DESIGN AND FABRICATION OF 3DPRINTED PROSTHETIC ARM

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Abstract
There are nearly 2 million people living with a limb loss in the United States alone, which can either be due to accident or due to some other medical conditions. Our project which is a prosthetic arm built using a 3D printer is one that gives prominence towards the creation of an affordable, rugged and a semi-functional arm for the disabled. Many people throughout the world do not have sufficient money to buy a prosthetic arm which approximately costs about $15,000 to $50,000. The arm that we have created would cost below $155(₹10,000). For this study, we have only given a few basic and very important movements like arm rotation and gripping. In a general study, it was found that the upper limb prosthesis users, 76% relied on visual feedback, particularly for grasping tasks, 67% of users relied on auditory feedback, primarily for knowing if the limb is moving. In the same study, the users were asked to rate the importance of sensory feedback. Sensory feedback was said to be absolutely important for 45% of the participants, and the most important type was grip force, followed by movement and then positioning, which are vital for most of the daily tasks that people come across. In the arm that we have focus on, the user has to rely on his vision to check the position of his arm which acts as a natural feedback mechanism. But we have enabled the user with the ability to feel the grip, and a control over the force of grip he has on an object by using a muscle sensor. user with the prosthetic arm can do Pick and place, squeeze action, turning action and push and pull on the muscles that are active on the user's arm, for example the upper portion comprising of the shoulders, biceps, the elbow etc. we can custom design an arm, that will cover for the missing motoring functions, or the degree of movement.

Key Words: 3-D Printing, Prosthetic arm, Muscle Sensor

1.Introduction

The cost of a modern prosthetic arm in Canada price ranges from $15,000 to $50,000. The average arm amputee owns a more moderately priced device costing about $15,000. These higher cost arm create a significant economic barrier to ownership for many amputees in Canada and other parts of world. Additionally, hand functionality is limited among these moderately high-priced devices. Many of these hands only have the ability to open and close in a single grip.

Meanwhile, the functionality afforded by high end, upper-limb prosthetics has never been greater. Products such as the I-Limb and the Be Bionic hand operate using independently actuated fingers and are capable of many grips. Unfortunately, the prohibitive costs associated with these devices prevent all except the best funded amputees from taking advantage of this revolutionary technology.

There is a clear deficiency of low-cost, high functionality devices in the upper-limb prosthetics market. The goal of this project is to address this deficiency by developing a 3D printed prosthetic arm that has similar functionally to the most expensive arms available at a cost dramatically lower than the least expensive arms.

3D Printing technology has been around since 1986. The cost associated with the technology and the fragility of the parts that were produced prevented the widespread adoption of 3D printing as a manufacturing technique. Over the past few years, this paradigm has begun to shift.

Introduction of high quality consumer 3D printers available to a much wider audience.

All of the signal processing must be performed on a microcontroller. Fortunately, the cost and accessibility of microcontrollers has been improving over the past few years. Arduino microcontrollers are still a mainstay in the inexpensive microcontroller category, characterized by their low cost and simple C++ based programing environment. Other more powerful microcontrollers are also beginning to enter the market. As the quality and access to advanced components and manufacturing techniques improves, many previously specialized applications will begin to see lower cost alternatives. One of these areas of growth is prosthetics and our 3D- printed prosthetic arms exemplifies that trend.

1.1 Type of Prosthesis

In theory, any part of the body, from your ear or nose to your finger or toe, could be replaced by a prosthesis. In practice, there are four common types of prosthetic limb, which replace either a partial or complete loss of an arm or leg:

Below the knee (BK, transtibial): A prosthetic lower leg attached to an intact upper leg Above the knee (AK, trans femoral): A prosthetic lower and upper leg, including a prosthetic knee Below the elbow (BE, trans radial): A prosthetic forearm. Above the elbow (AE, trans humeral): A prosthetic lower and upper arm, including a prosthetic elbow.

