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Development of Prosthetic Arm for Disabled Persons

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Abstract

The development of artificial hands is important to increase the life of disabled people. This program focuses on the design and innovation of hands incorporating advanced technologies such as biotechnology and hand control systems. The purpose of the proposed model is to make the range of motion and function of the human hand easier, more accurate, and more consistent. Using light weight, durable materials and an intuitive user interface, the prosthetic arm has been designed to be comfortable and accessible to a wide range of users. With a focus on affordability and customization, the project explores how 3D printing technology can be used to produce specialized devices at a lower cost and available to the public. In addition, the integration of neural signaling systems improves the user's ability to control the natural hand and creates an integrated interface between the brain and the prosthesis. The main objective of this program is to bridge the gap between the artificial and biological branches and promote more independence and employment for the disabled. By promoting the technical and functional aspects of prosthetic development, this project contributes to ongoing efforts to empower the disabled community and transform future technologies.

Keywords: *Biomechanical Prosthetics, Neural-Controlled Prosthesis, 3D-Printed Prosthetic Hand, Sensor-Based Dexterity.*

INTRODUCTION

The development of prosthetic devices is crucial because of the high incidence of debilitating diseases, accidents, and congenital issues that result in between 150000 and 200,000 amputees annually worldwide. Ongoing research to solve this issue is leading to significant advancements in the field of prosthetic arms.

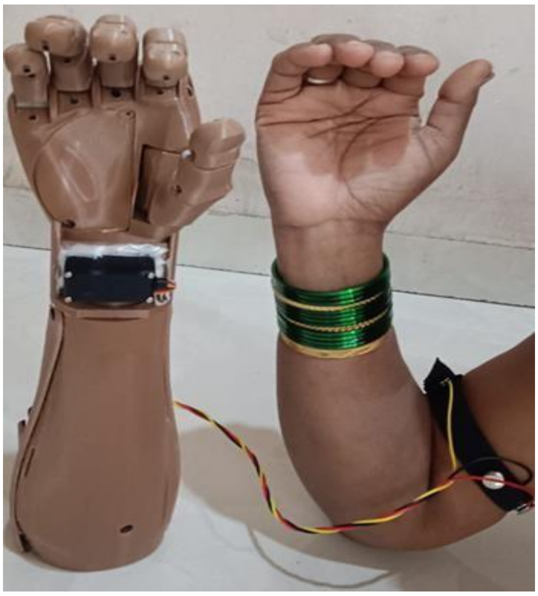

Figure no.1

The goal of this research is to design and build an arm that almost exactly mimics the activity and motion of the human hand. Creating a fully functional replacement that can grasp, move, and manipulate like a hand is the ultimate goal. Our research identified some important problems that need to be fixed to improve the functionality of prosthetic hands. There are few opportunities for gripping. There is no natural command interface and the actuator receives insufficient sensory feedback. A typical finger movements during grasping, the need for a lightweight structure. To overcome these challenges, we are developing a my electric hand prosthesis based on robotics that aims to mimic as closely as possible the structure and function of a natural hand and by creating a natural interface between servomotors, controllers, and muscle sensors, the first four difficulties can be resolved. This paper discusses work that focuses on lightweight design and battery replacement. Rechargeable Li-ion batteries and PLA materials can assist with these problems. Actually, active joint flexion is usually limited to two or three joints, with the remaining joints locked, due to the lack of degrees of freedom in prosthetic hands.

Since prosthetic hands also have trouble with poor grip because of their limited number of degrees of freedom, this paper describes a multi-degree-of-freedom hand with several active joints designed to improve grip and natural finger motion. With servomotors and muscle sensors built into the design to control its several degrees of freedom, the arm is robotically developed. The proposed hand's actuation system consists of a differential mechanism and five motors. The fingers have several joints in order to ensure proper and seamless joint motion.

In the present world, 3D printing technology has revolutionized production methods and fused deposition modeling, or FDM, is a widely used 3D printing technique that produces parts for a variety of applications, including robot design and building. The proposed arm significantly lowers the weight of the prosthetic arm by utilizing PLA material and 3D printing technology.

METHODOLOGY

The methodological structure of the paper is as follows

- Delves into the mechanical design of the prosthetic hand and its fabrication through 3D printing technology.
- Covers the differential mechanism.
- Discusses the material and 3D printer settings used.
- Explores the grasping of objects with various shapes.

