

**PROJECT REPORT ON**  
**Design and fabrication of a bionic arm.**

**SUBMITTED IN PARTIAL FULFILMENT OF THE**  
**REQUIREMENTS FOR THE DEGREE OF**  
**BACHELOR OF ENGINEERING**

**BY**

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**UNIVERSITY OF MUMBAI**  
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## **CERTIFICATE**

This is to certify that the project entitled  
**Design and fabrication of a bionic arm.**

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## **ABSTRACT**

There are anywhere from 10 million to 25 million amputees in the world, with an additional 250,000 added each year. India alone has more than 500,000 amputees. Out of a sample population 130, 77 per cent had bilateral amputation. Soldiers that protect us end up as amputees that eventually face numerous challenges. According to Indian medical experts, the robotic prosthetic limbs cost anywhere between Rs.40,000 and Rs.100,000. The causes for amputation include road accidents , polio , leprosy , land mines , mass panic , terror attacks etc.

Most patients stop using their prosthetic arms simply because it “It is not worth the hassle to carry it around”. Building a robotic prosthetic arm that can help them in all day to day life activities like holding a glass of water or holding onto a mobile phone. Even the smallest thing which can help make them independent counts .

Hence we aim to design and fabricate an arm for the bilateral amputee patients or a prototype that is easily available for the masses.

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# Chapter 1

## 1. Introduction

Bionic devices, including bionic arms, have been in science fiction for quite some time. So, we have used the idea that lost limb replacement should be possible and as easily accessible as just as easy as a cough treatment. From time to time we can read popular science publications that claim that controlled and fully usable prosthetic arms are just around the corner. Arms are so perfect and easy to use that it is possible to play the piano with them. But in reality, things are a bit different. We've read articles like that for fifty years now, but a real, working, accessible, and functional bionic arm is nowhere near for most people who'd need one. And even if they are available the price of the bionic arm is too high.

In reality the development of bionic arms lags behind the development of bionic knees. This is because a human arm is much more sophisticated than a leg, and the desired general functions of an artificial arm are not as straightforward as those of legs - walking and running. This doesn't mean that bionic legs are easy to design, it just implies that it is possible to make software that figures out the desired response from an artificial knee by monitoring values like acceleration, speed, applied load, or by mimicking the sound leg. It is not possible, however, in case of an arm; voluntary control is an essential requirement to achieve the functionality sought. So, in order to design a functional bionic arm one has to solve the difficult neural control problem as well.

Here we as a team strictly stick to the manufacture of a prosthetic arm firm which is easily available at a cheaper budget cost and then figure out the way to interface the brain to the arm by using myoelectric sensors.

### 1.1 History of prosthetic arms

The evolution of prosthetics is a long-storied history, from its ancient start to its current present, to the exciting visions of the future. As in the development of any other field, some ideas and inventions have worked and been expanded upon, such as the fixed-position foot, while others have fallen by the wayside or become obsolete, such as the use of iron in a prosthesis. Attached below is the pictorial representation of how the bionic arm and leg have evolved since the Stone Age era.



**Fig 2.1** Evolution of prosthetics

As shown in the above figure, the most common method used by an amputee was the use of a wooden support which is even famous today amongst various masses who cannot afford fully functional prosthetic arms .

The long and winding road to the computerized leg began about 1500 B.C. and has been evolving ever since. Since then, there have been many refinements to the first leg and hand hooks that have led to the highly individualized fitting and casting of today's devices. As depicted in the second half of the above figure the idea of using a hand-hook for certain functional requirements was incorporated by the human. This was a significant improvement as compared to the original wooden stand that would just provide stability and no functionality. Even today the "Jaipur Boots" that only provide a little stability are completely made up of plastic . This just gives the common user a feel

of an arm or a leg but provides no functionality.

The Egyptians were the early pioneers of prosthetic technology. Their rudimentary, prosthetic limbs were made of fiber and it is believed that they were worn more for a sense of “wholeness” than function. However, scientists recently discovered what is said to be the world’s first prosthetic toe and it appears to have been functional.

## **1.2 The types available today**

The main types of arm prostheses are categorized as transradial or transhumeral. Transradial prosthetics attach below the elbow, while transhumeral prosthetics attach to the upper arm when the elbow joint is missing.

### **1.2.1 The transradial prosthesis**

Transradial amputation is the partial amputation of the arm below the elbow, at some point along the radial bone. This type of surgery leaves your elbow and most of your arm intact, which makes recovery easier and makes it more likely that you will be able to continue to use your arm even after the amputation.

After amputation, one would most likely be fitted with some type of prosthetic. There are 3 basic types of transradial prostheses:

A cosmetic prosthesis is for appearance only and does not move.

A conventional (or body-powered) prosthesis is connected to the body by a series of cables. By moving your body in different ways, it is possible to move the prosthesis and even open and close the artificial hand.

A myoelectric prosthesis is the newest and most advanced form of transradial prosthesis. It connects an electronic hand to the muscles in your arm. As the muscles contract, electrodes send a signal to the artificial limb, causing it to move in much the same way as your real hand.



**Fig 2.2.1** Transradial prosthesis

### **1.2.2 Transhumeral prosthesis**

A transhumeral prosthesis is a prosthesis designed for people with an arm amputated above the elbow. It is available in electronic and mechanical versions. The design has a functioning elbow that can be used for bending the arm.

It is attached above the elbow. Amputations above the elbow constitute a special challenge since the function of the elbow has to be replaced in addition to that of the hand.



**Fig 2.2.2** Transhumeral prosthesis

### **1.3 MOTIVATION AND SCOPE OF THE PROJECT**

Possessing a common interest in the field of design and having studied industrial robotics as a course and wanting to make the world a better place to live, we had a cumulative affinity towards fabricating a bionic arm for the amputees. After a fruitful brainstorming among the group, it was then unanimously decided to pursue the same topic further to accentuate our knowledge in the field of prosthetics.

In medicine, a prosthesis is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or congenital conditions. A typical prosthetic limb costs anywhere between \$15,000 and \$90,000, depending on the type of limb desired by the patient.

This was our main motivation for manufacturing an arm under a price range of Rs 15000 to Rs 20000 which can be afforded by everyone and can provide a bit of functionality along with stability.

Also we were admired by the fact that this project would cover all the basic aspects of mechanical engineering such as design using a CAD software, hands on experience of fabrication and manufacturing the product, and also automating it by using gear mechanisms and DC motors.

## **1.4 NEED**

Due to the increasing rate of amputations, there is an ever-growing demand for prosthetic limbs. Next to an immediate need for a person's initial prosthetic limb, multiple replacement limbs and repairs are necessary over a lifetime. For children, a prosthetic replacement is needed typically every 6-12 months. Adults need such a replacement every 3-5 years. This means that youngsters may need around 25 limbs throughout the course of their life, whilst adults will use up to 20 limbs

(Credits - Prosthetics Outreach Foundation, 2005).

In many developing countries like India, many limb deficient people are farmers, herdsmen, nomads or refugees who rely on physical labor for survival. Thus, having affordable and readily available prosthetic limbs is essential. Unfortunately, a prosthesis is very costly. A typical limb made in a developing country costs approximately \$1250 to \$1,875 USD. Our project aims at cutting the costs to as little as \$100-200USD. However, the costs over a lifetime of replacements and maintenance can still amount to thousands of dollars. This presents a major problem since the average family income in rural areas is typically around \$300 USD annually. It can take them over a decade to earn the money for an initial prosthesis

(Credits - Walsh, 2003)

All the above factors state that there is a sense of urgency for fabricating a low cost driven prosthetic arm.

