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SAMARTH: AN ADVANCED BIOMECHATRONIC PROSTHETIC HAND WITH ENHANCED DEXTERITY, AFFORDABILITY, AND USER EXPERIENCE

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Abstract

The development of prosthetic hands has evolved significantly over the past three decades, yet challenges remain in achieving optimal functionality, affordability, and user acceptance. This research paper presents the design and development of "SAMARTH," an advanced prosthetic hand that leverages biomechatronic and mechatronic principles to closely emulate the natural human hand in terms of both aesthetics and functionality. The prosthetic addresses critical issues such as high costs, limited functionality, and user discomfort associated with existing models.

SAMARTH integrates a lightweight design with an emphasis on biomimetic movement, incorporating a closed feedback loop system for enhanced sensory perception and control. The design process involved a comprehensive analysis of existing prosthetic hands, focusing on optimizing actuator systems to reduce complexity and weight while improving functional capabilities. The hand features a modular design, customizable appearance, and multiple control options, including electromyographic (EMG) sensors, voice recognition, and a touch screen LCD.

The hand's mechanical design replicates human anatomy with 27 degrees of freedom and utilizes innovative materials such as PLA+ for cost-effective production. Key features include sensory feedback mechanisms, varied grip patterns, and a customizable aesthetic to enhance user acceptance. SAMARTH aims to provide a practical, affordable solution for amputees, bridging the gap between high-end bionic limbs and accessible prosthetic technology. The paper discusses the challenges faced during development, including material availability and pandemic-related delays, and highlights how SAMARTH differentiates itself through its user-centric design and advanced features.

Keywords: Prosthetic Design, Biomechanics, Upper-Limb Prosthetics, Mechatronics, Prosthetic Hands, Pattern Recognition

1. INTRODUCTION

"A prosthesis is a device that is designed to replace, as much as possible, the function or appearance of a missing limb or body part."

Hand is one of the most important part of the human body which allows a number of tasks to perform operations like, examination, adaptation & exploration. The loss of a hand has two main penalties for the amputee: a severe reduction of the functionality (amputee is unable to carry out most of the grasping & manipulation tasks) and the commencement of psychological dilemma. In the last 30 years, several novel prosthetic hands have been developed and research is still going on. Surveys indicate that 30% to 50% of upper extremity amputees do not make use of their prostheses. Hence, in order to get over present prosthesis limitations and enhance the level of acceptability of the artificial prosthetic, the design of prosthetic hand must be implemented as close as possible to the human hand in terms of cosmetics, grasping ability, controllability. (S. A. Schurr et al. 2023) The hand should provide the user with the same functions of a natural hand: tactile exploration, grasping, and manipulation ("cybernetic" prosthesis).

Before developing this hand, we've analyzed and researched many previous designs and papers related to this topic and a good review of dexterous robotic hands. Existing dexterous artificial hands are primarily using conventional means of actuation and fabrication, which result in high system complexity and large weight, volume and fabrication time. In most of the cases studied, the actuators used do not have a biomimetic behavior and this creates human interface control problems. Finally, the actuators and transmission elements that are used in existing artificial hands do not provide several grips and gestures which are used in our daily life which should be easily functioned with muscles or any other functionality and this creates difficulty for the human operator and they are very expensive too. (F. X. Liang 2020)

In order to resolve the previously mentioned problems, we're developing a prosthetic hand - **SAMARTH**, using biomechatronic approaches and mechatronics principles to make the prosthetic hand that closely resembles the human hand along with its lightweight design to make it user friendly and effortless for its human operator. The design of the artificial hand is based on the idea of mechanically reproducing bone connection structure and ligaments. In the making, we've also contemplated the right balance between affordability & functionality keeping in mind our Indian customers. (S. A. Schurr et al. 2023)

2. PROBLEM SPECIFICATION

According to estimates, there are more than 57.7 million people living with amputations worldwide, India has more than half a million amputees, with tens of thousands added to the amputee population every year yet only a small fraction of them have access to prosthetic care and technology. The major reason is highlighted below:

- The price of bionic arms like Bebionic Hand & Atom hand available in the market ranges from $20,000 to $100,000 which makes it unaffordable for the majority of the amputee.
- Affordable hands offer only one or limited action, opening or closing generally have a very blocky appearance, and often have three fingers instead of five. This prosthetic hand does not provide proper functionality for the user.
- Lack of resources to detect the muscle signals precisely.
- Lack of Sensory feedback system
- There is a wide gap between affordability and functionality

3. OBJECTIVES

In order to resolve the previously mentioned problems, we came up with an idea of developing ***Arm Samarth*** using

- A biomechatronic approach, mechatronics principles, closed feedback loop system to make the prosthetic hand that can be as close as human hand.
- Maintaining proper balance between functionality and affordability
- Our main focus is to cure **Amputation Below elbow (ABE)** or Transracial Prosthesis. It is an artificial limb which replaces missing arm below the elbow.