MECHANICAL STRUCTURE AND COMPONENTS

The prosthetic arm comprises two primary components: A flexible fingers and a palm. The complete CAD design of the arm and its prototype are depicted in Figure 1. Each flexible finger features a modular structure, with each module consisting of number of joints. Both links and joints are 3D printed using PLA material, as detailed in the accompanying table 1. Actuation is achieved through the use of actuators and tendons made of nylon thread, which are connected to the actuator to facilitate finger movements.

Table no1: Characteristics of PLA Material

Sr. No.	**Characteristics**	**Parameters**
1.	Diameter	1.75 mm
2.	Tolerance	+/- 0.05 mm to+/- 0.1 mm
3.	Melting Temperature	1800 C to 2200 C
4.	Strength	50 MPa
5.	Odar	Odar free
6.	Density	1.24 g/cm3
7.	Net Weight	1 Kg

The proposed prosthetic arm is engineered to enhance the dexterity and functionality for amputees by integrating cutting-edge technology within a traditional prosthetic form factor. The arm utilizes a Raspberry Pi Pico-W as its central controller, a DC-DC converter for voltage regulation, muscle sensors, servo motors, and a 11V battery are depicted in table 2.

Upon activation, the 11V battery powers the DC-DC converter, which consistently provides a 5V supply to the Raspberry Pi Pico W, muscle sensors, and servo motors. The muscle sensors detect changes in muscle activity and transmit these signals to the controller. The Raspberry Pi Pico W processes the input signals and sends corresponding commands to the servo motors. These motors then actuate, mimicking the natural movements of human muscles. This integration of advanced miniature mechanisms, sensors, and embedded control systems aims to significantly improve gripping abilities and sensor motor coordination for users, offering a seamless and intuitive prosthetic experience.

Table no 2: Components of Prosthetic Arm

Sr. No.	**Component Name**	**Quantity**
1.	Raspberry Pi Pico- W	1
2.	Muscle sensor	1
3.	Servo motor	1
4.	Li-ion Battery	1
5.	DC to Dc Converter	1
6.	Nylon thread	1 Role
7.	3D Hand	1

DIFFERENTIAL MECHANISM

The palm of the arm incorporates a two- layered differential mechanism that integrates all the fingers into a single structure, allowing the fingers and arm to adapt to the shape and dimensions of the object being grasped. Most existing prototypes of under-actuated compliant robotic hands have between 2 and 5 fingers. When actuated by one or a few actuators, a differential mechanism becomes essential. To address this challenge, we employ a 5-motor configuration, with each motor dedicated to actuating a single finger. The motor mounted on the arm rotates the drive pulley via a shaft, and a nylon thread acts as a tendon, connecting each motor pulley to a finger. When power and control signals are supplied to the motors, the nylon threads contract, causing the fingers to actuate.

MATERIAL AND 3D PRINTER SETTINGS

The arm is 3D printed using PLA filament, with several crucial settings influencing the process. Key parameters include infill density and pattern, printing speed, type of support structure, layer height, and print temperature, which determines the amount of material deposited by the printer are summarized in Table 3.

Table no 3. Printer Settings and 3D Printing Infill Density

Sr. No.	**Parameters**	**Values**
1.	Infill Density	30% to 50%
2.	Printing Speed	40 mm/s to 100 mm/s
3.	Layer Hight	0.1 mm to 0.2 mm
4.	Nozzle Temperature	2000 C to 2300 C
5.	Bed Temperature	300 C to 600 C
6.	Support Structure	Tree slim

Infill density, expressed as a percentage, typically ranges from 10% to 100%. These settings for the arm design are configured using Creality Print software. The STL files of the arm design are loaded into the 3D printer, which then executes the printing task.

GRASPING OF OBJECTS WITH VARIOUS SHAPES

To qualitatively assess the grasping ability and shape adaptability of the prosthetic arm, we conducted tests using various everyday objects. The experiments evaluated the device's capability to adapt to different shapes to achieve a stable grasp. We tested the prosthetic Arm with objects of varying shapes, sizes, textures, weights, and rigidities. During these tests, a muscle sensor was used to control the hand's movements. The accompanying figure illustrates some examples of these grasping tasks. The prosthetic hand demonstrated its ability to conform to the shapes of different objects, thanks to its appropriate closing trajectory and inherent compliance.

Prosthetic arms enable users to perform tasks independently, thereby enhancing their overall quality of life. The proposed prosthetic arm supports a diverse range of movements, allowing users to handle objects with greater precision. This capability to manage tasks on their own can significantly boost self-esteem and reduce feelings of helplessness. Additionally, the improved functionality of the prosthetic arm facilitates participation in various activities and employment opportunities, thus fostering better social interactions.