## **1.5 Objectives**

Man depends upon his legs to support the body and to move it from place to place as occasion warrants. Since mobility is nearly Indispensable to most human activities, the loss of part or all of a leg—through accident, war, or disease—imposes serious limitations and has always made a replacement of some sort more or less of a necessity. Accordingly, artificial legs of one kind or another have been made and used since the most ancient times. As a result of the long-continued effort, leg prostheses have undergone progressive, if slow, development through the centuries, so that many

lower-extremity amputees have in the past been successfully restored to some - thing resembling a normal life.

The following are a set of objectives that need to be achieved during the entire course of this project

1. To study the different models of prosthetic arms already available in the market.
2. To come up with a most feasible design for the prosthetic arm so that it can be used without any severe complications.
3. To select the most suitable gear mechanism for the movement of the fingers.
4. Selecting an appropriate and cost-effective manufacturing method, as the entire objective of the project is to develop a cost-effective prosthetic arm.
5. Study and determine the most durable and lightweight material that can be used for the manufacture.

## **1.6 Applications of prosthesis**

1. To perform day-to-day applications like lifting certain weights.
2. To use the mobile phone and computer in which the thumb plays an important role.
3. Used by a wide range of people from army men to peasants.
4. Avoid unemployment due to the disability.
5. With future advancements the technology can be extended for animals as well as to provide them with increases stability
6. Most importantly, to not have the feeling of being an amputee.

## **Chapter 2**

### **Literature Review**

**Background:** Bionic prosthetic hands are rapidly evolving. An in-depth knowledge of this field of medicine is currently only required by a small number of individuals working in highly specialist units. However, with improving technology it is likely that the demand for and application of bionic hands will continue to increase, and a wider understanding will be necessary.

**Methods:** We review the literature and summarize the important advances in medicine, computing and engineering that have led to the development of currently available bionic hand prostheses.

**Findings:** The bionic limb of today has progressed greatly since the hook prostheses that were introduced centuries ago. We discuss the ways that major functions of the human hand are being replicated artificially in modern bionic hands. Despite the impressive advances bionic prostheses remain an inferior replacement to their biological counterparts. Finally, we discuss some of the key areas of research that could lead to vast improvements in bionic limb functionality that may one day be able to fully replicate the biological hand or perhaps even surpass its innate capabilities.

**Conclusion:** It is important for the healthcare community to understand the development of bionic hands and the technology underpinning them as this area of medicine will expand.

The human hand can perform a complex repertoire of sophisticated movements that enables us to interact with our environment and communicate with one another. The opposable thumb, a rarity in nature, has helped us achieve high levels of dexterity allowing our evolution to proceed rapidly over other creatures. To perform complex hand movements, we need to synthesize an enormous amount of information about our environment including fine touch, vibration, pain, temperature, and proprioception. The sensory and motor cortices span large, complex areas of the brain and are devoted to interpreting the vast sensory input and using it to fine-tune the motor control of over forty separate muscles of the forearm and hand. This delicate, sophisticated arrangement allows us to perform precision activities such as writing and opening doors whilst simultaneously avoiding noxious stimuli. Loss of a hand can devastates and unlike losing a leg the functional limitations following hand loss are catastrophic. The primary causes of hand loss are trauma, Dysvascularity and neoplasia.<sup>1</sup> Men are significantly more likely



than women to lose their hands with 67% of upper limb amputees being male. Upper limb amputations most commonly occur during the productive working years with 60% between the ages of 16 and 54. The functional demands in this patient group are high and their expectations of a prosthetic limb mirror this. A few hundred years ago a hand amputee would have been condemned to a hook prosthesis that had limited function and carried significant social stigma. However, today a hand amputee can expect a replacement hand that replicates a whole host of normal hand functions and looks remarkably life-like. Significant advancements in bionic hand technology have occurred and this field is now considered to be a triumph of medical engineering excellence.

## **2.1 Patient acceptance**

Older robotic design bionic arms could not be attached to the body. Instead, they had to be mounted on a desktop or chair. They were heavy and cumbersome with a variety of control input devices such as voice input or computer control that were unacceptable to many users. Currently available bionic hands can achieve a better range of functional grips including key, power, precision, index point and thumb park that confer far wider application of the replacements than previously achievable. The drawback is that extensive training with occupational therapy input is required to achieve successful function and despite this even the best bionic limbs still do not come close to replicating the complex intrinsic functions of the innate hand. Servicing bionic limbs requires specialist input and often requires the affected component to be sent back to the manufacturer. Introduction of modular components such as the limb Hand allow the individually powered digits to be removed for servicing so that the user can maintain some functionality with the remainder of the limb intact. Development of modular components has also meant that prosthetic replacements can be custom adapted for partial hand amputees that were previously unavailable. The perceived stigma arising from use of a prosthetic hand has been considerably reduced because of aesthetic improvements. Commercially available coverings range from the life-like to the futuristic. Coverings have been developed which can closely approximate the natural skin tones and appendages of the wearer or alternatively they can allow visualization of the metallic infrastructure beneath which is especially popular with military personnel. However the durability of the coverings requires diligent care and adds further costs to the prosthesis.

## **2.2 Motor control**

The human hand is by nature so complex that replicating its functions using a bionic device is a significant challenge. Controlling a bionic limb must be quick, easy and reliable

for it to have any advantage over a non-functioning alternative. The most basic, controllable, artificial limbs rely on a system of cables attached to a harness that the user wears. Motion of the residual limb relative to the patient's body controls the movement of the prosthesis. These limbs require the user to have enough strength to operate them and they are limited to a small repertoire of movements. However, they are cheap to produce and are relatively easy to use, so they can be a suitable option for people with low demands. Achieving a more complex set of movements relies on integration with a digital control method. These can be very basic, such as placing a controlling unit into the user's shoe, or very complex such as myoelectric control that interprets electrical activity in the neuromuscular of the limb stump to allow motion. Myoelectric control is the most widely used method of control in commercially available bionic limbs. It relies on complex algorithms to make sense of the massive amount of electrical activity in the stump, which is affected by everything from movement in the shoulder or elbow to the heartbeat. Techniques such as electrical pattern recognition can be used to activate whole muscle groups that form components of certain movements. For instance, electrical activity in the flexor compartment of the forearm will lead to flexing of the bionic hand. Nevertheless, learning how to use a myoelectrically controlled prosthesis can be time consuming and difficult and there must be enough electrical activity in the limb stump for them to work. Improving the accuracy of computer algorithms that decode the signals is a substantial area of research at present.