The arm is made to help the disabled in every way it can because "Disability is not inability"

4. BACKGROUND

Till now we have worked on two myoelectric prosthetic hands which were also tested on an amputee. Our first prosthetic hand was based on a tendon mechanism with an open loop-controlled model which could open and close based on the muscle signals of the amputee. The given muscle signals can be calibrated for office mode, sports mode, home mode ,etc. that enables different gripping patterns for different applications. Initially we were lacking behind because of the open loop system. We had analyzed the need for a closed feedback loop system. That's why we have optimized our second prototype with sensory feedback that proved much more efficient than the previous one. As the approach had already been in the global market from the last few years and we also believe that the results found on the sensory feedback arm were quite efficient and needs proper technique for more precision.(M. B. Goldfarb 2021)

Fig. 1 Electric prosthetic hands

5. ANATOMY OF HAND

In order to define clear parameters for the operation of the bionic hand, it is necessary to examine the anatomy behind a functional hand. The aim of the project is to produce a bionic hand capable of replicating the movement of the hand as close as possible, so having some basic knowledge regarding the anatomy of the hand is essential. The motion of the hand should be biomimetic, meaning that the movement of the hand should visually appear human and realistic. (M. B. Goldfarb 2021)

The human hand has 27 degrees of freedom: 4 in each finger, 3 for extension and flexion, and one for abduction and adduction; the thumb is more complicated and has 5 DOF, leaving 6 DOF for the rotation and translation of the wrist. There are a total of 27 bones with 36 articulations and 39 active muscles. Most manufacturers of prosthetic hands limit their designs keeping less degrees of freedom considering its power consumption, bulkiness, weight, and control parameters, but as a biomimetic mechatronic hand, this project should aim to imitate the hand as closely as possible.(J. D. Kim and P. H. Singh 2021)

Each finger (not including the thumb) consists of four bones. The visible finger segments which protrude from the palm are called phalanges. Distal, Middle & proximal from tip to base respectively. In the palm, metacarpals attach each phalange group to a group of bones called the carpals at the base of the palm and these bones allow the wrist to rotate and translate on the radius and ulnar bones of the forearm. Much of the hand's actuation originates from muscles in the forearm, which move the hand using tendons attaching to the various bones of the hand,

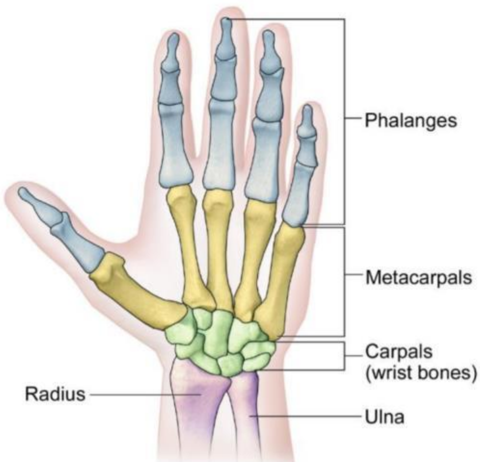


Fig. 2 Bionic hand

these are referred to as extrinsic muscles. Some motion comes directly from muscles inside the hand called intrinsic muscles.

6. MECHANICAL CONSIDERATION

6.1 Finger Linkage Design

The human hand was thoroughly studied visually and anatomically while grasping and handling many different objects. The entire designing process started with selecting the best mechanism for finger actuation. The adjustment and positioning of each finger are functionally very important in order to get a more life- like output without any interference. (J. P. Bell et al. 2020)

The presented finger design has one degree of freedom to control flexion and extension.

Fig. 3 Finger Linkage Design

6.2 Finger Routing

Two routings of nylon cables are used in each finger, one for closing and the other for the opening of the finger. Fishing line nylon cables are used which are capable of lifting heavy objects, nylon provides enough elasticity that prevents snapping of cable. The torque capacity of the cable is 10kg/cm which enables the fingers for lifting heavy objects.

The cables are routed from the distal phalangeal joints, where it is attached to a fixed point and directed through the middle, traveling from proximal phalanges into the pulley. In our first- generation prototype, we had only one pathway for both the cables. But that was generating more friction, to solve this problem our team evaluated & concluded to use two separate routings for each cable giving us optimum loss in friction enabling smoother motion. (J. P. Bell et al. 2020)

Fig. 4 Finger Routing

6.3 Finger joint

Phalanges in the biomechatronic hand are designed such that it resembles the human hand as close as possible. For this purpose, each finger is segmented into three phalanges just like in Human hand and the movement of phalanges is controlled by the cables.

Fig. 5 Finger joint

Phalanges are connected to each other through knuckle joints and pins. These knuckle joints are designed & calculated for stress to get the desired output without breaking. These are rigid to prevent wear and tear. It also provides smooth movement. For better grip, a Rubberized layer is coated over the fingertips. (J. P. Bell et al. 2020)

6.4 Thumb and Palm design

The thumb in a prosthetic hand plays a significant role in performing different grasp types, much like the important role of the opposable thumb in the biological human hand. Depending on the shape of the thumb, prosthetic hand users are able to perform different grasps such as fine pinch, normal pinch, handle, and power grip.

In order to realize the three, grasp types (pinch, handle and power), at least two degrees of freedom (DOF) are needed for the thumb, one for adduction/abduction of the thumb and the other for flexion/extension so we've used two actuators for both motions.
The thumb is mounted on the palm, inclined at 30 degrees w.r.t fingers. The thumb is rotated by a servo mounted in the palm and the bending of the thumb is controlled by a micro servo. The design of the palm is based on the human palm. The contribution of the thumb is mandatory in almost all gripping movements of a hand therefore thumb location is proposed in such a way that when it is closed, it points at the center of the palm.
It can couple up with three of the four fingers at any point of its flexion route to grip any object. Routings of cables are used for bending the thumb. (J. P. Bell et al. 2020)

Fig 6. Thumb and Palm design

In the last prototype, all the servo actuators for the motion of fingers were situated in the forearm; it took the majority of the arm space but in our upgraded arm we've kept a modular design, making it less complex and easy for maintenance; we have efficiently packed all the actuators in the palm. This was possible by using micro metal gear servos instead for MG966R which takes far less space providing more than required torque**.**

