Every year, about 1,500 children are born with upper limb reduction deformities, but they grow too quickly to justify buying expensive prostheses [1]. By inexpensively 3D printing the bulk of a prosthetic, debilitating costs are avoided, making it possible. They are currently producing prosthetics with a grasping mechanism for children with amputations below the elbow, but there is no open source design for a transhumeral prosthetic with a grasp function.

We have expanded the existing open source design called the Raptor by adding a upper arm and elbow joint using a knurling joint design [3]. The knurling joint has adjustable elbow movement that will only move deliberately. The grasp function includes inputs from a sensor on the index finger, a sensor on the palm, and a sensor on the upper arm which all output to mechanical movements from a servo motor. These inputs and outputs will be managed through an Arduino and a breadboard [4]. There are limitations to the functionality of this prosthetic, due to the cost restrictions set by HOPE. It also cannot be worn safely in water because the electrical components are not waterproof. While this prosthetic will not provide the full functionality of a human arm, it will allow more functionality than they would have with no prosthetic. Having a prosthetic will also boost the child’s self-esteem and improve their standard of living.

Another significant need is a prosthetic with a grasp function for children in need and is sponsoring this project [2]. HOPE is in need of a load-bearing and functional prosthetic using 3D printing. Deforming costs, due to the cost restrictions set by HOPE, it cannot be built. It also cannot be worn safely in water because the electrical components are not waterproof. However, this prosthetic will provide the full functionality of a human arm, it will allow more functionality than they would have with no prosthetic. Having a prosthetic will also boost the child’s self-esteem and improve their standard of living.

GOALS

- Use force sensors and a motor to create a mechanism that will grasp and release the fingers of the prosthetic

OBJECTIVES

- Motor will activate when a 0.5N pressure is applied to the force sensor on the palm, and will stop rotating when a 0.5N pressure is applied to the sensor on the end of the index finger
- Mechnically balance the forces of the forearm and upper arm in order to create a hinge model for the elbow with an angle range from 35° to 180°
- Be able to print a load-bearing and functional framework of the prosthetic made using PLA and aluminum
- Successfully integrate electrical components and mechanical elbow joint while maintaining a design that is under 3 lbs and has intuitive functionality

METHODOLOGY

- Determine appropriate force sensitivity of sensors to initiate gripping motion
- Construct Arduino breadboard circuit incorporating power source, force sensors, and motor
- Determine proper dimensions for forearm, elbow, and upper arm by extending the open-source “Raptor” design using Creo Parametric
- Build prototype combining mechanical and electrical components
- Prototype is a combined composition of PLA and aluminum to maintain a total weight under 3lbs while being functional

CIRCUITRY AND ASSEMBLY DIAGRAMS

Figure 1. Proposed Force Sensor and Motor Schematic.

This circuit incorporates three force sensitive resistors with an Arduino in order to operate a Servo motor for the gripping function of the prosthetic arm.

Figure 2. Diagram Sensor and Motor Integration. The schematic above shows the placement of the sensors and motor on the raptor design.

BUDGET

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<th>Material/Part</th>
<th>Description</th>
<th>Quantity</th>
<th>Cost</th>
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<td>Flexible Serve Motor</td>
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<tr>
<td>Printing Costs</td>
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<td>Creo Parametric Software</td>
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Total Cost $410.00

Figure 3. Elbow Joint. The elbow joint will be based off of an existing HOPE design, which contains a knurled hinge joint. This will enable the user to adjust the angle of flexion, but will only be mobilized with deliberate adjustment.

Figure 4. Forearm. Original CAD design for underside of forearm created to protect internal electrical components. The piece will snap into the upscaled wrist brace. The overall length is 146.7 mm.

Figure 5. Final Prototype. The Arduino, flexible breadboard, and other circuitry will be integrated into the forearm of the prosthetic and covered with PLA to protect the user from the electrical components.

REFERENCES


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