## **2.3 Conclusion**

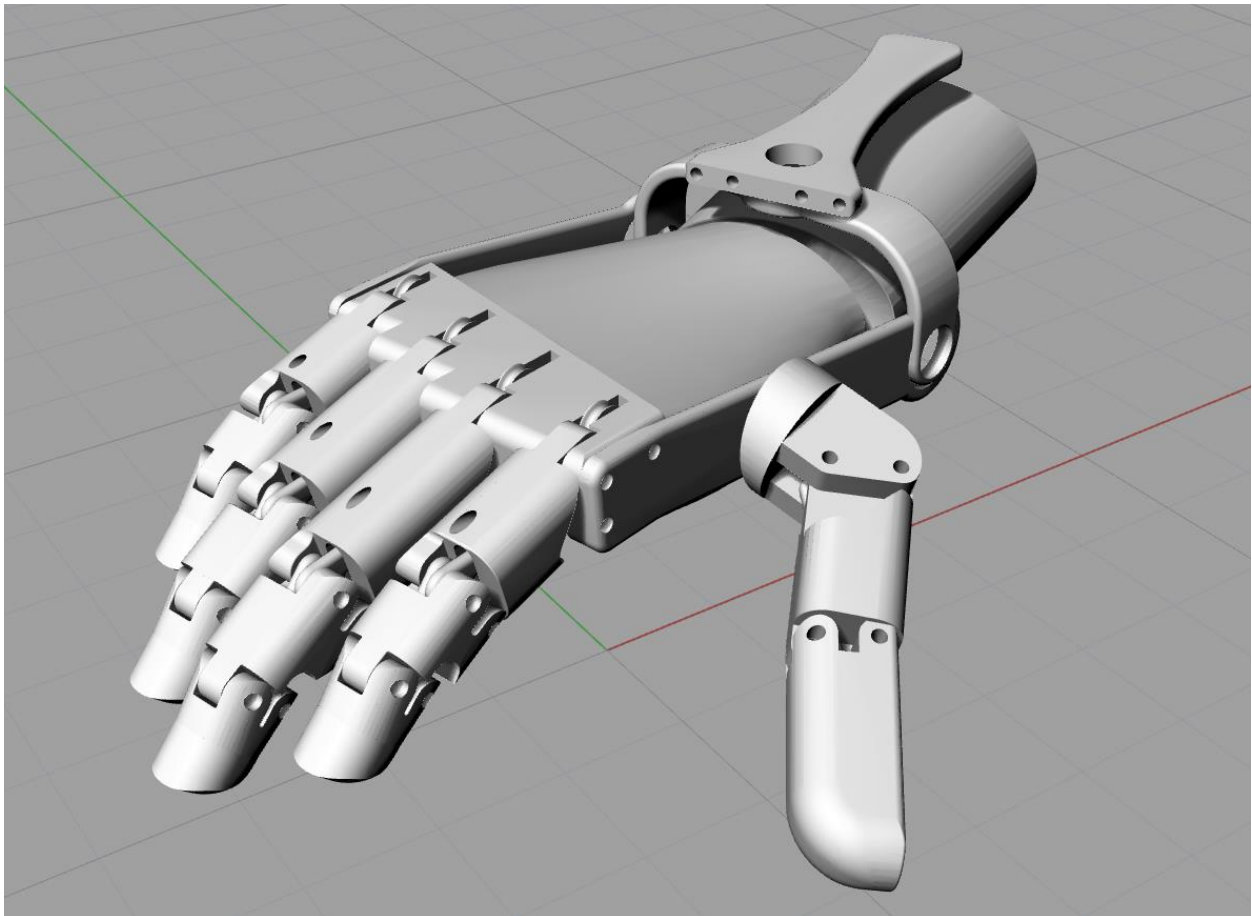
The prosthetic hand of the Middle Ages was present merely as a prop. Today we have bionic hand prostheses that give much better functionality, are acceptable to more patients and are durable and comfortable. However, these prostheses still have to overcome considerable hurdles in order to mimic or even improve upon the intrinsic hand and they carry significant economic implications. The advancements in this field of medicine are exponential and it is likely that within 10 years there will be commercially available limbs that provide both sensation and accurate motor control from day 1. The progress to bio artificial organs that are fully integrated into the central nervous system and have capabilities that surpass our own may still sound more like science fiction than science fact but can cohesive work between medicine, engineering and materials science make the world a better place to live?

## CHAPTER 3

### 3-D MODELLING USING SOLIDWORKS

#### 3.1 Introduction

This was the biggest challenge ahead of the team to design a hand with the most feasible design, so that it can be light weight as well have enough room for all the motors, gears, and other components. Here we decided to build the arm in such a way that it can accommodate 4 degrees of freedom (DOF).



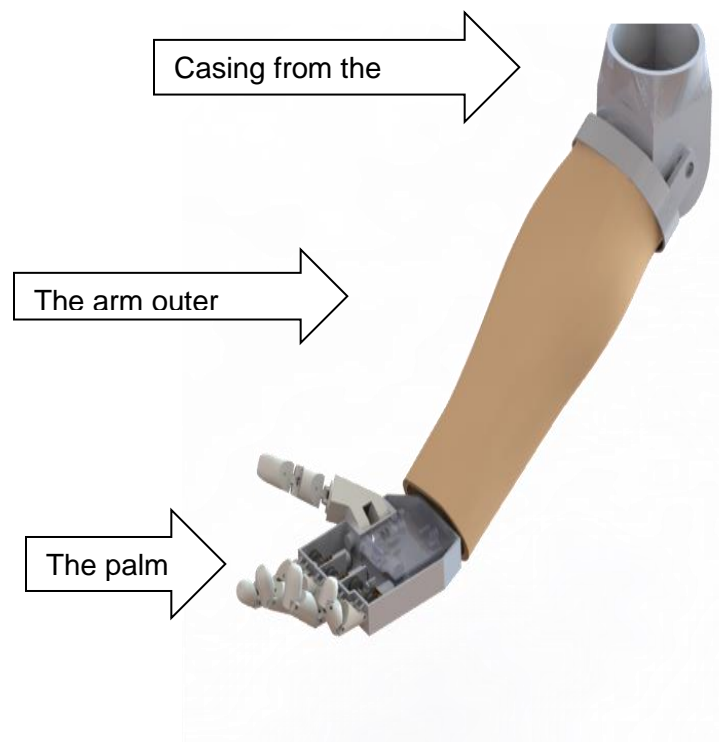
**Fig 3.1** Basic palm design with thumb (credits – open bionics)

There were a lot of designs currently available in the market from the very basic ones to the extremely complex ones. On research these were the ones we found to refer,

The above design is eye-catching mainly because of the thumb, as it was the most important and complicated part to design and link it with the rest of the palm.

### 3.2 Basic design

Taking reference from the above design, attached below was the first basic design that we were able to come up with.



**Fig 3.2** First draft of the model (Transhumeral)

As shown the initial design consisted of 3 major parts,

- 1) The casing from the elbow, where in would be the first attachment for the arm
- 2) The outer arm casing in which all the motors and the mechanical components would

fit in, hence the main motive was to make this portion as light in weight as possible so that the user gets added functionality.

3) The third and the last part was the palm which was the heart of the project and could be used for gripping and other activities.

### **3.3 Myoelectric prosthesis**

Myoelectric is the term for electric properties of muscles. A myoelectric-controlled prosthesis is an externally powered artificial limb that you control with the electrical signals generated naturally by your own muscles. Hand, wrist and elbow myoelectric components are available.

A myoelectric prosthesis uses the existing muscles in your residual limb to control its functions. One or more sensors fabricated into the prosthetic socket receive electrical signals when you intentionally engage specific muscles in your residual limb. Sensors relay information to a controller, which translates the data into commands for the electric motors and moves your joints. If muscle signals cannot be used to control the prosthesis, you may be able to use switches with a rocker or pull-push or touch pad.

The strength and speed of movements can be controlled by varying your muscle intensity. All of it happens in an instant. For those with damage to nerves or muscles in the residual limb or for people with no arms, muscles in the chest or back can be used to direct movements of a myoelectric prosthesis.

When a myoelectric prosthesis has several joints, each joint might need to be controlled by the same muscle. Sequential control allows positioning of one joint at a time. For example, you might use a muscle contraction to signal the elbow to bend, then use another contraction to signal the hand to close

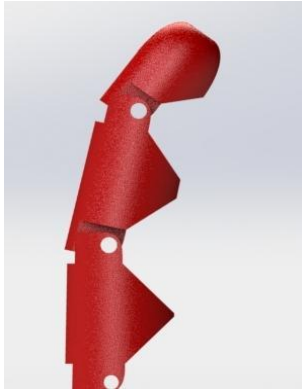
The initial design would require a lot of myoelectric sensors as well interfacing them with the neuro-cortex of the brain which becomes a tedious task for students. Also installing such sensors would cause a huge increase in the cost of the arm since the myoelectric sensors available are very costly. The entire budget of the project could be shifted up by at least \$10000-\$25000.