6.5 Wrist and Forearm

For wrist rotation we have made a 2DoF motion platform by using linear actuator ACTUONIX PQ-12-R and Mg996r servo motor that makes a similar motion to the real human wrist.
The size of the linear actuator is compact that can easily be fitted in the palm and adding the torque capacity of such a small linear actuator is around 10kg/cm and the torque of servo is also around 10kg/cm which makes it perfect for holding little heavy objects.
In our last prototype we used 3 linear actuators for the wrist motion but this time we've reduced it to just one linear actuator and one servo motor because using 3 linear actuators exerts load on the hinge of the linear actuator which can break when additional load is applied. (T. S. Parker and L. K. Nguyen 2021)
The forearm houses one servo, battery compartment, and all the electronic components. The forearm's design is kept modular so that its maintenance becomes easy and doesn't require much time.
On the upper part of the forearm, we have added a microphone for voice controlling operations. Two slots are provided in the forearm, one slot particularly for charging the prosthetic hand, and another port which enables Qualcomm 3.0 fast charging. So that one could even charge the Smartphone and electronic accessories with their prosthetic hand.

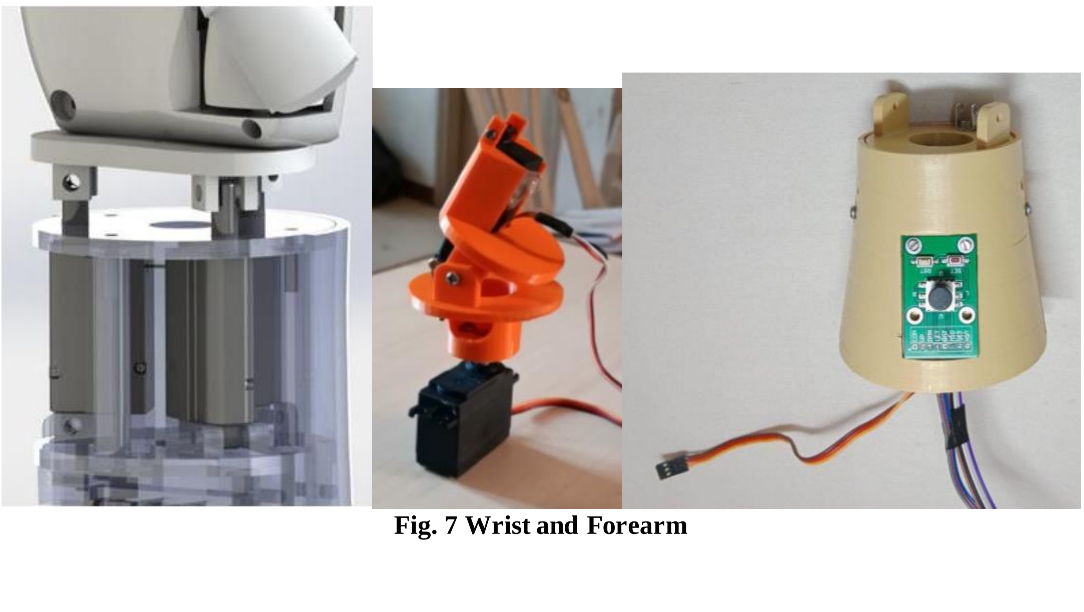


Fig. 7 Wrist and Forearm

Learning from the previous gen prototype, this time we've kept the forearm in such a way that any amputee without a hand below the elbow (less than 50% residual limb) can wear it. The forearm is made in such a way that it is comfortable to wear and easily attached to the elbow of the amputee adding comfort to the amputee.

6.6 Forearm shell

The sleek and light design of the shell makes the hand look like an actual hand. The shell is divided into two parts Upper shell and Lower shell that can be mounted with fixing screws on it.

On the Lower shell, we have designed a mounting case for touch screen LCD. It is mounted in such a way that a user with a prosthetic arm can easily read the data on it and also operate some of the functionalities.(H. L. K. Lam 2020)