1.2 Prosthetic Arm Overview

The low-cost prosthetic arm developed for this project consists of four primary components:

3D-Printer arm • MyoWare Muscle Sensor • Driving Motors • Microcontroller

The 3D printed arm is a prototype model, printed and assembled. The hand contains over 30 components, including 19 unique printed components. It is actuated with high-torque servos that are controlled by microcontroller

2. 3-D Modelling

Solid modeling of the 19 unique arm components was performed, the index, middle, ring and pinky fingers are each made up of a tip segment, a middle segment and a base segment, which is connected to the palm of the hand. The thumb is composed of just two segments but mounts on a raised platform away from the palm, allowing it to directly oppose the other fingers when contracted. Fig 1 shows 3D CAD Model of Palm. Fig 2 shows the assembly of the printed arm as well as the hands major design features.

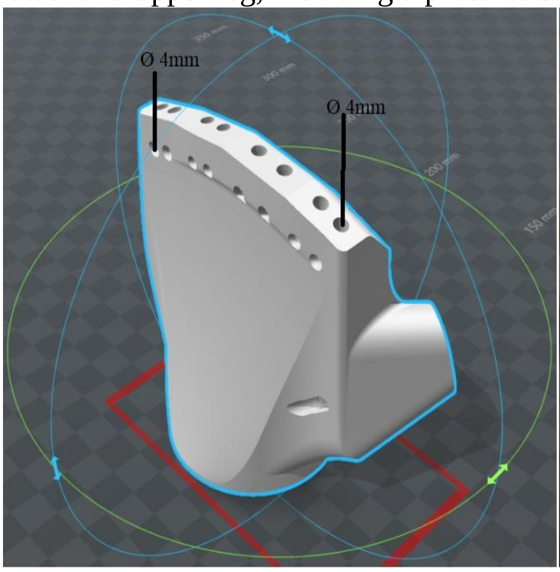

Fig 1. 3D CAD Model of Palm

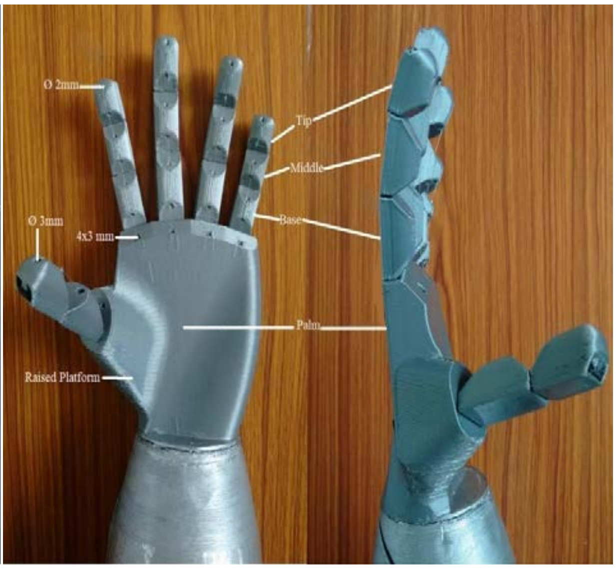

Fig 2. Prototype Hand Assembly

3. 3D Printing

Upon completion of virtual mechanical simulations, the arm was ready to manufacture. The method of manufacture selected was rapid prototyping on a Fused Deposition Modeling (FDM) 3D printer. Fused Deposition Modeling, also known as Fused Filament Fabrication is a type of additive manufacturing where a thread of molten plastic is used to trace out a layer of a part in the X-Y plane. Once an entire layer is traced, the print platform is lowered and the next layer is printed.

The prototype hand model was loaded into the printer's software, arranged for printing, and converted to G code using the software Repeater-Host. G code is the control code that provides the printer with instructions regarding the velocity of the print head, extruder temperature and the filament extrusion velocity. The hand parts were printed in 18 hours on an Indigenously built 3D printer.

Fig 3. Prototype Finger Printing in Progress

Fig 3 shows the Finger about one third of the way into the print. The Gray material being printed is the polylactic acid or polylactide (PLA) that will be printing on the hot base, which has a linear movement, for every unique print the base should be kept clean for the adhesive quality while printing that can be obtained by cleaning it by methanol solution. The printing can be carried out at a room temperature with continuous supply of PLA material. After the print is complete, parts are taken out from the 3D printer.

3.1 Myoelectric Sensor

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 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.

