeling application or a 3D scanner.
- We should create a virtual design of the object they want to print in 3D.
- we saved our design as a Computer-Aided Design file, or CAD for short.
- We then sliced our CAD file before sending it to the printer.
- We uploaded the sliced CAD file to the 3D printer.
- The printer reads each slice in the 2D file to create the three-dimensional object.

Fig 1.20: 3D Printer

7.2 TYPES OF 3D PRINTERS

- Stereolithography (SLA)
- Digital Light Processing (DLP)
- Fused deposition Modeling (FDM)
- Selective Laser Sintering (SLS)
- Selective Laser Melting (SLM)
- Electronic Beam Melting (EBM)
- Laminated Object Manufacturing (LOM)
- Binder Jetting (BJ)
- Material Jetting (MJ)

7.3 COMPONENTS OF 3D PRINTER

Knowing about the 3D printer in detail would help you to better understand the printing process. There are many parts, and each one plays a crucial role in the printing process. We're not going to get too technical here. It's still important, however, to know what the main components are. This helped us in understanding the 3d printing process better which was very helpful in the next tasks.

The main components, and their use, in a 3D printer, are:

- 3D Printer Frame: Holds the machine together.
- 3D Printer Head movement mechanics: moves relative to the print bed in all directions.
- 3D Printer Head: Nozzle that deposits filament or applies colors and a liquid binder.
- 3D Build Platform or Build Bed: The part of the printer where the object is printed.
- 3D Printer Stepper Motors (at least 4): Used for precise positioning and speed control.
- 3D Printer Electronics: Used to drive motors, heat the extruder and much more.
- 3D Printer Firmware: Permanent software used to control every aspect of a 3D printer.
- 3D Printer Software: Not part of the actual printer but still needed for the printing process.

7.4 OUR 3D PRINTER

We have many types of 3d printers and 3d printing types. If we have many options then we can choose one with knowing all the pros and cons.we had only one choice of printer. We had the availability of a 3d printer naming Creality Ender 3. The process involved in it was FDM(Fused Deposition Modelling). The material used was PLA(Polylactic Acid). We used Cura software for slicing the file.

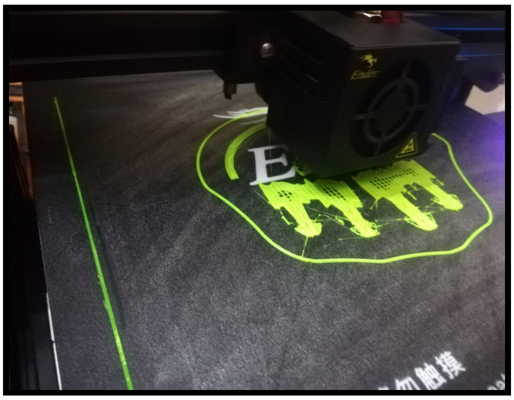


Fig 1.21: 3D printing

7.5 FDM (FUSED DEPOSITION MODELLING)

FDM is a 3D printing process developed by Scott Crump and then implemented by Stratasys Ltd. in the 1980s. It uses production-grade thermoplastic materials to print its 3D objects. It's popular for producing functional prototypes, concept models, and manufacturing aids. It's a technology that can create accurate details and boasts an exceptional strength to weight ratio.

Before the FDM printing process begins, we had to slice the 3D CAD data (the 3D model) into multiple layers using CURA software. The sliced CAD data goes to the printer which then builds the object layer at a time on the build platform. It does this simply by heating and then extruding the thermoplastic filament through the nozzle and onto the base. The printer can also extrude various support materials as well as the thermoplastic. For example, as a way to support upper layers, the printer can add special support material underneath, which then dissolves after the printing process. As with all 3D printers, the time it takes to print all depends on the object's size and its complexity.

7.6 ULTIMAKER CURA

Cura slices 3D models. It translates the 3D STL, OBJ or 3MF file into a format that the printer can understand. Fused filament fabrication (FFF) 3D printers print one layer upon another to build up the 3D object.

Steps:

- Open 3D files. Click on the 'Open File' button in the top left corner of the screen.
- Printer, print core and material configuration. You can find your selected printer in the top right corner of the screen. ...
- Print setup.
- Preview.
- Save the file.

The print setup contains many steps, it depends on us which settings we want to use for the model.

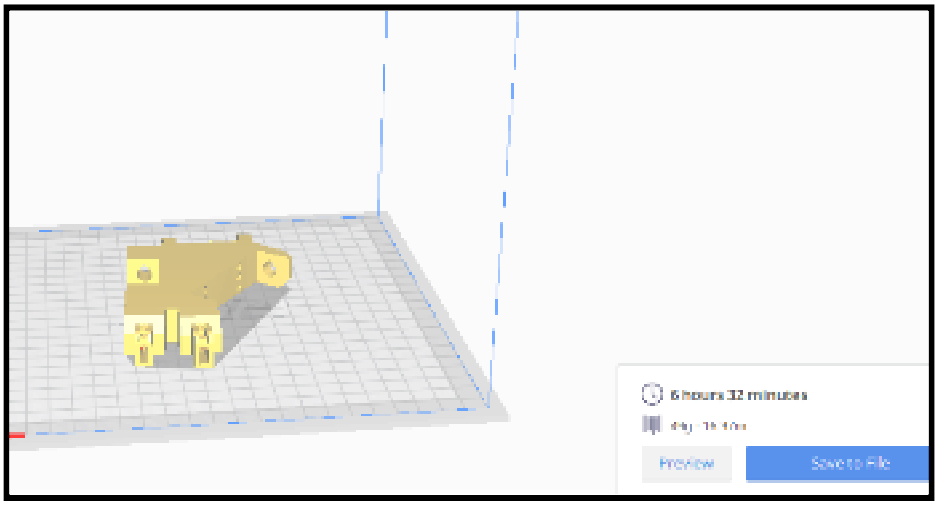


Fig 1.22:cura software for 3D printing with palm part setup

7.7 WHY 3D PRINTING

- Sustainability
- Ease of access
- Customization

3D printing is useful to architects for creating mockups and mechanics for creating tools. ... 3D printing is an innovation which fuels more innovation. 3D printing is inexpensive prosthetics, creating spare parts, rapid prototyping, creating personalized items and manufacturing with minimum waste.

CHAPTER VIII

MECHANICAL DESIGN OF PROSTHETIC ARM

The design which we select for the product has a lot of impacts. This will be responsible for accurate movement, appearance, and working efficiency. The mechanical designing can be done in Autocad and then an STL file is developed. Since we are using 3D Printing Technology, the 3d printer understands only gcode.we can get the gcode from the STL file by slicing it.

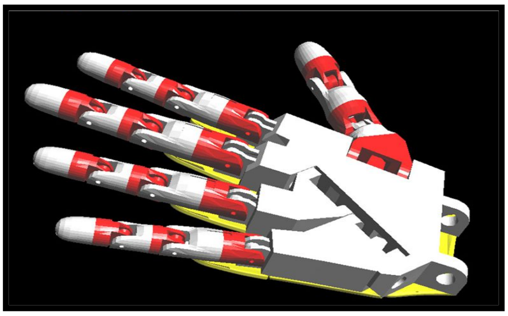


Fig 1.23: 3D view of Palm

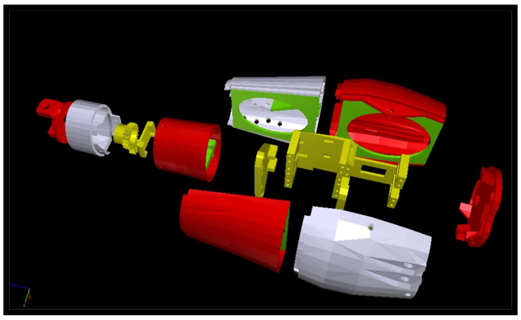


Fig 1.24: 3D view of Forearm

8.1 OVERVIEW AND OPEN-SOURCE DESIGN

The open-source design was chosen to save time, and the emphasis of this project is on electronics design and embedded system coding, not on 3D modeling. There are many different 3D printed open-source prosthetic hands available on the internet. After reviewing all the pros and cons aspects of many available models, the palm design by IN-MOOV was selected. Thanks to inmoov for open source which was very helpful to us.

Out of many available hand models on the open-source website, this hand model was chosen because it represents the human hand anatomy most accurately. In addition, this hand model fixes perfectly the project's purpose which is free movement between individual fingers. However, to be applied for this project, the hand design needs to be considerably modified and adapted to many different features.