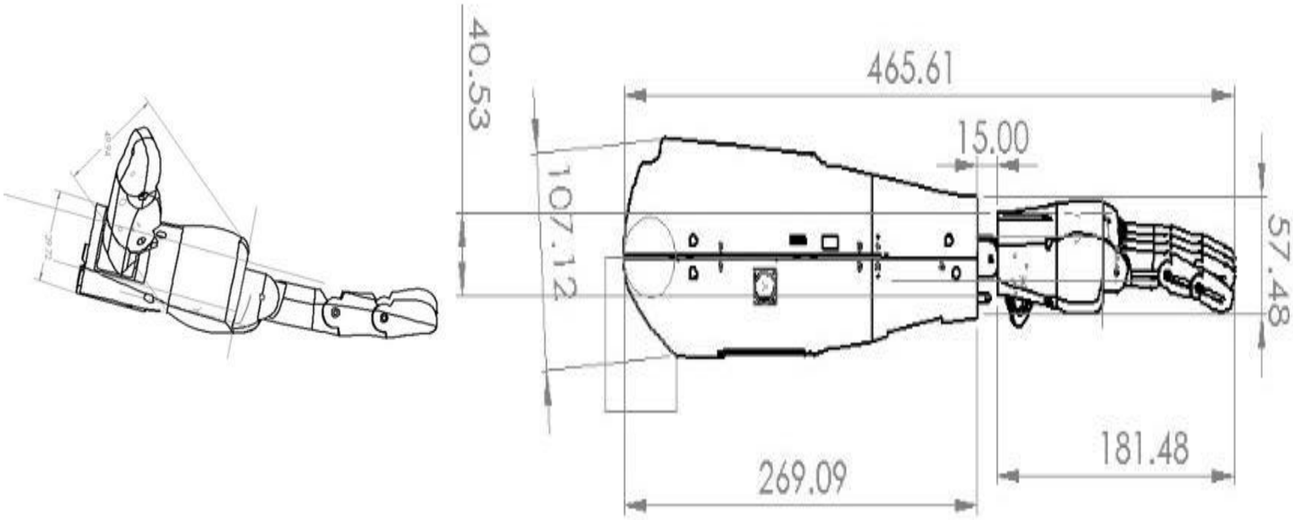
6.7 Changeable Panels

As a human we don't have a choice to change the color of our skin but for this prosthetic hand, we have provided the functionality for changing the panels on the forearm. So, users can customize the color or hand aesthetics according to their choice varying from a simple hand to their favorite fiction character like iron man. (H. L. K. Lam 2020)

Fig. 8 Foream Shell

7. DESIGN CONSIDERATION

7.1 CAD Drawings



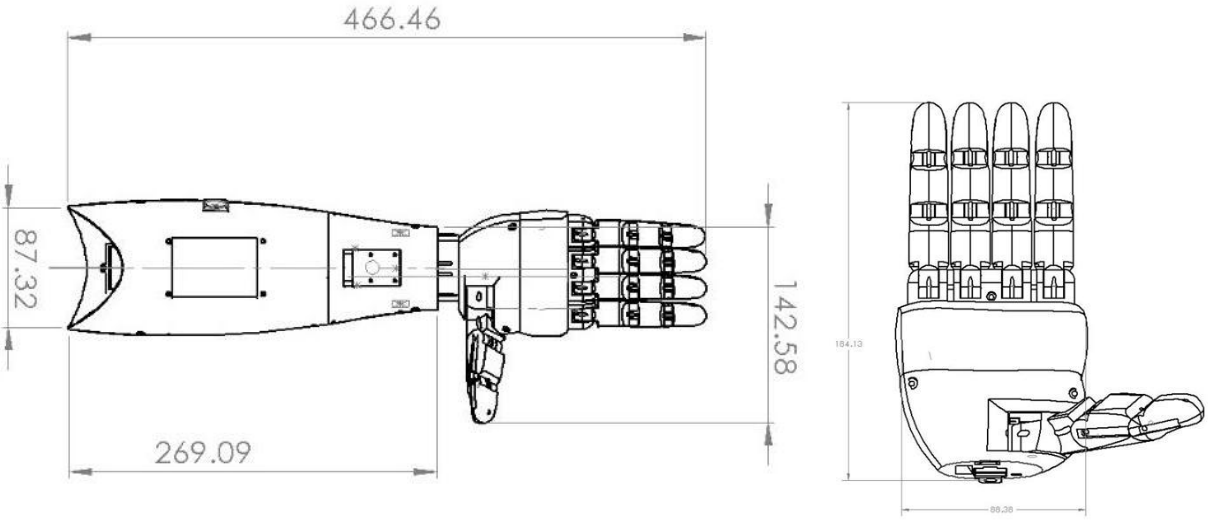


Fig 9. CAD Model

8.MANUFACTURING CONSIDERATIONS

8.1 3D Printing Technology

Currently-available bionic arms are inaccessible as they cost thousands of dollars, can only be bought in a few developed countries, and must be continuously changed if you're a young person, as your body is constantly growing, we believe that these problems can be solved by approaching the [bionic arm] technology differently. Using 3D printing technology to create a user-friendly bionic arm that is 1/30th of the price of existing prosthetics.

Samarth can be 30 times cheaper than the most demanding bionic arm in the market. Samarth is made up of PLA+ material. PLA+ has high rigidity, good glossiness. Also, Toughness is ten times more than PLA on the market.

Fig. 10 PLA parts

9. CONTROL CONSIDERATION

9.1 Microcontroller selection

While making a prosthetic arm, managing space has always been a challenge!!

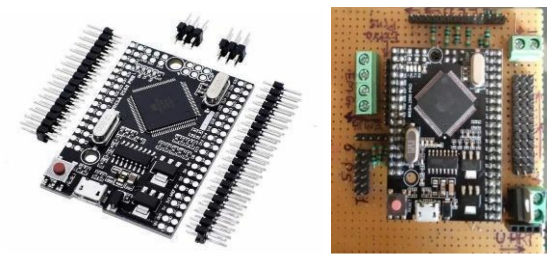


Fig. 11 Microcontroller

To fit hardware in a compact manner we have designed our own PCB. The development board should be small and efficient, that is why we have decided to choose the development board atmega 2560 mini CH340.

A Microcontroller is simply a "Computer on a Chip". ATMEGA 2560 mini CH340 single-chip serves as the microcontroller of the system; it accepts the analog and digital signal for the working of different electronics components. The use of a microcontroller in the proposed design is to take the different signals resulting from the different electrical components which are used for the limb. We make use of the microcontroller (2560 mini CH340) in our design because of the advantages of the microcontroller from our perspective as follows: Size is Compact, Programming is Easy, SPI communication available and can be used for multipurpose use. (H. L. K. Lam 2020)

9.2 SENSORS & ACTUATORS

9.2.1 Fingertip Force-Sensing

Fig 12. Sensor

Sensory feedback is the key way to make prosthesis a part of the human body. The most important aspect we felt was making a prosthetic arm based on a closed-loop feedback system. To get the feedback of fingers force we have used A101 FLEXI force sensors. Currently available prosthetic arm in the market does not give any feedback to the user, so it is difficult to perform precision tasks. As a result of the lack of force feedback, users may inadvertently drop objects because they are not being gripped firmly enough, as there is no indication before it is too late and the object falls. (P. R. Wilson and A. J. Rodrigues 2020)