The MyoWare measures muscle activity through the electric potential of the muscle, commonly referred to as electromyography. The greater the number of motor units, the more the electrical activity of your muscle increases. The MyoWare will analyze this electrical activity and output an analog signal that represents how hard the muscle is being flexed. The harder you flex, the higher the MyoWare output voltage will go.

All our muscle sensors have had this ability but we've redesigned our sensor from the ground up to make it more user-friendly and more affordable.

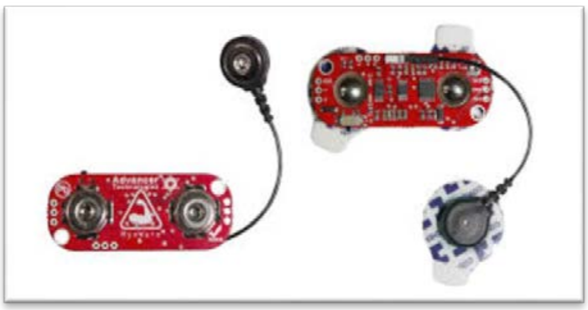

Fig:4 Myoelectric Sensor

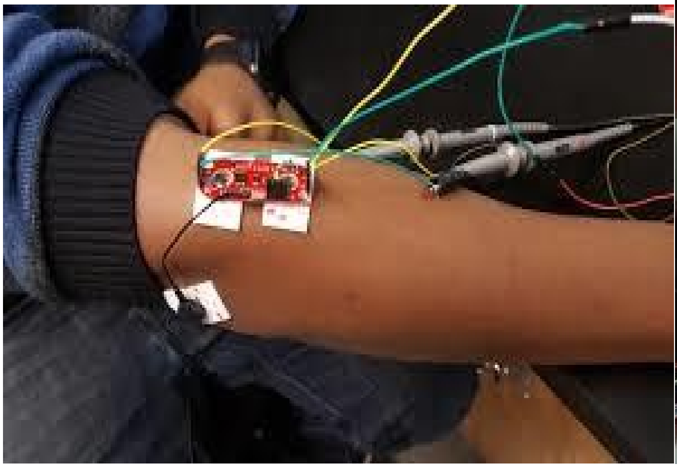

Fig 5. Placement of The Sensor on The Arm

Fig 6. Fully Functional 3D Printed Arm

4. Conclusion

There are two major advantages to producing prosthetic hands with 3D printers. First, it is very inexpensive. The accelerating adoption of consumer grade printers and the decrease in the price of feed stock means that replacement and upgraded parts can now be printed in many materials for only tens of dollars.

Second, 3D printing allows for mass customization, a sought after quality in prosthetics. Using this technology, every hand can be designed to meet a specific user needs, including the size of the hand and its complexity. The size of each hand can inexpensively be modeled to match the proportions of the opposite hand. Also, some people lack the fine motor skills, experience or need or an advanced hand with many degrees of freedom and a myriad of functions. Due to the modular nature of the hand design, these users can use a simpler hand and upgrade individual components as they grow and their abilities or preferences change.

5. REFERENCES

1. Shadow Robot Company Ltd, “Shadow Dexterous Hand E1M3 R, E1M3L”, 2013. Available:http://www.shadowrobot.com/products/dexterous-hand/

2. Festo Exo-hand, 2012. Available: http://www.festo.com/cms/en_corp/12713.htm

3.B.D. Darnall, "Self-Delivered Home-Based Mirror Therapy for Lower Limb Phantom Pain", American Journal of Physical Medicine & Rehabilitation, vol. 88, 2009, pp. 78-81.

4. Po 3D prints personalized prosthetic hands for the needy in South America https://techcrunch.com/2016/11/21/po-3d-prints-personalized-prosthetic-limbs-for-theneedy-in-south-america/

5.Accessory for prosthetic limbs lets users interact directly with digital media https://techcrunch.com/2016/09/20/accessory-for-prosthetic-limbs-lets-users-interact directly -with-digital-media/

6.The Arduino Uno is a microcontroller board based on the ATmega328http://digital.csic.es/bitstream/10261/127788/7/D-%20Arduino%20uno.pdf

9. http://www.cel-robox.com/sla-vs-fff-fdm-workflow-and-space-requirements/