In reality, every patient has unique physiology of the stump and a unique gauntlet design should be made for each individual patient. This would be a challenge for this project to scale up in the future; however, with inexpensive 3D printing technology, it is possible to print new prosthetics and gauntlets every few months.

8.2 INMOOV-CHOSEN OPEN SOURCE

InMoov is a DIY mostly 3D printable humanoid robot controlled by Arduino microcontrollers that were originally designed as a prosthetic arm by French designer Gael Langevin in 2012. Since then it has turned into a personal project for Gael with him posting new improved pieces every couple of months with plans to add functional legs as it is currently being rolled around on wheels due to the major difficulties of making functional legs that can carry the weight of all of the hardware in the rest of the body.

This thesis will guide on the processes of building an InMoov robotic hand which will include the total cost, the struggles throughout the project and how they were solved as well as some of the basic difficulties that other people have had with the project.

CHAPTER IX
3D PRINTED PARTS

As we had chosen the INMOOV 3D design for our hand. The STL files are available on the inmoov website or u can also refer this document to understand in detail about the 3D printed parts. We had done the product keeping in mind, the right hand. This depends on the requirement of an individual so that doesn't matter.

9.1 DIVISION OF PARTS

The parts have been divided so that there will be no confusion and we can assemble the parts easily.

9.1.1 RIGHT HAND

- Arduino support & Bolt_entretoise
- Coverfinger1
- Index3
- Majeure3
- Ring finger3
- Thumb5
- Auriculaire & Robcap3v2
- Robopart2V4 & Robopart3v4 & Robpart4v4
- Robpart5v4 & Wristsmall & Wristlarge
- Topsurface

9.1.2 FOREARM

- Robcableback
- Robcablefron & RobRing
- Servo-pulley & TensionerRight

9.1.3 WRIST

- Cableholderwristv5
- Rotawrist1v4
- Rotawrist2v3
- Rotawrist3v3
- Wrist gearsv5

CHAPTER X

ASSEMBLY OF PROSTHETIC HAND

We divided our assembly into 3 categories. first, we started with the forearm, then the wrist and palm and fingers.

These instructions are for the right hand, the steps are the same for the left hand also, just mirroring of it.every

10.1 PRE ASSEMBLY CHECK

Pre-assembly check of all the material like 3d printed parts, electronics, PCB board.so that to verify all the parts available.

Fig 1.25: Pre Assembly check

10.2 ASSEMBLY OF FOREARM

Step- 1: Remove all the supports for the robpart 2,3,4 and 5. Assemble robpart 2 and 5 with the help of super glue. Make sure that the glue doesn't come out because it looks ugly if the glue comes out.

Fig 1.26: Fixing of robparts 2 and 5 with super glue

Step- 2: Similarly assemble robpart 3 and 4, sand/file the parts so that it looks neat.when u finish with this. When u finish this u have finished with 40 percent of the forearm.

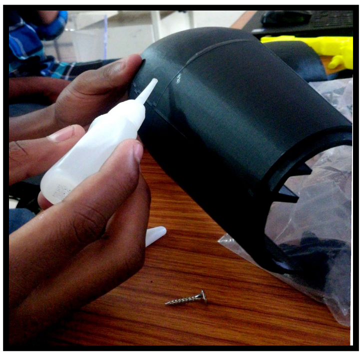


Fig 1.27: Fixing of robparts 3 and 4

Step- 3: In Robpart5, insert two nuts for 3mm bolts in the printed cavities. I heated them slightly with a lighter flame to make them fit. Take bolts and nuts of size M3x20.

Step- 4: Take the part named as servo bed, fix this in the robpart5, take self-centered screws of the desired size so that it fits.

Fig 1.28: Servo bed placed in robpart 5

Step- 5: Place all the servos with the self-centered screws which fit them. Place the servos in the orientation as shown below for efficient output.

Fig 1.29: Placement of Servos

Step- 6: After placing the servos, test if all the servos are working or not with the help of sample sweep code.

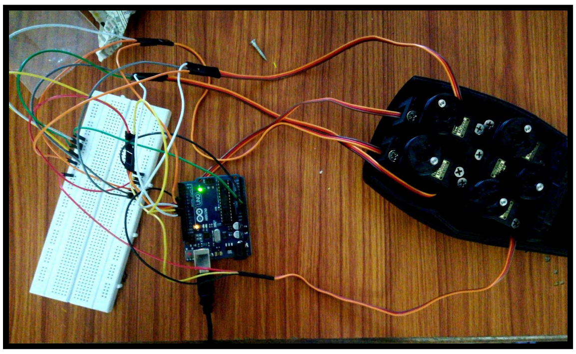


Fig 1.30: Testing of servos

Step- 7: Now your 60 percent of the forearm work is done.

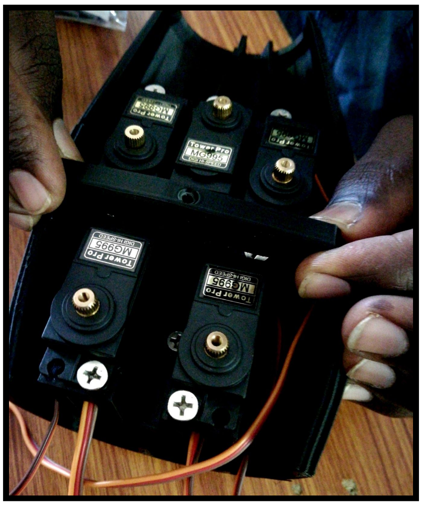


Fig 1.31: Fixing of robcable

Step- 8: Now place the rob cable Back, on the servo bed as shown in fig [1.31].

Step- 9: Now place the rob cable Front, in the front of servo bed (ie) near the joint of Robpart2 and Robpart5 as shown in fig [1.31].

Step- 10: Now place the TensionerRight which would be helpful for tensioning the fishing braid.

Step- 11: Now take the Servo pulleys,u can take either one of them servo pulleys or robring. I would suggest u take the servo pulley. Now attach the servo pulley with the ring which we get in the servo packet.

Step- 12: Use the screws which we get with the servos packet, we had used the screws which we got in the sg90's servo.

Fig 1.32: Screws used for servo pulley

Step- 13: Now the major part of the forearm is completed, The remaining part is the tensioning of strings which can be done after the assembly of all the parts.

10.3 ASSEMBLY OF THE WRIST

Step- 1: Take the rotawrist1v4 and remove the support structure, now glue it with Robpart2 as shown below:

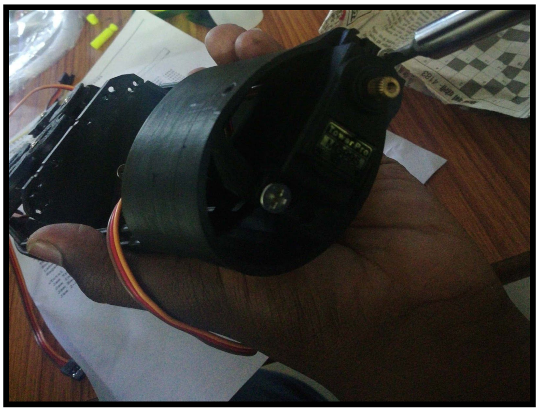


Fig 1.33: Fixing of rotawrist1v4

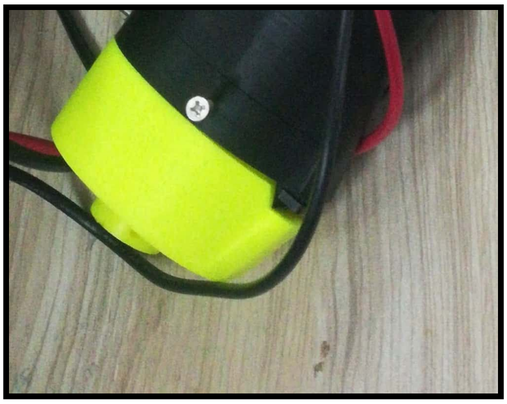


Fig 1.34: Assembly of Wrist

Step- 2: Now place the servo in the desired location and screw it tightly shown in fig [1.33].

Step- 3: Now screw the Cableholderwrist on the side of the servo where there is no rotating wheel.

Step- 4: Now take the parts from the servo packet and break it such that, the middle part remains. Now take one of the Gear and glue it to the servo.After attaching all gears and total covering as shown in fig [1.34].