For example, if a user is eating a meal and is holding a spoon with a prosthetic arm, then it would be very difficult to hold a spoon without sensing the actual force. So, it is very essential for fine precision grips too. The sensors are located on the hand portion of the prosthetic mounted on fingertips. The sensors allow the user to understand how much force is being exerted when they grasp and release objects and this works as the force sensor provides some feedback to the vibration motor module which is mounted on the biceps and elbow of the amputee. During a precision pinching operation, the thumb is in a fixed known position, and only the index finger is actuated. In that situation, one could perform sensitive tasks, such as picking up a grape and not crushing it, simply by having feedback from that finger. During a power grip, or cylindrical grip, all the fingers are actuated at same time, but they would essentially share the load, so force feedback from the index finger should provide enough information to have practicality in theory.(L. G. Hargrove 2019)

One important component of prosthetic hand design is grip force sensing. Having the ability to measure actual grip force within a finger, and then be able to react to that force, opens up many possibilities for advanced control algorithms, and a potentially better user experience.

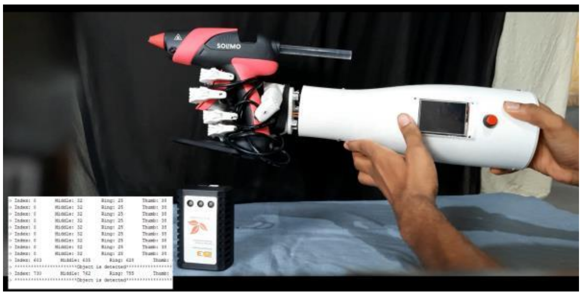


Fig. 13 Development of prosthetic hand

9.2.2 Voice recognition module

Suppose you are in a condition where you don't have another hand free and the second arm is engaged in some kind of work, putting you in a situation where you can't access either the touch display. We've thought this through and come up with a solution which leads us to another important feature of Samarth and that is Voice controls for that, we have used Speak (Voice) Recognition Module V3. You can control your arm with simple voice commands and it is not necessary that you have to speak the commands in English only. It is not just limited to one dialect but the arm can be configured with commands in your own languages which you speak and are comfortable with. We can even train the model according to your use and your native language. .(L. G. Hargrove 2019)

So, the arm is also suitable for amputees who have both arms amputated. Well, this doesn't mean that you won't be able to control your arm with EMG. EMG will always be there to help you with controlling but voice recognition will add an extra feature with EMG.

9.2.3 Actuators selection

According to studies it has been found that for a human to perform 90% of our daily task, 4kg of grip strength is required in the human hand. So, by considering a factor of safety 2 we've taken per finger force as 2.2kg. Taking into account the force (MG90s high torque Servo Motor) is the best suited for this purpose.

Fig. 14 Actuators

As our wrist will take much load, we have used MG996r for the wrist actuation which has 10kg/cm torque. We have also added a pq-12 linear actuator in our wrist which weighs 5 gm only and can work on maximum forces between 18N and 50N.

9.3 User control input

The biggest question people ask about prosthetic hands is, “So, how is it controlled?” Connecting to nerves through surgery would be an expensive and stressful process, and surgery should always be avoided if possible due to the risk of complications and recovery. The best control systems need to be easy to adjust because otherwise, a user would have to visit a prosthetist.

Firstly, we have used the EMG sensor for controlling the gestures and grips, and secondly, we have customized everything on the LCD which is placed on the SAMARTH and the interesting thing is, we have used touched LCD so whatever the features you were getting on the Bluetooth app will be available on the LCD display itself so simply you have your smart app on your LCD i.e., your arm. Furthermore, we have also added a joystick for the manual control and a voice recognition module for controlling the arm with your voice. A detailed description is given in the below segment. (N. W. Schmitt 2021)

9.3.1 Electro-myography Sensors

Electric prostheses, also commonly referred to as EMG prostheses, are controlled using electric signals that are actually created by your body’s muscles. Specifically, these prosthetics work by using your existing muscles in your residual limb to control the functions of the prosthetic device itself.

A sensor within the device is able to Obtain electrical signals from these muscles. Two electrodes (red and green) are placed on the targeted muscle and one is placed on the reference muscle(yellow) near the targeted muscle. Then you can contract or relax the muscle. An electrode will take electric signals from the targeted muscles and then the EMG sensor will translate these electric signals into an analog signal which then can be obtained on the microcontroller and we can integrate our code for the threshold we want for the particular gesture and this is done using coding the particular microcontroller. We can also observe the data on Serial Monitor or plotter on the Arduino IDE. (N. W. Schmitt 2021)

The Arm can create several different grips which provide different muscles data and using the particular data for the particular gesture we have coded our arm in such a way that once you choose your gesture you just have to contract your muscles once and you can perform the particular gesture/grip you have chosen and once you want to open your arm you have to again contract you muscles once and your hand will be ungripped or you will be set to open palm gesture. We have used such a simple controlling feature which is rarely available in the market.

We have added more than 15 gestures and grips in our arm which an amputee can control with his hand itself.

