e-NABLE: Create a hold and release mechanism for hand designs

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Date: 9/16/2018

Function:

e-NABLE is a large community of volunteers serving people in need of low-cost prosthetics. To date, over 10,000 volunteers have made and delivered 2,500-3,000 prosthetics to people in 90+ countries. Currently, all e-NABLE hand designs have the same closing mechanism: the wrist is bent causing cables to clench the fist. If the user wants to continuously hold an object they must keep their wrist bent at an awkward angle. This fatigues the forearm and wrist, making it difficult to hold things for an extended time. The purpose of this project is to create a locking mechanism on the prosthetic so that objects can be held more long term. To do this, we must design a way to pull the contraction cables and lock them in place until the user wishes to release the item.

Client Requirements:

- The device fingers should be able to close and stay closed without continuous wrist flexion.
- Materials should easily be sourced in developing countries.
- The new design should be relatively simple to assemble.
- The final product should cost $12-$20.

Design Requirements:

1. **Physical and Operational Characteristics**

- *Performance requirements:*
    - User should be able to hold simple objects such as a water bottle without fatiguing the wrist.
    - Comparable gripping abilities compared to current designs available.
- *Safety:*
    - The device should have rounded corners and dull edges where possible to avoid injuring the user.

    - Metal hinge components should be avoided to allow for a shearing break of the prosthetic joints in the case of a fall, avoiding potential harm to the user being caught in the device being bent at an awkward angle.
- *Accuracy and Reliability:*
    - The device's grip mechanism should allow for comparable or improved hold maneuverability to the existing Raptor Reloaded prosthetic.
- *Life in Service:*
    - The plastic parts should outlast the strings, rubber bands, Velcro straps, etc. On a Raptor Reloaded, in a high heat region, such as Africa or southeast Asia.
    - The Velcro straps and flexor cord should last one year and the extensor stretchy cord should last 3 months.
    - If the part is destined for use in the USA, the extensor cord should last closer to a year.
- *Shelf Life:*
    - The device should be able to be printed and sit in a box put together without degrading or falling apart.
    - In terms of durability, the limiting factor will be rubber bands or elastic strings shelf lives.
- *Operating Environment:*
    - These devices are often sent to war-torn developing countries, where the climate is hot and humid.
- *Ergonomics:*
    - The device must comfortably fit on the user.
- *Size:*
    - The gauntlet of the device will fit snugly around the wrist and/or forearm of the user, being large enough to provide mechanical stability to the user.
    - The device can be scaled to match the size of the user.
    - The size will be more constrained by the final weight of the device.
- *Weight:*
    - The device should be as light as possible while maintaining mechanical strength.
    - It has the potential to be used my small children so keeping the materials light and keeping a weight/material reducing design should be considered.
    - The typical weight of existing eNABLE devices is ~1lb, so our design should be as close to that as possible.
- *Materials:*
    - Materials must be able to withstand the specified environmental conditions and be resistant to degradation due to chemical and temperature exposure.
- *Aesthetics, Appearance, Finish:*

- The final product shall be aesthetically pleasing to look at as it will be in plain view on the user.
- The product shall have no burs or sharp edges that can possibly harm the user or snag on clothing.
- There is no finish needed as 3D printed plastic is ready to use once cured.

2. Production Characteristics

- *Quantity:*
  - Device part files will be available online for volunteers to 3D print and assemble.
- *Target Product Cost:*
  - Current e-nable designs typically cost between $12-$20. Therefore, to maintain affordability, this device should not exceed $20.

3. Miscellaneous

- *Standards and Specifications:*
  - N/A
- *Target Population*
  - The target group for this device is a user who has one working hand and one hand that is missing all digits (palm intact).
  - Users of the device range in age from children to adults, so the design must be scalable in size.
- *Patient Related concerns:*
  - Materials must be easily found and replaced.
- *Competition:*
  - The Bebionic prosthetic hand utilizes motors and sensors to achieve precise hand movements, [1]
  - Prosthetic hands which are solely cosmetic range from $3,000 to $5,000 [2].
  - Prosthetic hands which operate using elastic cables, typically cost about $10,000.
  - Cosmetically realistic myoelectric hands may cost $20,000 to $30,000 or more. These contain processors that can tell how much pressure the user is putting on a held object and whether it is hot or cold [2].

References

[1] "The world's most advanced Prosthetic Hand - bebionic", Bebionic.com, 2018. [Online]. Available: http://bebionic.com/. [Accessed: 17- Sep- 2018].

[2] G. McGimpsey and T. Bradford, Limb Prosthetics Services and Devices. Worcester, Massachusetts: Worcester Polytechnic Institution, 2018.