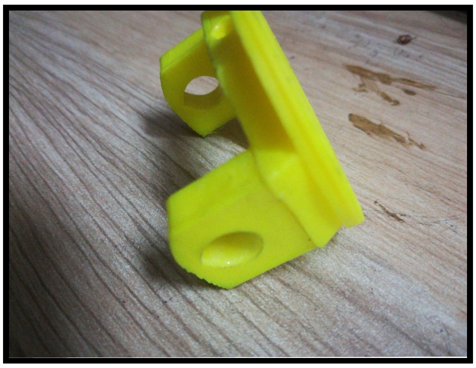


Fig 1.35: Rotawrist2v3

Step- 5: Now take the part rotawrist2v3, Place the large gear inside that. Also, fit the bolts in the place provided. We require M3X16 bolts and nuts for this as shown in fig [1.35].

Step- 6: Now take the rotawrist3v3 and fit it such that the big gear from rotawrist2v3 inserts within this. Make sure the hole of the gear and rotawrist3v3 coincide and screw them up.

Step- 7: Now the part of rotawrist1v4 with 3v3 is ready, fix this with the rotawrist1v4 with the help of M3X16 bolts and nuts. Make sure that the gear to the servo and the big gear attach correctly.

Fig 1.36: Bolts of M3 X 16

Step- 8: Now the assembling of the wrist is completed, your hand presently will look like this. I had briefly explained the procedure, but when u see the images u might not have a problem. Anyhow, u can also refer to the INMOOV tutorial for the procedure.

10.4 ASSEMBLY OF PALM

Step- 1: Take the parts named wrist part large and wrist part small, fix them as shown in the fig below.

Fig 1.37: Placing of wristparts **Fig 1.38:** Bolts used for fixing wristparts

Step- 2: Redrill the holes of the wrist parts with an 8mm drill, so that it would be easy to fit the bolts.

Step- 3: We need 3 types of bolts, the larger one goes through the wristpartsmall, and the next larger is used for attachment of wrist and palm, and the last one goes through the part of thumb and wristpartlarge as shown in fig [1.38].

Step- 4: Now the major part of your hand assembly is completed.

Fig 1.39: Drilling finger parts

Step- 5: Now the hectic task is the assembly of the fingers. Use super glue to paste some parts of the fingers.

Fig 1.40: Placement of finger parts

Step- 6: Now your fingers may look like this, we should provide the movement to finger parts.so we made the choice of a metal rod of 3mm.

Fig 1.41: Finger assembly

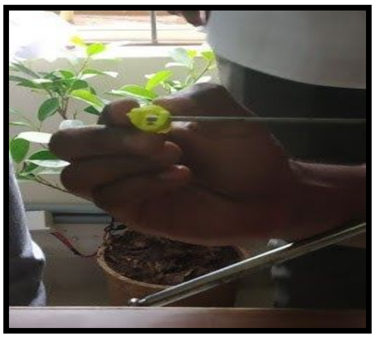


Fig 1.42: Inserting Metal rod

Step- 7: Redrill the holes of fingers with 3mm, or u can heat the end of 3mm rod with a blower and then widen the holes fig [1.42].

Step- 8: Now place the metal rod inside the hole, and cut off with a specific tool. Make sure to place glue on both sides so that the metal rod doesn't slip out.

Step- 9: Placing glue is not compulsory, it may depend on requirements.

Step- 10: At this stage, your project may look like this, now we are left with tensioning of the fishing line braid**.**

10.5 TENSIONING OF WIRE

Step- 1: Cut the braid into two pieces for each finger, of the desired length. Start placing the braid from the top of the finger, one from the bottom and one from below.

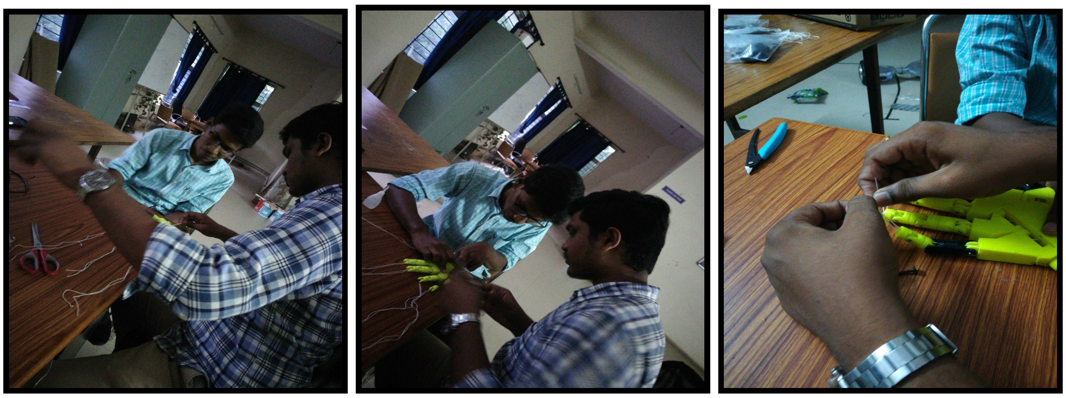


Fig 1.43: Tensioning of wires

Step- 2: Now it should pass through the palm part, through the specified holes. While placing the threads we will understand easily through which hole to pass

Step- 3: Now take all the threads and insert them through rotawrist3v3.(Make sure that u detach the parts attached with the screw for easy tensioning.)

Step- 4: Now it should pass through the big gear attached to the rotawrist3v3.make sure the alignment of the threads doesn't change as shown in fig [48].

Step- 5: Now pass it through the cable holder wrist, Use phone torch from below so that the holes will be clearly visible.

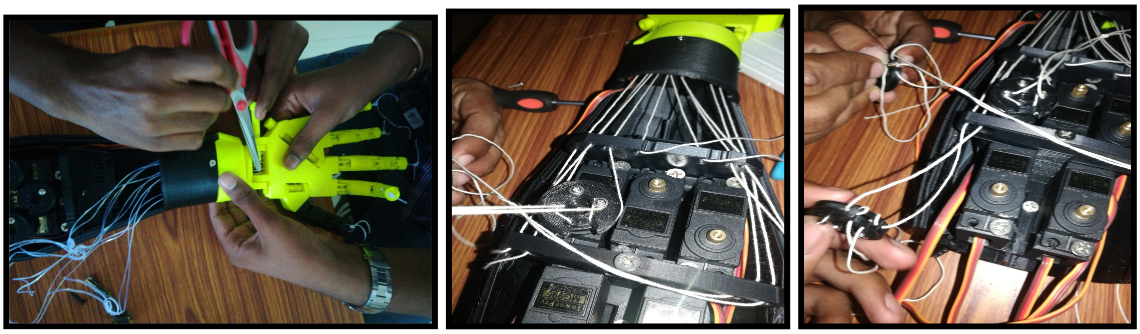


Fig 1.45: Next step in tensioning

Step- 6: Now the threads will reach the forearm, place through the desired holes of rob cable front and rob cable back such that it provides perfect tensioning.

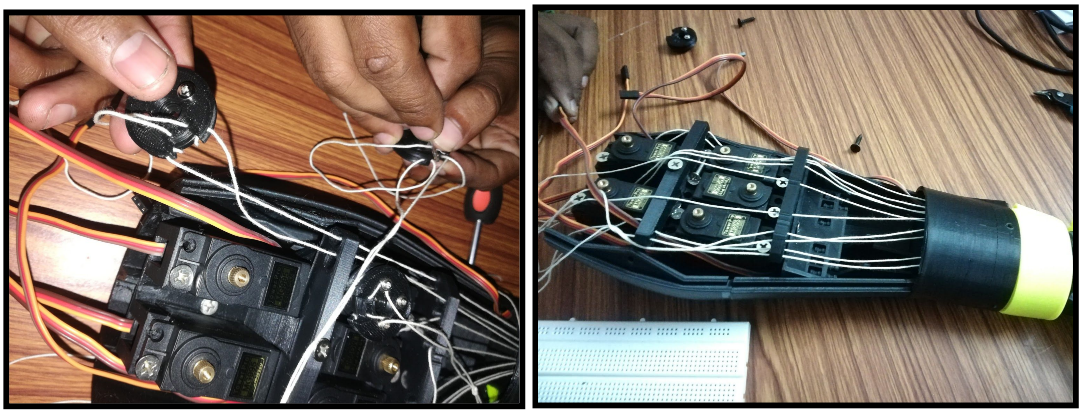


Fig 1.46: Passing the wire through servopulley

Step- 7: Now place the threads through the hole of the servo pulley from two sides, and pull that thread from bottom to top and then tighten the thread and bing it round the screw. We have not taken many photos in this phase, but I guess u will be able to understand.

Step- 8: We Checked all the above steps twice and then we watched the reference videos for assembling.