The basic gestures and grips we have given are as follows:

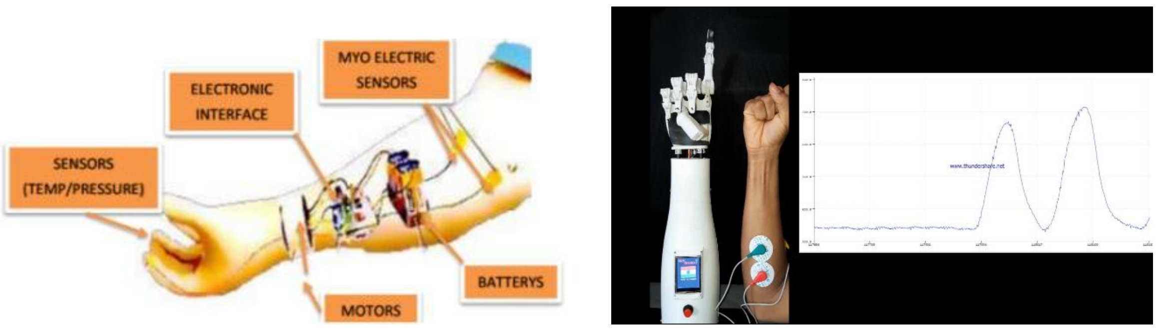


Fig. 15 Integration of components

GRIP 1 - PINCH GRIP
Used to grip any small object like pen, sharpener, pencil, any small component, etc.

GRIP 2 - PIPE GRIP
Used to grip any cylindrical object. suppose you are opening any door and it has a cylindrical handle then this grip will be very useful, if you want to pick any rod, etc.

GRIP 3 - BALL GRIP
Used to grip any spherical object.

GRIP 4 - COIN GRIP
Used to grip any coin, debit/credit card, etc. suppose you want to swipe your card at any store you can use this grip.
GESTURE 1 - CLOSE FIST
GESTURE 2- POINT GESTURE
GESTURE 3 - LIKE GESTURE
When you contract your muscle, a graph shown like above will be produced. We have chosen to use gelled electrodes which have 7% higher accuracy than dry electrodes. While using dry electrodes there are a lot of chances that it may displace from its position and might give different readings so we have used gelled electrodes that will not displace from its position.
The only disadvantage of the gelled electrode is, we have to change its pads every 2 to 3 days as its gel will spread after some days. But still choosing accuracy and positional advantage over others we have chosen gelled electrodes. You can also use dry electrodes also; it depends on the user. But for now, we are using gelled electrodes. (N. W. Schmitt 2021)

9.3.2. Touch Screen LCD
The screen doubles as a smartwatch also, showing you information like the arm's battery level. Additionally, one can monitor if the EMG is working without any error or not and can even troubleshoot it. As a smartwatch, you can also monitor the battery level of your Samarth using an LCD.(R. J. Smith 2021)
The screen will provide you with the visuals of which gestures the arm is currently performing.
One of the important features that make it stand out from the rest is that it **is touch controlled** and is **easily accessible** and due to its aesthetic looks it gives the impression of a top-tier quality product in the arm-Samarth. You can control all the gestures with the LCD also. .(R. J. Smith 2021)

Fig. 16 touch controller

The layout to control everything using LCD is as shown in fig. 16.

9.3.3 Vibration Motor Feedback
Communication of how the arm moves can reduce cognitive load, reduce the need for visual attention and help the user predict the initial grasping force. The results show potential for a low-cost and lightweight system that can communicate stimulations for up to three degrees of actuation in a prosthetic. .(R. J. Smith 2021)
One of the most important senses given to humans is the sense of touch giving us the opportunity to see the world without seeing with merely a touch. To give the user that feeling of touch the arm is equipped with a Vibratory sensor which will give you the sensory feedback. For instance, when your hand will touch anything, you will get feedback according to the pressure exerted on that object. We have designed a ergonomic band equipped with vibration motors and can be fitted on the biceps.
There are a number of tactile sensing methods found in the market. Multiple studies examine the use of vibrational feedback, as small and lightweight commercially available vibration motors can easily be applied to the skin, and the vibration sensation is preferred over electro tactile stimulation.

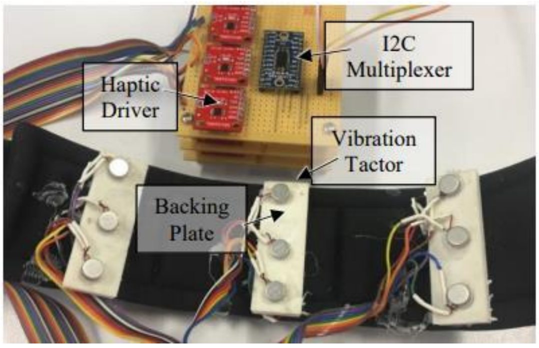


Fig. 17 Vibration motor feedback

10. AESTHETIC AND ERGONOMIC ASPECT

We believe that prostheses are perceived by users as attractive, can enhance a positive feeling, promote their psychological acceptance of the "new limb" and, in general, their well-being. "Prosthetic" is a term that refers to devices designed to replace a missing part of the body. This definition applies to devices that replace a limb segment rather than externally-applied devices which are referred to as "orthotics". The question is "what are the characteristics that make a prosthetic device look and feel aesthetically attractive?" What we want to explore are the aesthetic expectations of prosthetic users for their ideal devices and how wearing them could positively affect their self-confidence. .(R. J. Smith 2021)

What about a device adding new elements that differ i.e., in color, shape, and symbols? This device would have a higher level of "novelty", and by developing this design the risk of the observer to feel repulsion has to be faced, as the novelty proposed might not be accepted. (C. M. M. Paul et al. 2020)

However, many users are unsatisfied with the aesthetics of their prostheses. We have also kept this in mind while designing our prosthetic arm that feels less like a robotic arm and more like a human arm. The Amputee should not perceive it as an external tool but as his/her body part so for that feeling we've kept it as similar to our natural hand in appearance. we have added such a feature that only you can control your arm with your voice like google assistant and nobody can control it with his/her voice. (C. M. M. Paul et al. 2020)

"We are aiming to make the forearm in future in such a way that it fits perfectly and comfortably to the amputee's hand providing adequate airflow for the skin to breathe and not making the amputee's hand sweaty, making the user uncomfortable". We have made such a finished product that users can easily wear it and easily control it.