Hence as a cumulative idea we decided to design and fabricate the palm, as it is the most important element of prosthesis and will be able to provide the most suitable functionality to the product.

### 3.4 Final stage CAD models

After deciding to manufacture the arm we started working cumulatively on the design and attached below are the CAD models we were able to come up with.

#### 3.4.1 The index finger



3.4.1.1 Index finger



3.4.1.2 Exploded view

#### 3.4.2 The middle finger



3.4.2.1 Middle finger



3.4.2.2 Exploded view

#### 3.4.3 The little finger



**3.4.3.1** little finger

### **3.4.4 The ring finger**

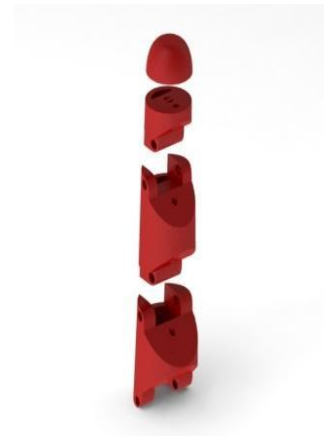


**3.4.4.1** Ring finger

### **3.4.5 The Thumb**



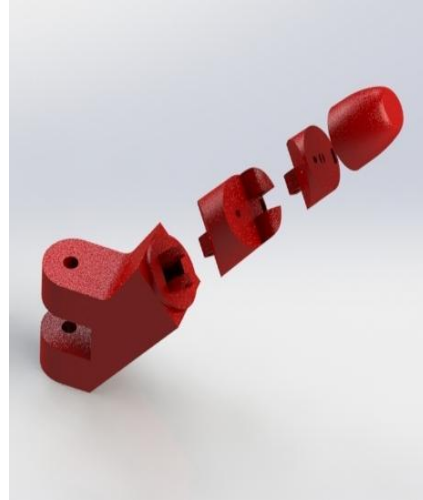
**3.4.3.2** Exploded view



**3.4.4.2** Exploded view



**3.4.5.1 Thumb**



**3.4.5.2 Exploded view**

Attached above were a set of pictures imported directly from solidworks which were designed cumulatively. Each of the five fingers consists of a normal view as well as the exploded view. The exploded view gives us an idea of the assembly to be done while assembling all the parts together.

As seen there are tiny holes in the parts that are to be drilled through during the manufacturing in-order to allow the string-gear mechanism to play its part in automation. This will be discussed later.

### **3.5 The palm**

The palm is basically the assembly of all the above fingers as shown. The small holes on the side of the fingers are for passing a shaft through it so that they are well attached to each other after manufacturing. Whereas the holes through the centre of the fingers are for driving a string through it for governing the automating mechanism.



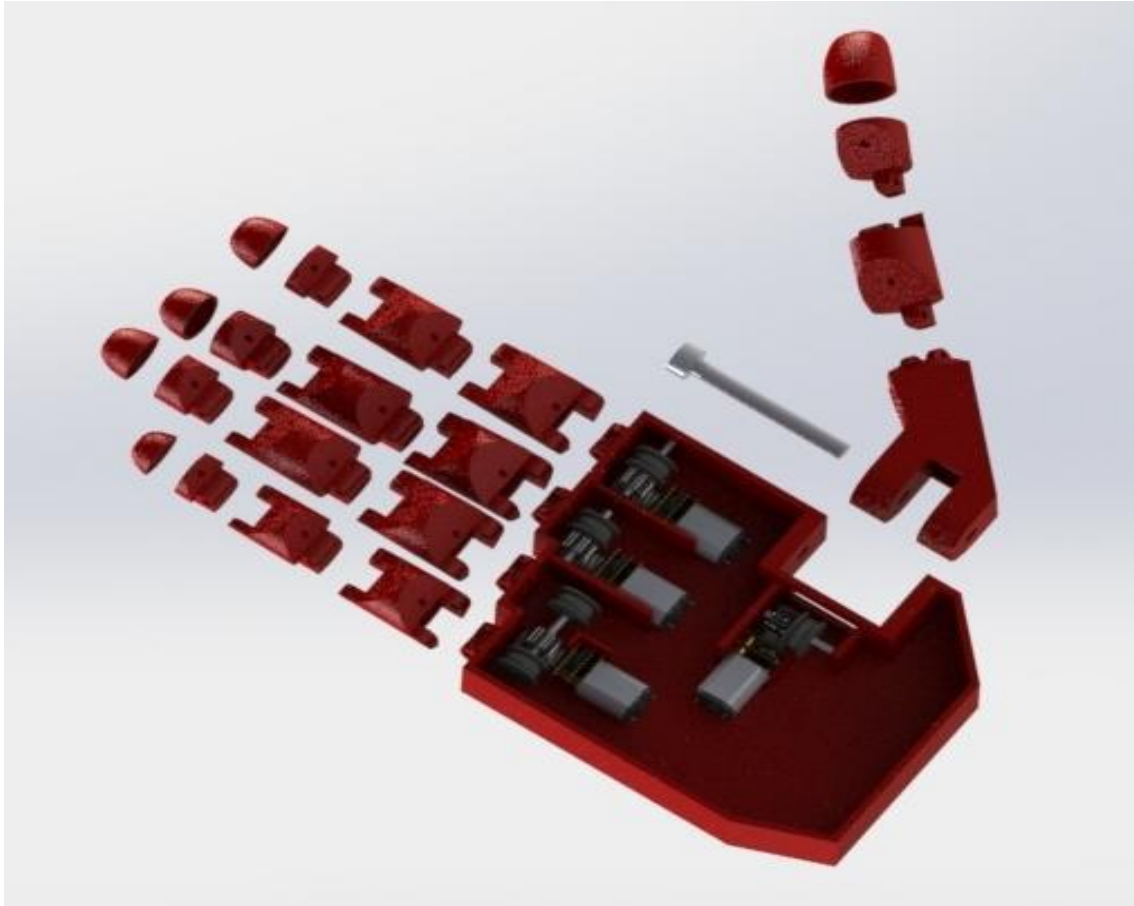


Fig 3.5.1

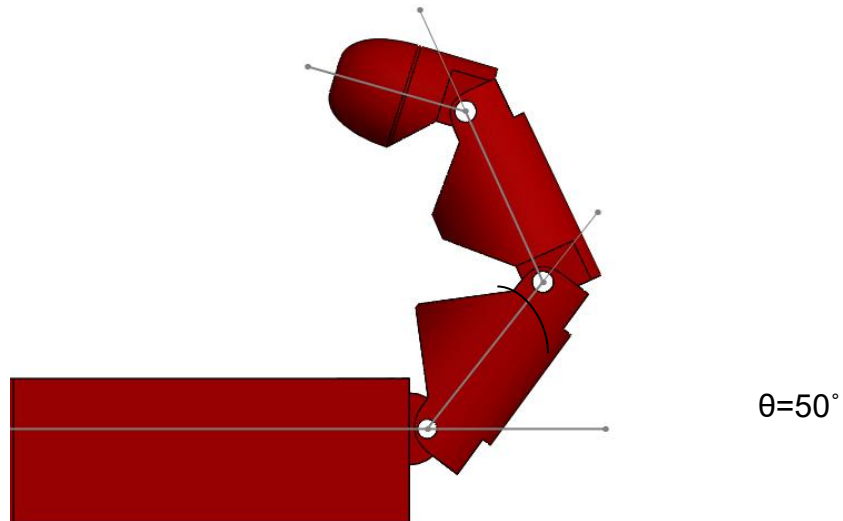
Here is the exploded view of the palm. It consists of all the components to be fitted inside it. The components are

- 1) DC motors
- 2) Worm and worm and spur gear arrangement
- 3) Shafts
- 4) Pulley

# CHAPTER 4

## COMPONENTS AND MECHANISMS FOR AUTOMATION

### 4.1 DC motors



Considering Index finger for calculation of motor power.