CHAPTER XI

EMG SENSOR PROCESSING

As we are creating a myoelectric prosthetic hand, we require an emg sensor to calculate the movements of muscles. We had gone through a lot of emg sensors and found that the sensor manufactured by the advancer technologies was perfect for our requirements.

11.1 ELECTROMYOGRAPHY

Measuring muscle activation via electric potential, referred to as electromyography (EMG), has traditionally been used for medical research and diagnosis of neuromuscular disorders. However, with the advent of ever shrinking yet more powerful microcontrollers and integrated circuits, EMG circuits and sensors have found their way into prosthetics, robotics, and other control systems. It is based on the simple fact that whenever a muscle contracts, a burst of electric activity is generated which propagates through adjacent tissue and bone and can be recorded from neighboring skin areas.

EMG measures the electrical activity of muscles during rest, slight contraction and forceful contraction. Muscle tissue does not normally produce electrical signals during rest.

The process, of course, begins in the brain. Triggering muscle movements begins in the motor cortex, where neural activity (a series of action potentials) signals to the spinal cord, and the information about the movement is conveyed to the relevant muscle via motor neurons. This begins with upper motor neurons that carry the signal to lower motor neurons.

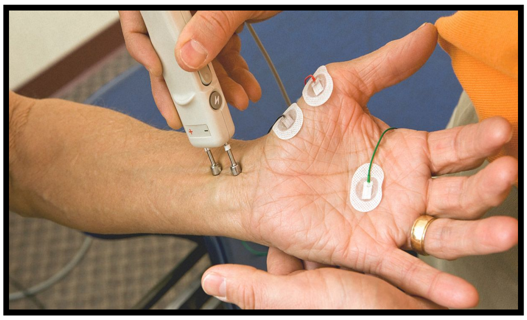


Fig 1.47: Electromyography

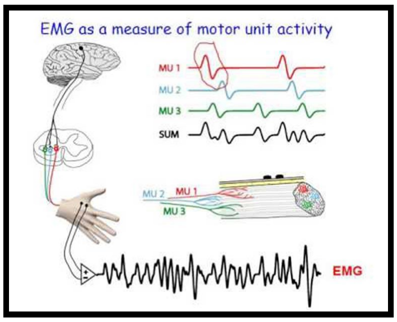


Fig 1.48: EMG sensor processing

11.2 WHAT DOES EMG SENSOR PROVIDE

EMG activity (measured in microvolts) is linearly related to the amount of muscle contraction as well as the number of contracted muscles – or in other words, the stronger the muscle contraction and the higher the number of activated muscles, the higher the recorded voltage amplitude will be.

As EMG activity is even measurable when we do not display obvious actions or even inhibit certain behaviors, EMG recordings represent an additional source of information into cognitive-behavioral processing which would be hidden based on pure observation fig 61.

CHAPTER XII

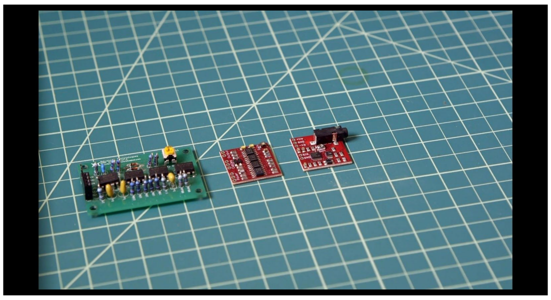
MYOWARE MUSCLE SENSOR

MYOWARE sensor is an emg sensor,which is used for sensing the muscle contractions, and converts that voltage to an analog range of values. We use that analog range of values to perform operations.

Fig 1.49: EMG sensor used(MYOWARE)

12.1 VERSIONS OF MYOWARE

Myoware is manufactured by advancer technologies, they currently release v4.0 of the myoware sensor. The last three versions of myoware were slightly heavy and had many connections, which made it difficult for carrying it. You can have a look at the images below.



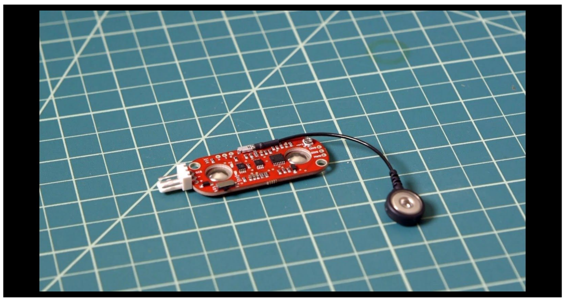


Fig 1.50: Previous versions of myoware **Fig 1.51: v4.0 version of myoware**

12.2 MYOWARE SHIELDS

Shields are nothing but external components that can be used for greater efficiency. Myoware consists of 4 shields.

- Led shield
- Power shield
- Proto shield
- Cable shield

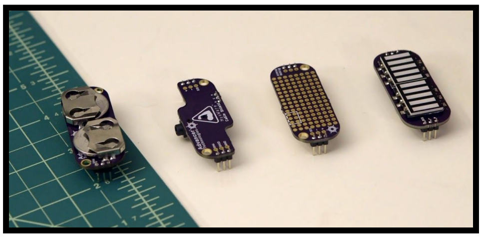


Fig 1.52: Various shields of myoware

12.2.1 LED SHIELD

The MyoWare LED Shield is designed to pair with the MyoWare Muscle Sensor. The blue 10-segment bar graph shows the magnitude of the measured signal. The more muscle activation measured, the higher up the board the lit LEDs will go. With this shield, you will be provided with a visual representation of the signals provided by the MyoWare Muscle Sensor and an on-board lithium polymer (LiPo) power source.

This shield is likely to be the top board in a stack, so solder on some 1x3 male headers and plug into the sensor board. The power is supplied on the LED shield but controlled by the power switch on the sensor. Once the stack is assembled, snap on some electrodes and stick the sensor on the target muscle.

Fig 1.53: Led shield

Fig 1.54: Power Shield

Fig 1.55: Proto shield

12.2.2 POWER SHIELD

The MyoWare Power Shield is designed to take two standard CR2032 coin cell batteries to power the MyoWare Muscle Sensor. We have made this board in a way that the coin cell batteries are connected in parallel for extended capacity at a nominal 3.0V. Connecting the MyoWare Muscle Sensor to battery power allows for a cleaner signal while also eliminating the possibility of creating a dangerous current path to the power grid.

One thing to note is that due to the size of the batteries, the remote cable header on the MyoWare Muscle Sensor can't be passed through. If you need access to these connections, this Power Shield will need to be stacked above the board(s) that need access fig 67.

12.2.3 PROTO SHIELD

This is the MyoWare Proto Shield, a simple proto-board for your MyoWare Muscle Sensor. With this shield, you will be able to use the area provided to solder on whatever custom circuitry you can come up with. This shield provides 8 x 15 solderable through-holes on a standard 0.1" grid.

The MyoWare Proto Shield is equipped with two rows of 3-pin plated through-holes on each end of the board. This allows for standard 0.1" headers to be used to stack the shield with other MyoWare boards fig 68.

12.2.4 CABLE SHIELD

The MyoWare Muscle Sensor is now designed to be wearable, allowing you to attach biomedical sensor pads directly to the board itself. However, there still may be cases where you want to mount the sensor pads away from the other hardware; this is where the MyoWare Cable Shield comes in. This shield provides a 3.5mm jack where you can attach a three-electrode sensor cable, allowing you to test and use the MyoWare Muscle Sensor without actually attaching it to your person.

The MyoWare Cable Shield is equipped with two rows of 3-pin plated through-holes on each end of the board. This allows for standard 0.1" headers to be used to stack the shield with other MyoWare boards.

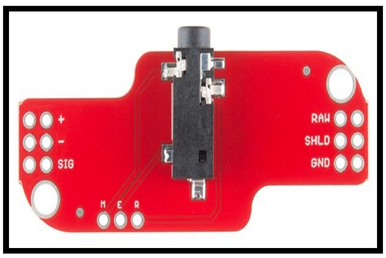


Fig 1.56: Cable shield

12.3 ABOUT MYOWARE

This muscle sensor from Advancer Technologies measures a muscle's activity by monitoring the electric potential generated by muscle cells. This is referred to as electromyography (EMG). The sensor amplifies and processes the complex electrical activity of a muscle and converts it into a simple analog signal that can easily be read by any microcontroller with an analog-to-digital converter (ADC), such as an A-Star or Arduino – or even a Maestro servo controller like we show in this blog post. As the target muscle group flexes, the sensor's output voltage increases. The exact relationship between the output voltage and the muscle activity can be fine-tuned using an onboard gain potentiometer.