11. FEATURES

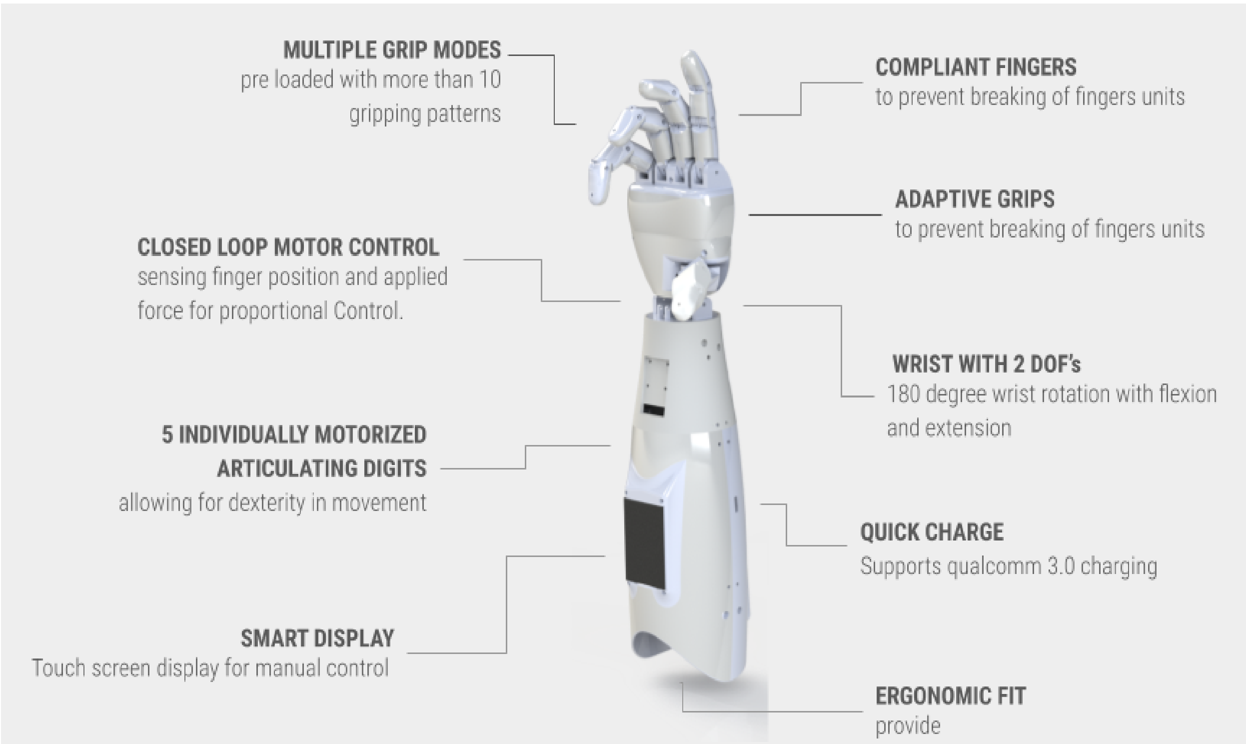


Fig. 18 Features

12. CHALLENGES FACED

a. Due to this pandemic, some of the components ordered from Overseas were delayed.

b. In the beginning, we decided to work together at a workplace but we faced a lot of issues in traveling and buying components.
c. Availability of materials
d. We wanted to use the MYO electric band but due to pandemics, and delays in delivery of components, as well as the manufacturer has stopped shipping, we were not able to use the MYO band.