We assume time taken for the base of finger to rotate by  $50^\circ$  is 2 seconds

By Newton's kinematic equation for angular displacement

$$\theta = \omega_i t + 0.5 \alpha t^2 \dots\dots\dots (i)$$

$$\omega_o = \omega_i + \alpha t \dots\dots\dots (ii)$$

Since initial angular velocity ( $\omega_i$ )=0

$$(50\pi/180) = 0 + 0.5\alpha \times (2)^2$$

$$\alpha = 0.436332 \text{ rad/s}^2$$

Substituting  $\alpha$  in eq (ii)

$$\text{We get } \omega_o = 0.87266 \text{ rad/s}$$

$$\text{Now we have } N = (60 \times 0.87266)/2\pi$$

$N = 8.33333 \text{ rpm} \approx 10 \text{ rpm}$

Since we are using Worm Gear assembly the gear ratio = 1:14

Therefore motor RPM required:

$$14 \times 10 = 140 \text{ RPM}$$

Selecting standard micro geared motor of 200 RPM



**Fig 4.1** Standard 6V 200rpm micro DC motor

## 4.2 Pulley

Pulley used are standard pulleys available in market. Each pulley is made from LDPE so as to reduce the weight as well as the cost of the assembly.

Material: LDPE

Dimensions:

Outer Diameter:  $\Phi 12 \text{ mm}$

Inner Diameter:  $\Phi 2$  mm



**Fig 4.2** Standard pulley used in the mechanism

### 4.3 Gear system

One of the most challenging issues when using motors is to hold them in a position. Most of the motors use up power while in the holding position. So, we installed a **worm gear assembly**. The worm gear assembly serves dual purpose. It increases the gear ratio therefore increasing torque and it also serves as a self-locking mechanism.

Using the worm gear creates a gear ratio of 14:1, this helps in increasing torque of the motor which helps in holding and gripping objects placed in hand.

As a self-locking mechanism the worm gear reduces the electricity consumption of the motor by approximately 50%. This helps in increasing battery life and therefore prolong the working time of the whole palm.



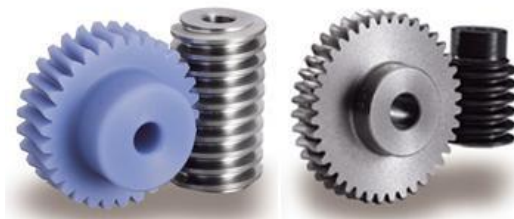
**Fig 4.3** Gear system used

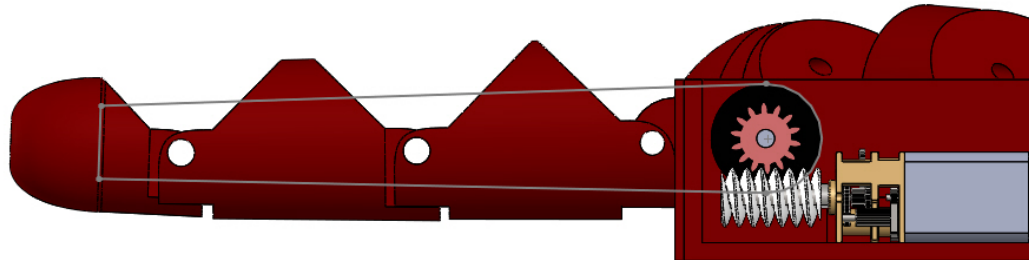
#### **4.4 Shafts**

Mild Steel shafts are used to connect the gear and the pulley together with a 2 mm diameter.

#### **4.5 The governing mechanism (CAD model)**

To raise and lower the fingers we are using a belt and pulley mechanism with a combination of worm gear assembly.



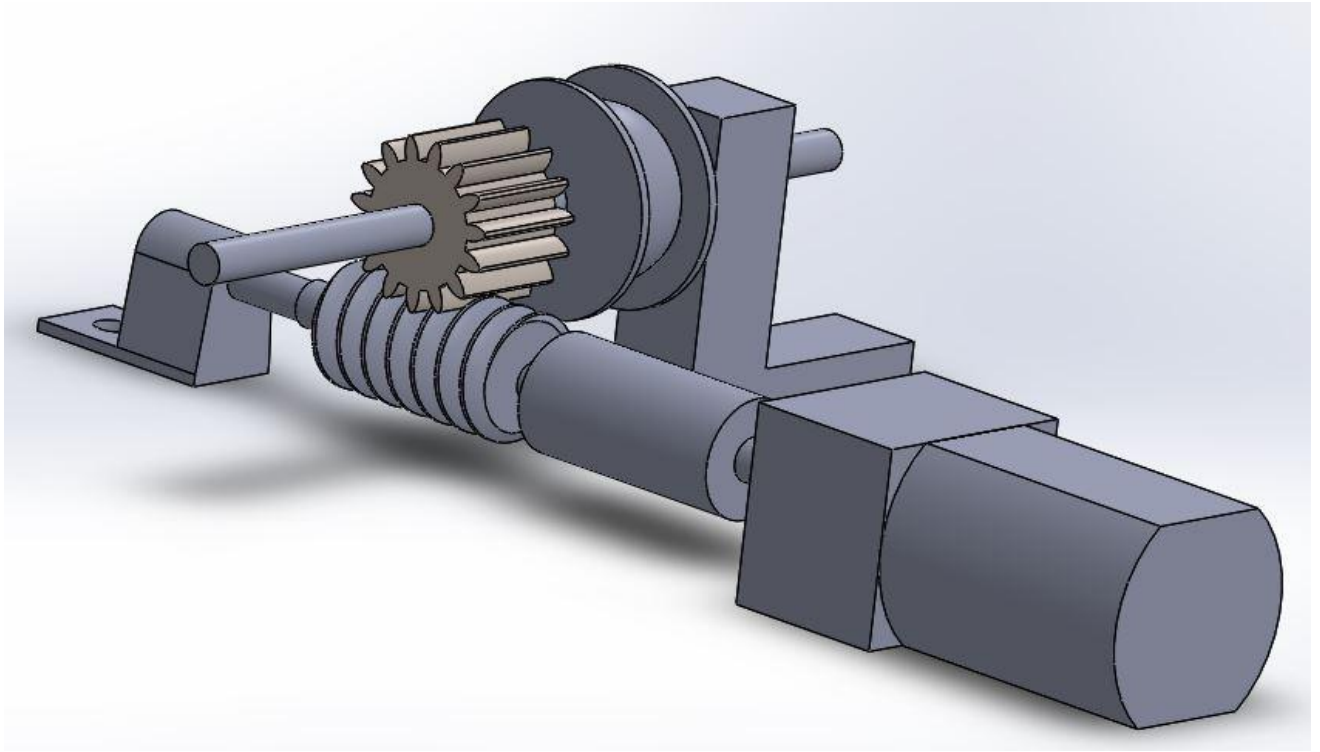


The DC motor of 200 RPM drives the whole mechanism. The motor rotates a worm gear that is directly attached to the motor shaft. The worm is in turn connected to a spur gear. The worm gear ratio is 14:1 and transmits a speed of 14 RPM to the spur gear.