The MyoWare Muscle Sensor is an updated version of Advancer Technologies' older Muscle Sensor v3 with a number of improvements, notably single-supply operation (no need for a negative voltage supply) and built-in snap connectors for electrodes. Other new features include a raw EMG output, reverse power protection, a power switch, and LED indicators.

In order to attach to the skin, the sensor requires three electrodes (not included) that snap into the sensor's snap-style connectors, which make it easy to attach and detach electrodes. Two connectors are located directly on the PCB, and the third is located at the end of the attached reference electrode cable. The board's pins have a 0.1″ pitch and work with 0.1″ male headers and 0.1″ female headers.

We had gone through the datasheet provided by advancer technology, when u read this you will understand everything.

12.3.1 SETUP INSTRUCTIONS

1) Thoroughly clean the intended area with soap to remove dirt and oil

2) Snap electrodes to the sensor's snap connectors (Note: While you can snap the sensor to the electrodes after they've been placed on the muscle, we do not recommend doing so due to the possibility of excessive force being applied and bruising the skin.)

3) Place the sensor on the desired muscle

- After determining which muscle group you want to target (e.g. bicep, forearm, calf), clean the skin thoroughly

- Place the sensor so one of the connected electrodes is in the middle of the muscle body. The other electrode should line up in the direction of the muscle length
- Peel off the backs of the electrodes to expose the adhesive and apply them to the skin
- Place the reference electrode on a bony or nonadjacent muscular part of your body near the targeted muscle

4) Connect to a development board (e.g. Arduino, RaspberryPi), microcontroller, or ADC a. See configurations previously shown

Fig 1.57: Taking values from myoware

12.3.2 SENSOR LAYOUT AND CONNECTIONS

The sensor has limited connections if we don't want to use the shields.It has 3 connections,first one is plus symbol on the sensor to Arduino voltage. Second one negative symbol connected to the ground on Arduino. Third, the signal pin is connected to the analog pin on Arduino. You can understand the layout and connections clearly in the figures below.

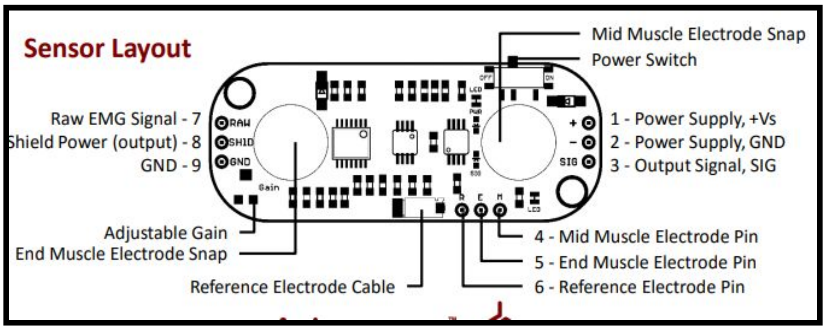


Fig 1.58: Sensor layout of myoware sensor

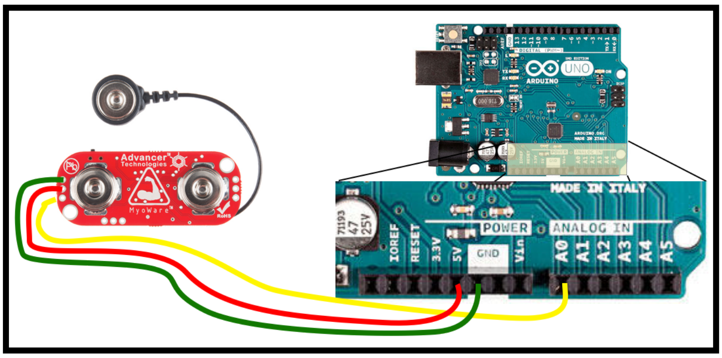


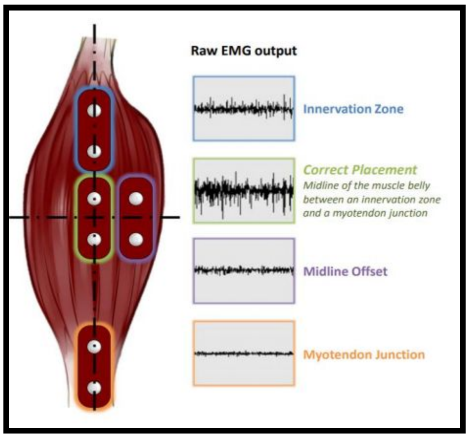
Fig 1.59: Sensor connections

12.3.3 WHY ELECTRODE PLACEMENT IS IMPORTANT

The position and orientation of the muscle sensor electrodes have a vast effect on the strength of the signal. The electrodes should be placed in the middle of the muscle body and should be aligned with the orientation of the muscle fibers. Placing the sensor in other locations will reduce the strength and quality of the sensor's signal due to a reduction of the number of motor units measured and interference attributed to crosstalk.

12.3.4 RAW EMG VS EMG ENVELOPE:

Our Muscle Sensors are designed to be used directly with a microcontroller. Therefore, our sensors primary output is not a RAW EMG signal but rather an amplified, rectified, and integrated signal (AKA the EMG's envelope) that will work well with a microcontroller's analog-to-digital converter (ADC). This difference is illustrated below using a representative EMG signal.



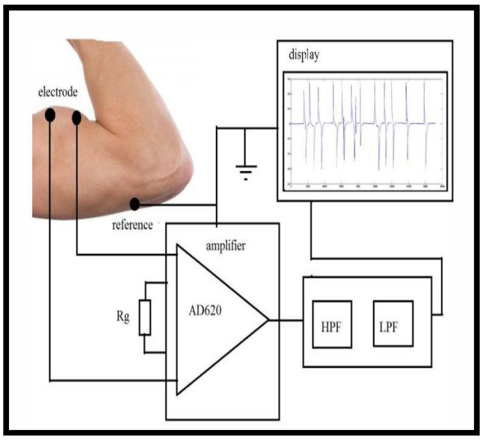


Fig 1.60: EMG Placement

Fig 1.61: Connection of electrodes

12.3.5 CONNECTING EXTERNAL ELECTRODE CABLES

This new version has embedded electrode snaps right on the sensor board itself, replacing the need for a cable. However, if the onboard snaps do not fit a user's specific application, an external cable can be connected to the board through three through-hole pads shown above. Middle Connect this pad to the cable leading to an electrode placed in the middle of the muscle body. End Connect this to the cable leading to an electrode placed adjacent to the middle electrode towards the end of the muscle body. Ref Connect this to the reference electrode. The reference electrode should be placed on a separate section of the body, such as the bony portion of the elbow or a nonadjacent muscle fig 74.

12.3.6 ELECTRICAL SPECIFICATIONS

This part plays a significant role because if the voltage is applied more than the sensor would be damaged. So we had gone through these specifications twice so that there will not be any problem.

Dimensions

Size:	2.1″ × 0.8″[1]
Weight:	7.5 g[2]

Fig 1.62: Physical Specifications

General specifications

Minimum operating voltage:	2.9 V
Maximum operating voltage:	5.7 V
Reverse voltage protection?:	Y
Supply current:	9 mA[3]

Fig 1.63: General Specifications

Parameter	Min	Typical	Max
Supply Voltage	+2.9 V	+3.3 or +5 V	+5.7 V
Adjustable Gain Potentiometer	0.01Ω	50 kΩ	100 kΩ
Output Signal Voltage EMG Envelope Raw EMG (centered about +Vs/2)	 0 V 0 V	 -- --	 +Vs +Vs
Input Impedance	--	110 GΩ	--
Supply Current	--	9 mA	14 mA
Common Mode Rejection Ratio (CMRR)	--	110	--
Input Bias	--	1 pA	--

Fig 1.64: Minimum and Maximum range of specifications

12.3.7 APPLICATIONS AND FEATURES

Applications:

- Video games

- Robotics
- Medical Devices
- Wearable/Mobile Electronics
- Prosthetics/Orthotics

Features:

- Wearable Design
- Single Supply +2.9V to +5.7V
- Polarity reversal protection
- Two Output Modes EMG Envelope Raw EMG
- Expandable via Shields
- LED Indicators Specially Designed For Microcontrollers Adjustable Gain

12.3.8 TESTING CODE

```
void setup() {
  Serial.begin(9600);
}
void loop() {
  int current-voltage = analogRead(A0);
  Serial.print(current-voltage);
  delay(50);
}
```

CHAPTER XIII
SELECTION OF ACTUATOR

As we know we are using servos for the movement of fingers, we had a task to decide which servo would be suitable for the movement of fingers. We had gone through the pros and cons and the operating voltages and current required. We decided to use the servos of model MG995 Metal gear.