13. GRIP PATTERNS AND GESTURES

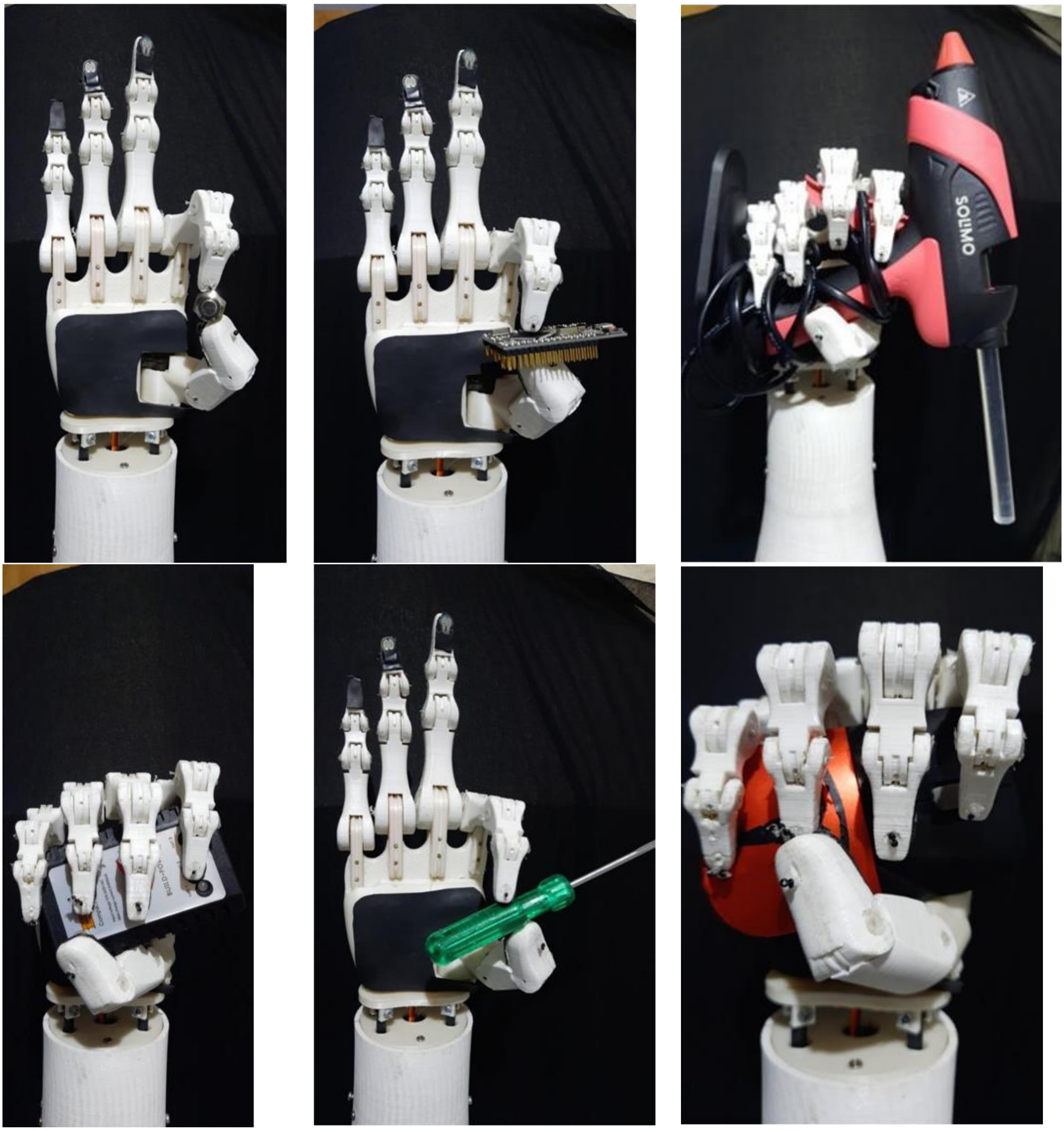


Fig. 19 Grip patterns and gestures

14. WHY IS OUR ARM DIFFERENT FROM OTHERS?

Aesthetically Designed: As the prosthetic arm is going to be a part of someone's body, so it should be comfortable keeping that in mind, whole arm is designed and manufactured considering aesthetical and agronomical aspects like easy and comfortable to wear and effortlessly-simple to control that anyone can become accustomed to it in a very brief period of time. Multiple control options are offered, Autonomous & manual Mode i.e., EMG Control, LCD Control, Voice Control.
Sense of Touch: Equipped with cutting edge Vibratory sensors in the band user can now perceive what he/she is touching through the feedback of vibration.

Tactile Sensors on fingertips: To gather information about the force pressure exerted on the tips of the finger to further fine-tune the amount of gripping force to be devoted by the arm empowering it for gripping diversity of objects ranging from soft tissue to brittle glass without damaging it.
Fast charging is presented so one can be ready on the GO. Low on phone battery? No worries, the arm got it covered for you, as you can charge it with fast charging and use it as a Portable Charger.
Pre-installed with many Different modes like sports mode, office mode, Wrist mode, etc. for gestures & can be further configured blending to your needs based on your usage.
Cost-effective - After a lot of surveys and discussion we came up with the conclusion that our arm must be cost-effective and anyone can be able to buy it. Last but not the least our Prosthetics arm is different than the rest because "Our arm is less Robotic & More Human".

15. USER EXPERIENCE AND FEEDBACK

Our model has focused on user experience instead of self-interest. We haven't made the product just for the sake of competition but our aim is much greater than it. So, we have collected public surveys and market surveys to enhance the quality of our SAMARTH because the utmost thing is the user experience, to have the most useful experience. After all the surveys and research, we found two-person with a hand amputee and our whole team sat together with them and discussed the problems, difficulties, and complications faced by them because of their disability. After a few meetups and discussions, we concluded that they needed easy-to-use, easy-to-control, comfortable, and cost-effective prosthetics that could help them with all kinds of work throughout the day.

16. ATMANIRBHAR BHARAT

Our main Focus is to make 3D printed prosthetics that can be affordable to anyone without compromising quality. In the market, below elbow prosthetic hands are generally costing around from 70k to 1 lac rupees and we want to reduce that to under 20k which becomes helpful to all amputees. Carrying our vision of Atma Nirbhar Bharat, all amputees shouldn't deserve a hand and we all have the right to learn and do our job without being dependent on others which is the ultimate goal of being atma nirbhar.

Conclusion

After a lot of brainstorming in making prosthetic hands, we thought to revolutionize the industry of prosthetic arms. To make it as close as human hand and affordable some of the points needs to be implemented.:

● The arm should be affordable to Indian markets too. Until now most of the companies are using metals and woods for manufacturing the arms. But new technologies like 3D printing can bring into picture to make the model affordable9

● Adding computer vision techniques into prosthetic arms can take the environment into consideration. It can be helpful to assign and learn various parameters of environment and feed those into the model with ML to improve gripping patterns with accuracy and precision simultaneously.

● Artificial hands which can feel the
sensations that sound amazing but adding sensory feedback into Samarth like a human hand is a big challenge.

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