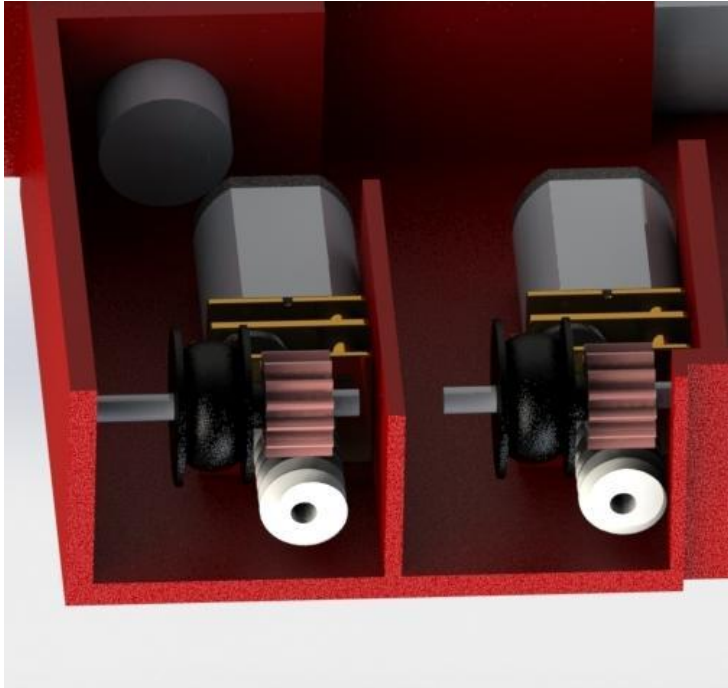
The spur gear is rigidly fixed with the pulley and therefore drives the pulley with the same speed. The pulley (black in the given figure) has a nylon thread of 2 mm diameter tied around it. The path of the nylon belt is shown by the grey line in the above figure.

For flexion of the finger the pulley is made to turn in clockwise direction which causes the upper side of the belt to come into tension and is pulled towards the pulley, this pull causes the topmost part of the finger to rise. When this part completes its rotation it stops being pulled and the next component i.e., the middle section is pulled, and it starts rotating and this process continues till the base of the finger is pulled and the finger is flexed.

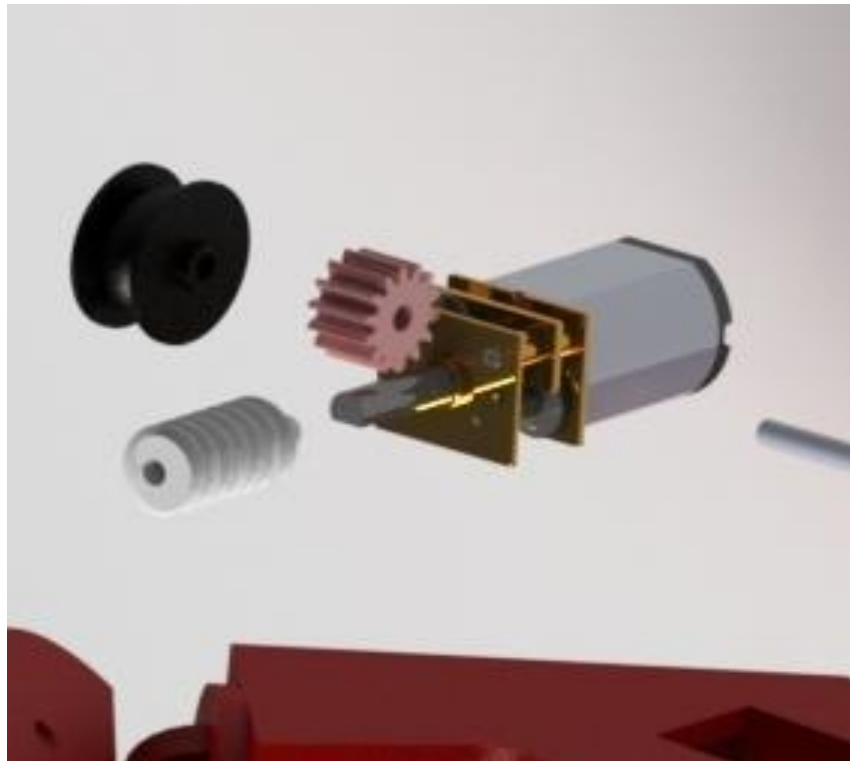
While, during extension the pulley is rotated in anticlockwise direction which causes the top side of the belt to slack while the bottom side comes into tension. The bottom side which is now in tension is pulled towards the motor and in turn pulls the base of the finger first which falls back, and the pull is transferred to the middle component and the process is repeated until the whole finger has achieved extension.