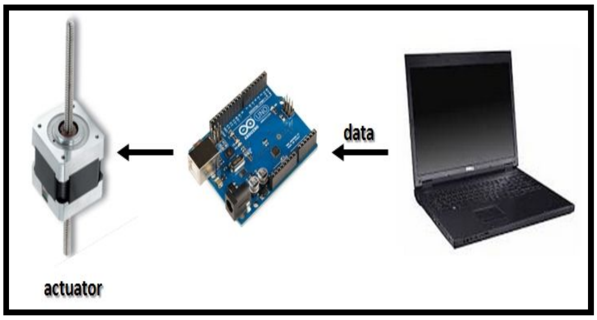


Fig 1.65: Process behind controlling the actuator

13.1 WHY MG995 SERVO MOTORS

It has metal gears which makes it robust and reliable motors. These TowerPro MG995 Metal Gear Servo Motors are the high-speed servo motors with the mighty torque of 10 kg/cm.

The optimized performance and reliability of this servo have made it the favorite choice of many.

The TowerPro MG995 High-Speed Digital Servo Motor rotates 90° in each direction making it 180° servo motor. It is a Digital Servo Motor that receives and processes PWM signal faster and better. It equips sophisticated internal circuitry that provides good torque, holding power, and faster updates in response to external forces.

Features :

- The connection cable is thicker.
- Equips high-quality motor.
- High resolution
- Accurate positioning
- Fast control response
- Constant torque throughout the servo travel range

- Excellent holding power

13.2 CONNECTIONS

Wiring:

- RED – Positive
- Brown – Negative
- Orange – Signal

Connections:

- The servo motor has a female connector with three pins. The darkest or even black one is usually the ground.
- Connect this to the Arduino GND.
- Connect the remaining line on the servo connector to a digital pin on the Arduino.

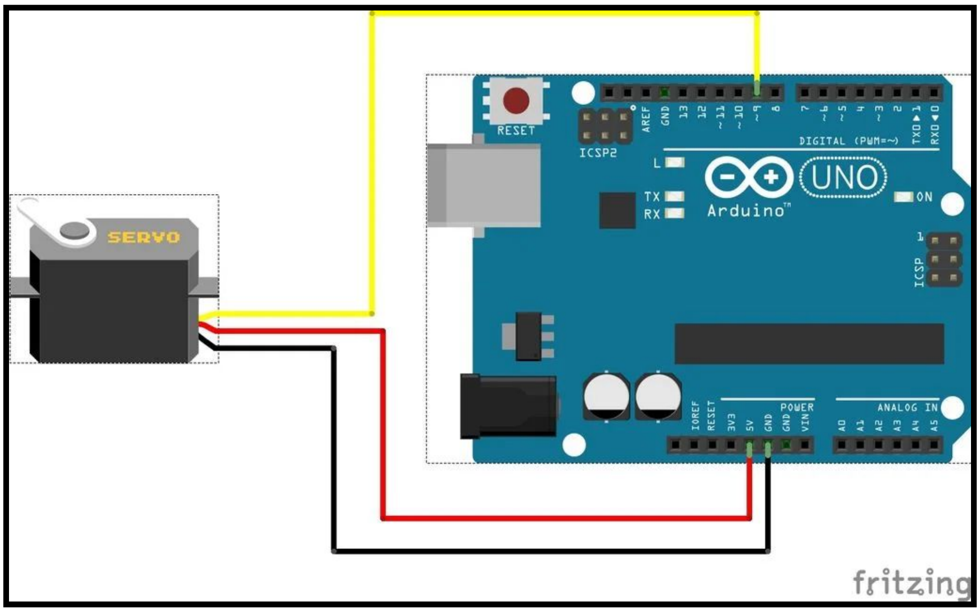


Fig 1.66: Connections of servo

13.3 SPECIFICATIONS

Model	MG995
Weight(gm)	55
Operating Voltage	4.8 – 7.2 V
Operating Speed @4.8V	0.20sec/60°
Operating Speed @6.6V	0.16sec/60°
Stall Torque @4.8V	10 kg-cm
Stall Torque @6.6V	12 kg-cm
Operating Temperature (°C)	-30 to 60
Dead Band Width	1 µs
Gear Type	Metal
Rotational Degree	180
Servo Plug	JR
Cable Length	30 mm
Length (mm)	40.5
Width (mm)	20
Height (mm)	44
Shipment Weight	0.175 kg
Shipment Dimensions	10 x 8 x 6 cm

Fig 1.67: Specifications of Servo motors

CHAPTER XIV

POWER SUPPLY

We need the power supply for a microcontroller, Emg sensor and also the servo motors.

We had gone through the specifications for all the above, as per basic ones we need 5v supply to Microcontroller and 3.3 to 5v for emg sensor. The major task for power supply comes here, each servo needs 5 v and 1200mA for each. So for a total of 6 servos, we need more than 9A of current and voltage of 5 to 6 volts. The stall current of MG995 servo is 1.5 amperes, which draws every time it starts to move. So we can use a regulator module which gives 5v voltage and 9A of current.

We are using an SMPS, and connected two modules(xl4015) which is voltage adjustable, and connected three servos to each module. We are still working to increase the efficiency of the servos with optimum current supply.

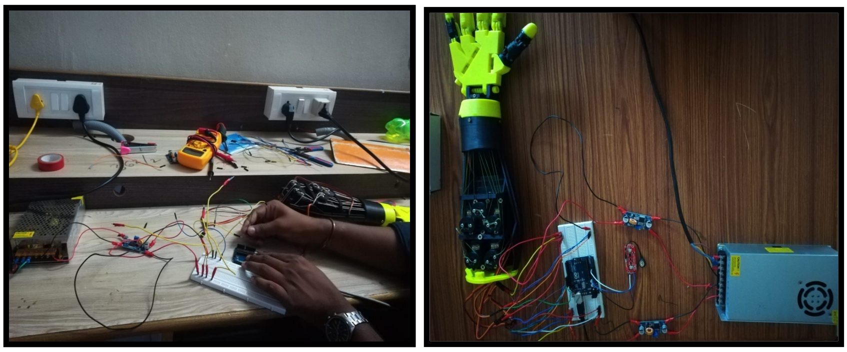


Fig 1.68: Connecting all the components

The other two components used for power supply are SMPS and xl4015 voltage step module.More details will be explained in the schematic and PCB design part.

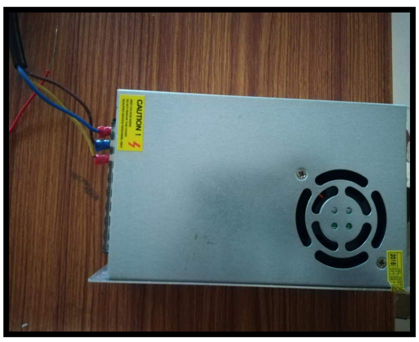


Fig 1.69: SMPS

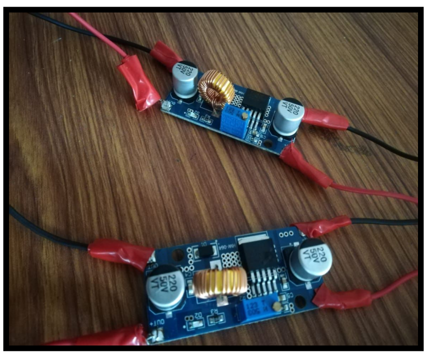


Fig 1.70: XL4015

CHAPTER XV

SCHEMATIC AND PCB DESIGN

We have not designed a PCB as of now, but if u design one for you it would be so handy. Since we wanted to showcase the functionality of the hand we wanted to focus and save time to improve the functionality.

Below is the circuit diagram of our connections. Let me brief you about that.

We have an SMPS that can provide 12 v and 10 A of current. So we feed this to the voltage adjustable module. We do this to give enough voltage to the servos. So this module allows us to adjust the voltage from 1.5 to 32 volts. So we used two modules of Xl4015 because each gives only a current of 5A. So for controlling 6 servos, we need two modules. You can get a detailed view of Output specifications in the below table.

