Designing a Hand Prosthesis for the Developing World (Target Market: Cambodia)

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Background

Cambodia, a war-torn country suffering from landmines, has seen a high rate of amputations in its population during the last two decades. But while lower limb amputations are the most common, innovation has been slow in upper limb prosthetics and incompatible with the needs of low-income communities.

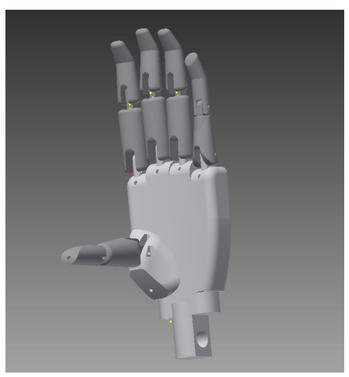
Recent advances in myoelectric hands opened a new realm of prosthesis that can help amputees have a “normal” life, but they unfortunately drive up the cost which makes them out of reach of most people in developing countries.

Project Overview

- To design a prosthetic hand that allows the amputee to lift heavy objects and perform well- defined daily tasks, while being cost-efficient, aesthetically pleasing and suited for the needs of the target market.
- The prosthetic hand is body-powered, which means that it relies on straps that transmit the movement of certain parts of the body to the hand. Another alternative is using electronics, but this solution increases the cost of the product and also raises maintenance costs.
- The desired grips that should be achieved by the hand are: Power, Hook, Pinch and Active Index.

Design

- We used a CAD software (Autodesk Inventor Pro 2015) to design our hand, in addition to 3D printing for rapid prototyping.
- The main problems we faced during the design process were related to the position of the thumb (opposed or non-opposed to the fingers) and the position of the string inside the phalanges.

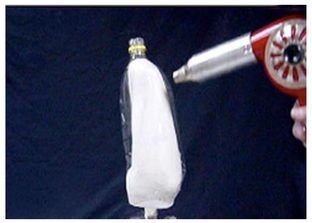


Materials

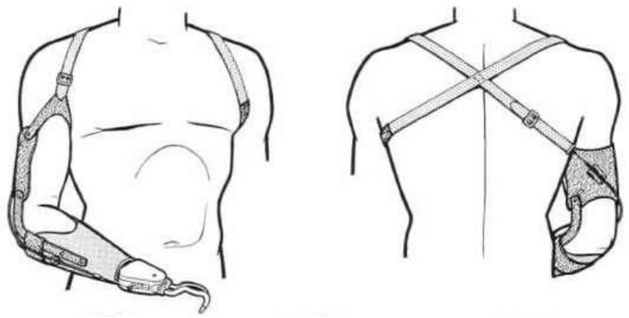
- We tried using bamboo, since it has good mechanical properties and is locally available. However, technical constraints, in addition to the fact that the manufacturing process can be quite expensive and time-consuming, made us give up the idea.
- We switched instead to 3D printed PLA/PHA plastic. It is cheap, easy to build with, and can allow us to quickly replace a part of the hand if it gets damaged. 3D printing, therefore, decreases both the initial cost and the maintenance cost.

The Socket

- The socket is built from a 2-liter plastic bottle that is melted using a heat gun, until it takes the shape of the positive plaster model of the residual limb.
- Several holes can be drilled on the socket so that the residual limb stays ventilated.



Body straps



Testing & Cost

- Mass of the hand: 127 g (for a high resolution print)
- Cost of the hand: $9
- Approximate cost of the system: $16
- The tests that the final prototype underwent included having the hand hold a bucket filled with various amounts of water in order to see the maximum amount that can be held. To test the pinching motion objects of various size and shape were picked up.
- Using the pinching motion, the hand was able to pick up small springs and medium sized pliers.

Conclusion and Future Steps

- During the test of our final prototype, the hand failed to successfully carry a bucket consisting of 500 mL of water, resulting in a tear of one of the strings from the metal wire.
- In an attempt to resolve this problem, we replaced the strings with a thin metal wire and used metal crimps to hold the two together. Although this addition to our project was not tested, we predict that it would increase the threshold level of the hand.
- Further considerations for this project would be to test the strength of the wire with the metal crimp, as well as add a non-slip surface to the tips of the fingers to enhance grip performance. A comprehensive finite element analysis should also be considered.

Acknowledgement: Carmen Michael LaMacchia

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