**Fig 4.4.1** CAD model of the gearing assembly



**Fig 4.4.2** Worm gear assembly as seen inside the palm



**Fig 4.4.3** Worm gear assembly in exploded view



## **CHAPTER 5**

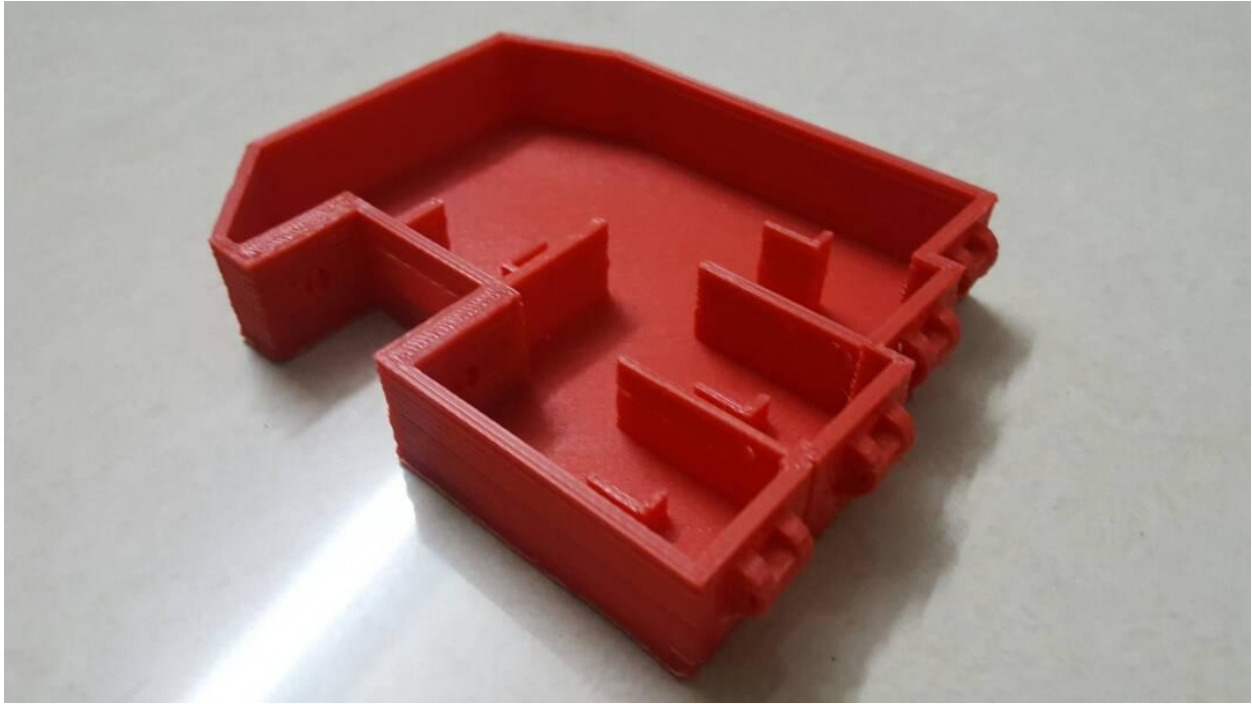
### **MANUFACTURING**

#### **5.1 3D printing**

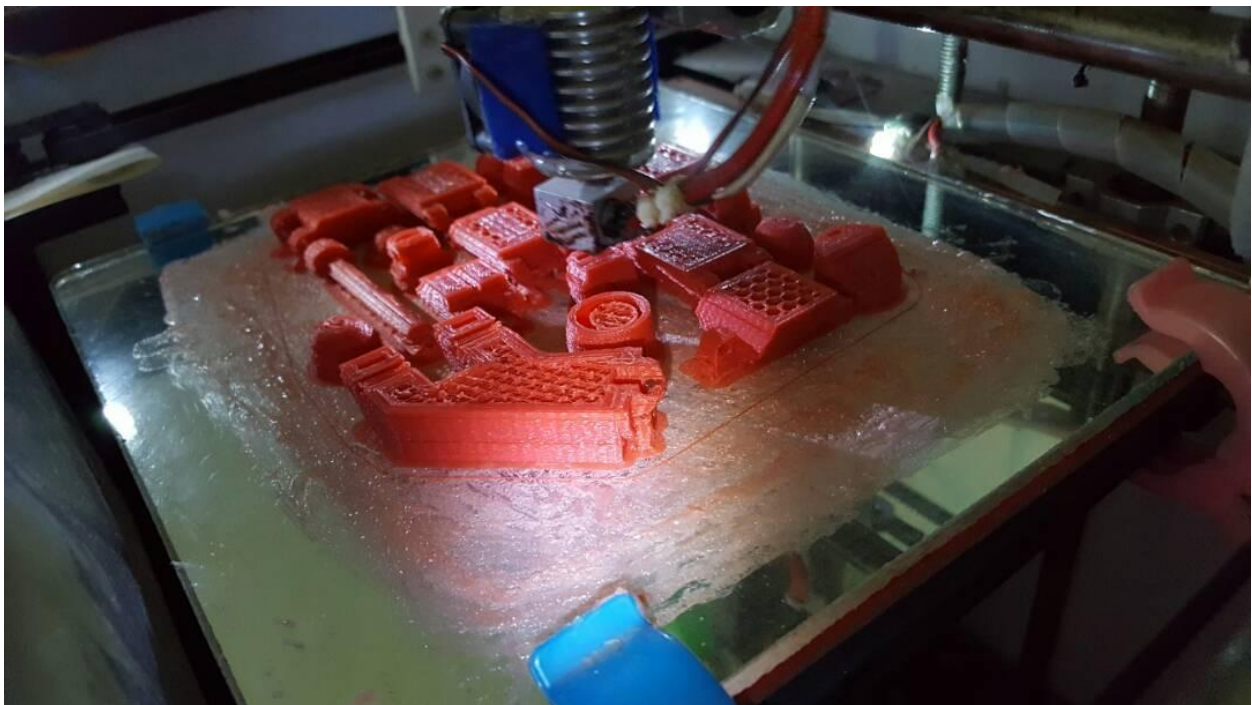
3D printing, also known as additive manufacturing (AM), refers to processes used to create a three-dimensional object in which layers of material are formed under computer control to create an object. Objects can be of almost any shape or geometry and are produced using digital model data from a 3D model. The term "3D printing" originally referred to a process that deposits a binder material onto a powder bed with inkjet printer heads layer by layer. More recently, the term is being used in popular vernacular to encompass a wider variety of additive manufacturing techniques.

Hence as a cumulative decision we took 3D printing as our option to get the required parts manufactured. The following were the main benefits that could be offered by 3D printing,

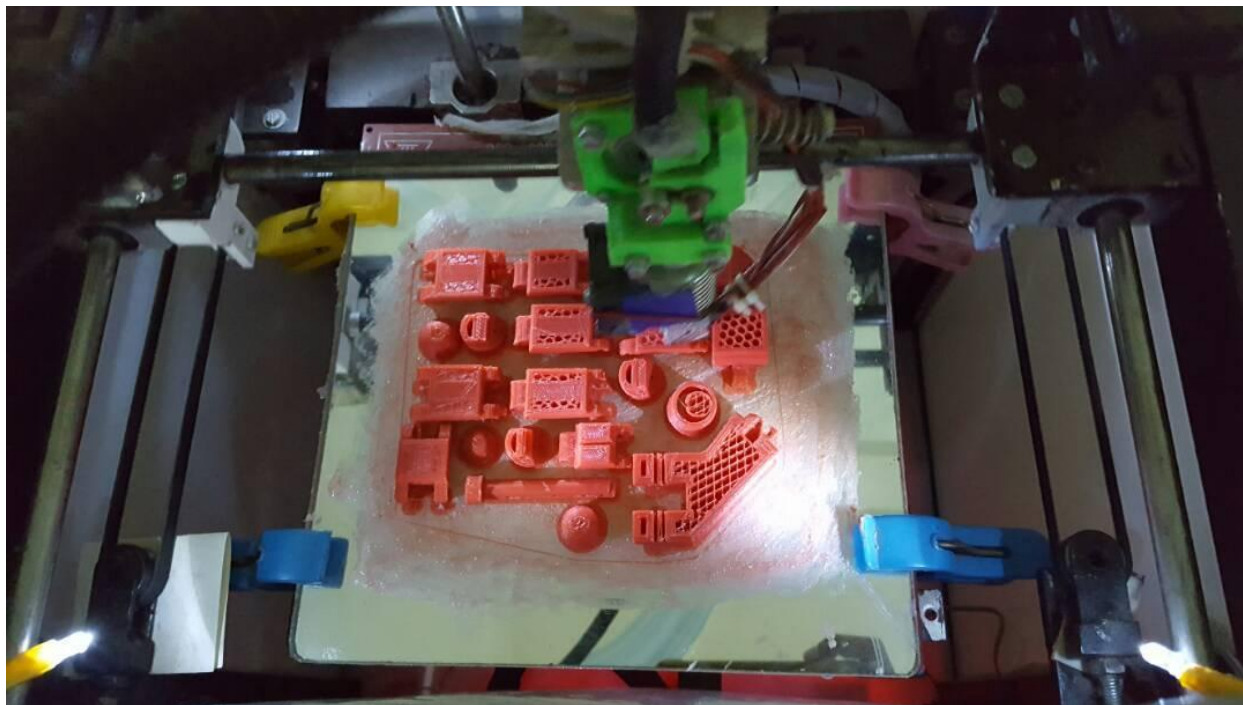
- 1) Save money, the entire process cost us only Rs 1200 which is very cheap as compared to the other methods of manufacturing.
- 2) We could use of our own choice of material, and hence we decided to go ahead with the ABS plastic as it was durable in nature and also had a great strength.
- 3) The process was comparatively faster as compared to any other process. Under a span of 24-28 hrs we had the fingers and the palm printed. This enabled us to have more time for other activities.
- 4) We were able to achieve 3D printing from a local college student, this helped us in saving the time and energy. We were also able to get it done at extremely concessional rates.