COMPONENTS NAME	VOLTAGE	CURRENT
MYOWARE	3 - 5 V	9mA
MG995 SERVO	4 - 7 V	0.1 - 1.2 mA
SMPS	12 V	10 A
XL4015	1.2 - 32 V	5A

Tab -1: Output specs of all components

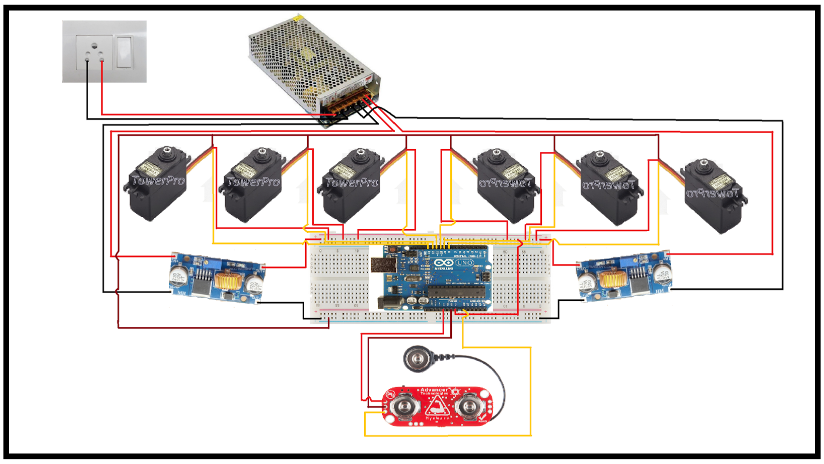


Fig 1.71: Circuit Diagram

CHAPTER XVI

CONSIDERATIONS

This section consists of all the considerations taken into account which consists of manufacturing, electronic and fabrication considerations. These are the snapshots of the template used.

Fabricated Part Check list

File Edit View Insert Format Data Tools Add-ons Help Last edit was on 31 October 2019

check list of all fabricated parts....

Part Number	Part Name	Quantity	Time Required	Mass	Dimention	Part Image	Status	Note
FABR001-IHPH	wrist part large	1	7hours 36min	53	89.2*119.4*18.9		Done	DONE
FABR002-IHPH	wrist part small	1	2hours 53min		62.0*80.8*17.7		Done	DONE
FABR003-IHPH	Index	1	1hour 53min		39.4*70.2*27.0		Done	DONE
FABR004-IHPH	Auriculaire	1	1hour 25min		33.8*60.3*23.2		Done	DONE
FABR005-IHPH	Majeure	1	2hour 17min		42.20*75.2*29.0		Done	DONE

Fig 1.72: Fabricated parts checklist

INNOVATIO HUB
(ROBOTICS RESEARCH CENTER)

BILL OF MATERIAL

Project: Prosthetic hand | Project id | IDIHBMPH

Part No.	Detail	Qty	Description	Item	Unit cost	cost
PURP001-IHPH	Micro USB Cable	1	USB A TO B	BUY	₹ 20.00	₹ 20.00
PURP002 -IHPH	self centered Screws	As Per Required	3 x 1/2 inch	BUY	₹ 55.00	₹ 55.00
PURP003 -IHPH	Bolt	12	M3 x 20	BUY	₹ 3.00	₹ 36.00
PURP004 -IHPH	Nuts	12	M3 x 20	BUY	₹ 3.00	₹ 36.00
PURP005-IHPH	Fishing line braid	2	90lb ,0.8 mm	BUY	₹ 15.00	₹ 30.00
PURP006-IHPH	Metal Rod	1	1m metal rod,3mm in diameter	BUY	₹ 80.00	₹ 80.00
PURP007-IHPH	Super glue	1	easily sticks plastic	BUY	₹ 85.00	₹ 85.00
PURP008-IHPH	Battery	1	2200 mah,11.1v,Lithium Polymer battery	BUY	₹ 1,200.00	₹ 1,200.00
PURP009-IHPH	Arduino	1	UNO	BUY	₹ 330.00	₹ 330.00
PURP010-IHPH	Servo motor	6	MG996	BUY	₹ 250.00	₹ 1,500.00
PURP011-IHPH	Jumper Wire	10	(M-M) set of 10	BUY	₹ 2.00	₹ 20.00
PURP012-IHPH	Jumper Wire	10	(M-F) set of 10	BUY	₹ 2.00	₹ 20.00
PURP013-IHPH	Jumper Wire	10	(F-F) set of 10	BUY	₹ 2.00	₹ 20.00

Fig 1.73: Bill Of Material Template

BILL OF MATERIAL LINK:

FABRICATED PARTS CHECKLIST LINK:

CHAPTER XVII

PROGRAMMING

As u have seen above we have written two separate codes, one for taking analog values from myoware, and another one to control servo motors. Now we need to merge the two codes to get desired output..we can add our own functionality for the movement of the fingers.

So follow some basic steps so that you would not get any failures.

17.1 TAKING VALUES FROM MYOWARE

CODE:

```
void setup() {
  Serial.begin(9600);
}
void loop() {
  int currentVoltage = analogRead(A0);
  Serial.print(currentVoltage);
  delay(50);
}
```

17.2 SETTING THE POSITION OF ALL SERVOS TO ZERO

CODE:

```
#include <Servo.h>
Servo myservo; //creating object
Servo myservo1;
Servo myservo2;
Servo myservo3;
Servo myservo4;
Servo myservo5;
int pos =0; // variable to store the servo position
void setup() {
  myservo.attach(8);
  myservo1.attach(9);  // attaches the servo on pin 9 to the servo object
  myservo2.attach(10);
  myservo3.attach(11);
  myservo4.attach(12);
```

```
  myservo5.attach(13);
  myservo.write(pos);
  myservo1.write(pos);
  myservo2.write(pos);
  myservo3.write(pos);
  myservo4.write(pos);
  myservo5.write(pos);
}
void loop() {
}
```

17.3 NOW COMBINING BOTH FOR A UNIFIED OUTPUT CODE:

```
#include <Servo.h>
Servo servo_1;
Servo servo_2;
Servo servo_3;
Servo servo_4;
Servo servo_5;
Servo servo_6;
void setup ()
{
  Serial.begin(9600);
  servo_1.attach(8);
  servo_2.attach(9);
  servo_3.attach(10);
  servo_3.attach(11);
  servo_3.attach(12);
  servo_3.attach(13);
}

void loop()
{
  Serial.println(analogRead(0));

  if( analogRead(A0)> 500 )
```

```
{
  servo_1.write(70);
  servo_2.write(70);
  servo_3.write(70);
  servo_4.write(70);
  servo_5.write(70);
  servo_6.write(70);
}
else if
(analogRead(A0)< 350 )
{
  servo_1.write(0);
  servo_2.write(0);
  servo_3.write(0);
  servo_4.write(0);
  servo_5.write(0);
  servo_6.write(0);
}
delay(50);
}
```

OUR PRESENT PROTOTYPE

Fig 1.74: Front view

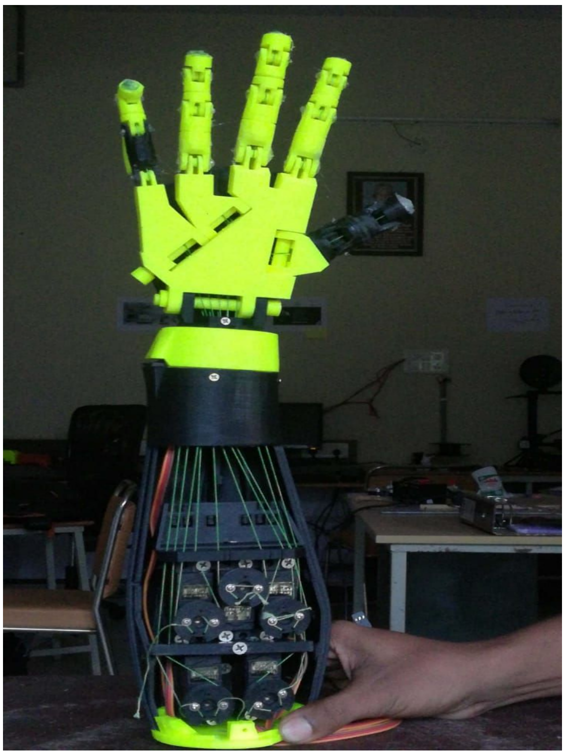


Fig 1.75: Back view

FUTURE SCOPE

We tried our best in improving the accuracy and scalability of our project, but in future we wanted to mainly focus on these areas:

- Increasing efficiency of the servos.
- Implementing various functionalities, according to the sensor values.
- Implementing computer vision.

