Product Design Specifications

Biomedical Engineering 200/300: Biomedical Engineering Design

Fall 2018

Title: e-NABLE: Add lateral wrist movement to an e-NABLE standard hand design

Client: Mr. Ken Bice, Wisconsin Chapter of e-NABLE: BadgerHands

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Function: e-NABLE international community 3D prints ultra low cost upper limb prosthetics and delivers them free to those in need. Almost all the hand designs (used for those missing fingers but still have a palm) strap a gauntlet on the forearm, and the functional part of the prosthetic hand to the remaining palm. The user then bends the wrist forward to clench a fist, and backward to release the grip. But that is the only degree of freedom of the device. For those with sufficient lateral movement of their wrist, a means of turning the prosthetic's wrist laterally would provide the benefit of a second degree of freedom. The project is to design and test a modified e-NABLE design that incorporates abduction and adduction to the wrist movement.

Client Requirements:

- Need to add a second degree of freedom to existing prosthesis.
- Current prosthesis design is for individuals with a palm but no fingers.
- Advancing Raptor Reloaded design
- Cannot lose any of the functions already implemented with the first degree of freedom.
- Must be 3D printed

Design Requirements:

1. **Physical and Operational Characteristics:**

   a. *Performance requirements:* The prosthesis should maintain its current capabilities with the addition of a lateral movement to give the user another degree of freedom. It needs to be able to withstand everyday use.

   b. *Safety:* The prosthesis needs to add a lateral motion without overusing the user's wrist or palm. The motion needs to be a simple motion that will not put strain on the user's residual limb. It needs to fit and be fully controlled by each individual user.

   c. *Accuracy and Reliability:* The precision and accuracy of this design depend on each individual user. Overall, it should have two degrees of freedom. The radial flexion should approach 17 degrees and the ulnar flexion should approach 40 degrees.

   d. *Life in Service:* The prosthetic will typically need to last 1-2 years, or until the child grows out of it. The material and strings should not be damaged with daily use.

   e. *Shelf Life:* The device will be given to the recipient within a couple weeks of being printed and assembled.

f. *Operating Environment:* The device will most likely be used in room temperatures(68-77 degrees Fahrenheit). Noise level will not affect the prosthesis. The device needs to be able to withstand subtle debris, such as dust, but the materials previously used for the prosthesis will be sufficient. Because children will most likely be operating this device, all the pieces must be well secured to ensure nothing is lost or damaged.

g. *Ergonomics:* The patient for this prosthesis must have a palm to be able to wear the *Raptor Reloaded* design. The device must be accurately measured to fit the patient comfortably. However, the design will be able to be repeated onto several prosthesis of different lengths and widths. The device must still maintain its original forceful grasp with the fingers and thumb.

h. *Size:* The device will be designed and printed specifically for each patient. The e-NABLE prostheses range from fitting kids to adults. The *Raptor Reloaded* prosthesis is just the wrist and hand so the length and size of the forearm will not be needed. A kid's(5-8yr) hand is between 5 and 7 inches and an adult's hand ranges from 7 to 10 inches.

i. *Weight:* The weight of the finished product should be anywhere from around 100-280g depending on the age and size of the user. (values from the similar 3D prosthesis *Cyborg Beast*) This means that the hand is generally lightweight so the user is relatively unhindered, even in the case of small children.

j. *Materials*: Current common materials are ABS, PLA, and Nylon. Nylon is not recommended because Nylon filament must be kept desiccated when not in use. ABS and PLA materials result in durable parts that rarely change with respect to mechanical characteristics over time.

k. *Aesthetics, Appearance, and Finish:* The prosthetic will be 3D printed. Aesthetics are not as important as function. New additions will fit the aesthetics of the current model.

2. Production Characteristics:

a. *Quantity:* There is a need for one altered prosthesis that can then be replicated.

b. *Target Product Cost:* The budget for this project has not yet been determined and will be discussed at the next client meeting.

3. **Miscellaneous:**

a. *Standards and Specifications:* In order to maintain quality prints across many different types of printers, e-NABLE asks for volunteer fabricators to target the following quality specifications:

- No large gaps in between shells. The print must be “water-tight”.
- Layer height between 0.1mm and 0.25mm.
- No experimental, scented, or chemically-treated filament.
- Printer must be properly calibrated to achieve the dimensional tolerances necessary for functioning hands.

b. *Customer:* While wearing the prosthesis, the customer must be able to move their hand two degrees of freedom with ease. The weight or size of the device must be appropriate to the size of the user so it does not hinder them. The prosthesis must be easy to put on and off and should be easy to clean in between uses.

c. *Patient-related concerns:* Each prosthetic is made unique to each patient, therefore sterilization is not necessary and since the design is general, sizing will be adjusted for each specific person, and there will be no patient data to store.