CONCLUSION

The field of prosthetics is a multifaceted discipline dedicated to human service. prosthetic arm significantly enhances the quality of life for disable persons by restoring functionality and improve psychological well-being. as technology advanced the future of prosthetic arm looks increasingly promising with development in sensory feedback. This innovation will make prosthetic arm more comfortable and this paper details the design and evaluation of a tendon (nylon thread) driven prosthetic hand, with fingers composed of rigid links connected by flexible joints. To control the motion of this prosthetic hand, we developed an Electromyography (EMG) based control interface. The hand was constructed using rapid prototyping and 3D printing techniques, specifically utilizing under- actuated compliant mechanical structures. This approach offers a strategic solution for designing simple, highly adaptable, and robust prosthetic arms that can be effectively used in clinical applications.

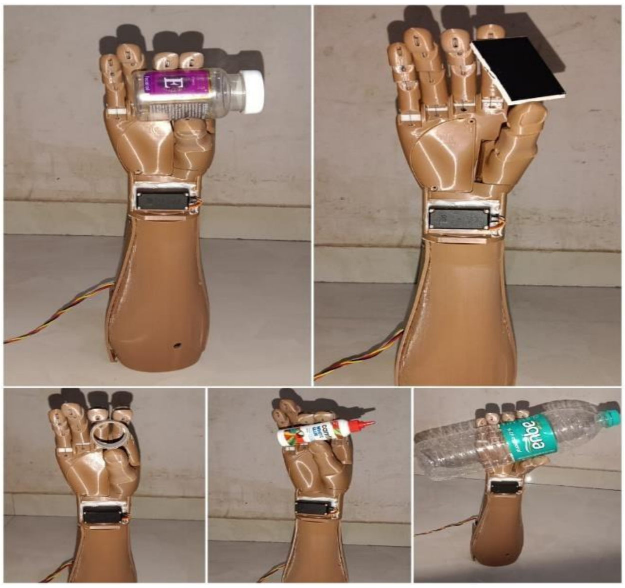

Figure no 2. The Prosthetic Hand Grasping Objects of Various Shapes, Sizes and Materials

Artificial arm is essential to improve the quality of life of people living without hands. This technology still causes adverse event. Our prosthesis body arm is useful for handless people. Which is used for their daily life and it gives happiness and get motivation to leave their life. prosthetic hand through additive manufacturing process is the ultimate solution for a cost-effective prosthetic hand. It is a multi-disciplinary project, a unique combination of medical science and computer aid designing and manufacturing. It is a bridge between the both discipline and future technology of manufacturing process. 3D printed prosthetic hand had enough strength, flexibility, durability and also it will appropriate for any environment. More than all this it is cheaper in cost compare to existing available prosthetic hand. Which makes it unique, most favorable and user appropriate product.

The development of prosthetic arms represents a significant stride in enhancing the quality of life for individuals with disabilities, providing them with increased mobility, independence, and a sense of normalcy. These technological innovations have transformed the way people with limb loss navigate daily life, enabling them to engage in activities they may have previously found challenging or impossible. prosthetic arm significantly enhances the quality of life for disable persons by restoring functionality and improve psychological wellbeing. As technology advanced the future of prosthetic arm looks increasingly promising with development in sensory feedback. This innovation will make prosthetic arm more comfortable and accessible.

FUTURE SCOPE

The future of prosthetic arms holds immense potential for continued advancement and improvement. Research and development efforts are focused on refining prosthetic designs to mimic natural limb movement more closely, integrating cutting-edge sensors and actuators for enhanced functionality and responsiveness, and reducing costs to make these devices more accessible to a broader population. Additionally, emerging technologies such as neural interfaces offer promising avenues for developing prosthetic systems that can be controlled directly by the user's thoughts, further increasing independence and integration into everyday life. With ongoing innovation and collaboration across various fields, the future of prosthetic arms is bright, offering hope for even greater levels of mobility and empowerment for individuals with limb loss.

Currently, we are working on designing and developing a multi-sensor, heavy-lifting arm to be integrated with an upper limb prosthetic. In the future, we plan to test the complete prosthetic arm, which will incorporate multiple sensory feedback mechanisms. These mechanisms will enable the user to feel pressure and temperature, enhancing the overall performance. This innovation will be evaluated and characterized through experiments with upper limb amputees to ensure its efficacy.

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