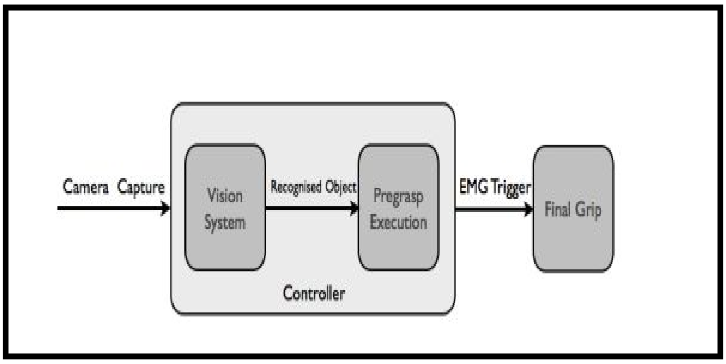


Fig 1.76: Flow diagram of Computer vision

- Implementing ROS / RPA.

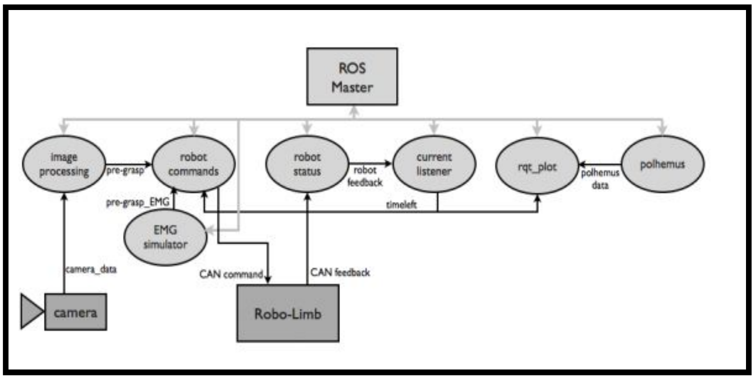


Fig 1.77: Flow diagram of Ros

- Mind Controlled prosthesis. (using EEG)- If electrodes can sense the electricity caused by muscle contractions, why can't they just go to the source of the information and measure the electrical signals carried in the nerves or even the brain? The answer is that they can, but recording from the brain and nerves is more challenging for several reasons. So there is a scope in this area, which could reduce or even close the gap between human hand and prosthesis.
- Besides this, we want to build biceps, that completes the whole hand. Step by step we wanted to build the entire inmoov body.

CONCLUSION

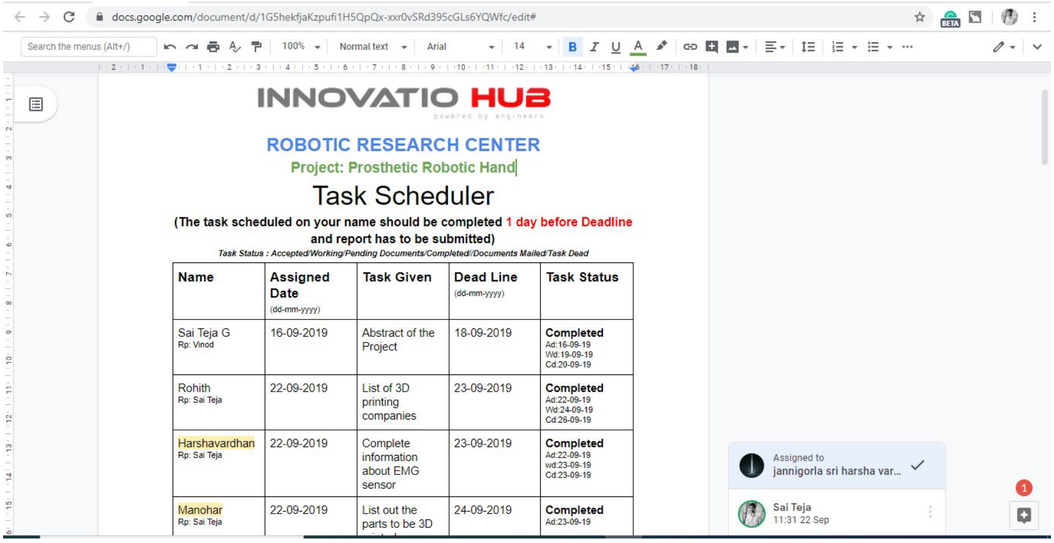
The prosthetic hand of the middle ages was present merely as a prop. Today we have bionic hand prostheses that give much better functionality, are acceptable to more patients and are durable and comfortable. However, these prostheses still have to overcome considerable hurdles in order to mimic or even improve upon the intrinsic hand and they carry significant economic implications.

The main goals of the project were to create low-cost prosthesis hand controlled by EMG signal from upper arm muscles. All goals have been achieved with different successes. The hand control using EMG signals has not been tested with the real patient which has lost its hand but only with healthy individuals. There is no collected data from real patient forearm and it is not possible to tell if muscle activity is enough for the sensor to detect the muscle activity. With better successes, feedback signals and low cost has been achieved. The visual feedback is provided by LED’s, the device has three LEDs that can be individually programmed to provide the user with information. In the prototype, the blue LED is used to display low battery warning and the other two show different stages of the device calibration. Haptic feedback is achieved with the small vibrating motor, that can be programmed to provide different information to the user, like the mobile phone. Although not everyone can afford a 3D printer, the technology is widely available at low cost or in some cases at no cost at all. For some examples, many educational institutions, hackerspaces, and charity organizations have a 3D printer available for use free of charge or by paying only for the used amount of the printing filament.

We can conclude like, we had developed a myoelectric prosthetic hand which demonstrates the functionality of the human hand. The disadvantage of this model is, its size-specific. It does not fit everyone. We don’t want to stop here. We want to continue our research and develop an accurate myoelectric prosthetic hand and step by step we want to build the inmoov robot. The solution to amputees is a prosthesis. Finally, mind-controlled prosthesis helps to close the gap between artificial and human hands.

PRACTICES

Task scheduler:



ROBOTIC RESEARCH CENTER

Project: Prosthetic Robotic Hand

Task Scheduler

(The task scheduled on your name should be completed 1 day before Deadline and report has to be submitted)

Task Status : Accepted/Working/Pending Documents/Completed//Documents Mailed/Task Dead

Name	Assigned Date (dd-mm-yyyy)	Task Given	Dead Line (dd-mm-yyyy)	Task Status
Sai Teja G Rp: Vinod	16-09-2019	Abstract of the Project	18-09-2019	**Completed** Ad:16-09-19 Wd:19-09-19 Cd:20-09-19
Rohith Rp: Sai Teja	22-09-2019	List of 3D printing companies	23-09-2019	**Completed** Ad:22-09-19 Wd:24-09-19 Cd:26-09-19
Harshavardhan Rp: Sai Teja	22-09-2019	Complete information about EMG sensor	23-09-2019	**Completed** Ad:22-09-19 wd:23-09-19 Cd:23-09-19
Manohar Rp: Sai Teja	22-09-2019	List out the parts to be 3D	24-09-2019	**Completed** Ad:23-09-19

Fig 1.78: Task Scheduler

REFERENCES

1. http://inmoov.fr/hand-and-forarm/ - (The parts required and procedure)
2. https://www.instructables.com/id/Servo-Controlled-Prosthetic-Hand/ - (Same as above)
3. https://www.youtube.com/watch?v=G4bmJK1GLrg&feature=youtu.be - (Homemade Flex Sensor Glove Controlled Robotic Hand)
4. https://youtu.be/uEd2B7fS8Eg
5. https://youtu.be/CIqzeBxkRws
6. https://youtu.be/TW4uw5EmYKQ(demonstration of myoware)
7. http://inmoov.fr/inmoov-stl-parts-viewer/?bodyparts=Left-Hand
8. https://drive.google.com/drive/mobile/folders/0B70A6QACCyueV0NrVHVpM1VLMVE?usp=sharing(Stl files)
9. https://drive.google.com/drive/mobile/folders/1e-wlQ0iiDdNyWz2fzkwzrQ9xNT1m0rEW?usp=drive_open(Stl files)
10. https://bluestampengineering.com/student-projects/sakura-d/ - BOM
11. https://drive.google.com/drive/mobile/folders/1FF5rWKKoE2A9jPiYpQXlUX7BQGU-XwOV?usp=drive_open
12. https://drive.google.com/file/d/1WEyg9SAvWWDY-3mp16LcI8IeZA7E1Kpf/view?usp=drive_open(Wireless controlled robotic hand using transmitter and receiver)
13. https://youtu.be/TW4uw5EmYKQ
14. https://www.makerguides.com/fsr-arduino-tutorial/ - force sensor
15. https://pimylifeup.com/arduino-force-sensing-resistor/ - force sensor
16. https://www.instructables.com/id/Making-an-InMoov-Left-Hand/ - assembling of hand