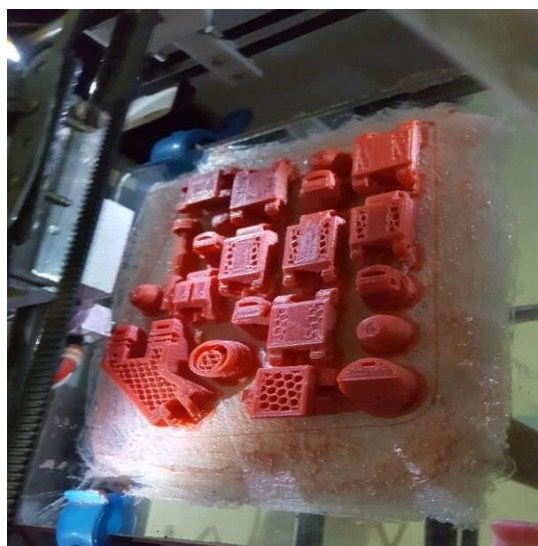
**Fig 5.1.1** Actual 3D printed palm



**Fig 5.1.2** 3D printed thumb



**Fig 5.1.3** in process 3D printing of the fingers



**Fig 5.1.4** Final models

## CHAPTER 6

### ELECTRONICS, INTERFACING AND AUTOMATION

#### 6.1 Arduino Uno

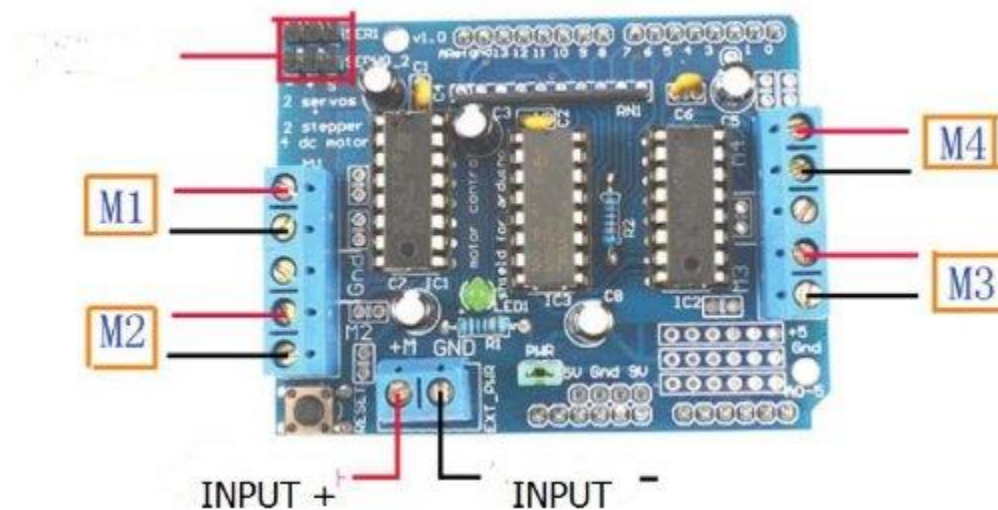
Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.



The above shown printed circuit board is an Adafruit motor driver. This pcb has the capacity to drive 4 dc motors simultaneously. It is a shield which can be directly mounted on an Arduino Uno board. It has a library of functions within it.

Arduino is a great starting point for electronics, and with a motor shield it can also be a nice tidy platform for robotics and mechatronics. Here is a design for a full-featured motor shield that will be able to power many simple to medium-complexity projects.

- **2 connections for 5V 'hobby' servos** connected to the Arduino's high-resolution dedicated timer - no jitter!
- **Up to 4 bi-directional DC** motors with individual 8-bit speed selection (so, about 0.5% resolution)
- **Up to 2 stepper motors** (unipolar or bipolar) with single coil, double coil, interleaved or micro-stepping.



Example: (This is a basic test function to control the motion of one finger)

```
#include <AFMotor.h>
```

```
AF_DCMotor motor(1);
```

```
void setup() {
```

```
    Serial.begin(9600);    // set up Serial library at 9600 bps
```



```

Serial.println("Motor test!");
// turn on motor
motor.setSpeed(200);
motor.run(RELEASE);
}

void loop() {
  uint8_t i;
  Serial.print("tick");
  motor.run(FORWARD);
  // for (i=0; i<255; i++) {
    motor.setSpeed(200);
    delay(7000);
  //}

  motor.run(RELEASE);
  // for (i=255; i!=0; i--) {
  //   motor.setSpeed(i);
    delay(500);
  // }

  Serial.print("tock");
  motor.run(BACKWARD);
  // for (i=0; i<255; i++) {
  //   motor.setSpeed(i);
  //   delay(10);
  // }

  // for (i=255; i!=0; i--) {

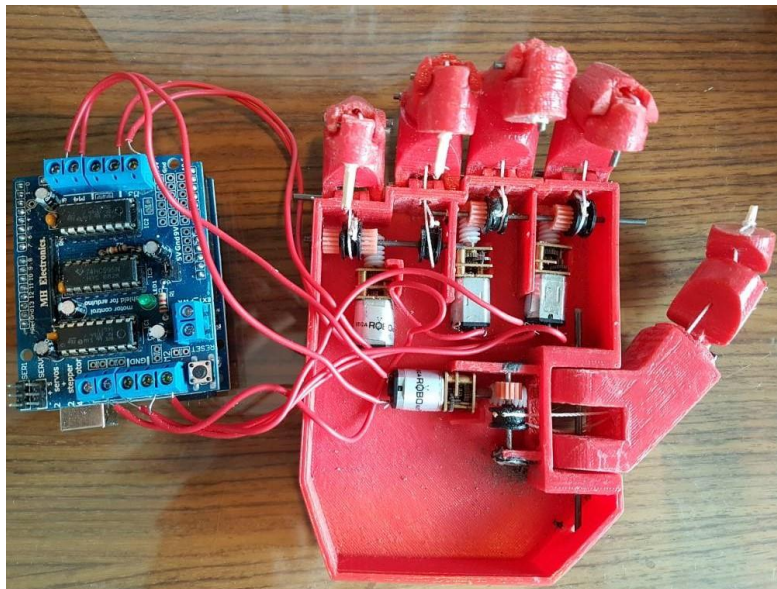
```

```

    motor.setSpeed(150);
    delay(6000);
// }
// Serial.print("tech");
    motor.run(RELEASE);
    delay(1000);
}

```

This is followed by a picture of the circuit diagram. It rightly shows the the Motor shield placed over Arduino Uno; motors ( finger flexion and extension actuators) connected to the motors shield. The shield is either power by a 9V High Power battery or an adaptor. The



**Fig 6.1** the motors synced with the arduino board

In this way the arduino board was interfaced with the motors. The arduino board requires its own power source every time. But it does not take up much of power consumption. It can very well function on the small amount of power available from laptops. In this way every time the board was powered on it was send the signals to the

motors as per the code written and power them on.

## CHAPTER 7

### OVERALL COST

#### Assembly Cost

Sr. No	Product/process	Cost	No.	Cost (₹)
1	3D printing			1500
2	DC motors	300	4	1200
3	Gears and Pulley	15	5	75
4	Arduino board	400	1	400
5	Motor Driver	400	1	400
6	Nylon Filament	25/m	1	25
	Total			3600

#### Auxiliary costs

Sr. No	Product/process	Cost	No.	Cost (₹)
--------	-----------------	------	-----	----------



1	SMPS supply	700	1	700
2	Electronics and components	500		500
3	Drill	1500	1	1500
4	Shafts	10	5	50
5	Other adhesives and components	250	1	250
	Total			3000

## CHAPTER 8

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