Get a Grip: An Exploration of 3D Printed Mechanical Prosthetic Hands

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The world of prosthetic hand design and production has seen many exciting developments in recent years with growing interest in 3D printing technology. 3D printing is changing the way prostheses are designed, produced, fitted, maintained, and distributed. e-NABLE is an organization that matches up people with 3D printers with those in need of prosthetic hands, arms, and fingers, (e-NABLE, 2015). I have focused on modifying one of e-NABLE's hand devices: the Raptor mechanical prosthetic hand. The Raptor is a simple, wrist-powered device. Substantial research is being done in the field of robotic prostheses. Robotic arm devices, such as one being developed at John Hopkins University, closely mimic the capabilities of a human hand and can even be controlled with one's mind (Ventimiglia, 2012). These sophisticated devices are extremely expensive and are still in their research and development phase, whereas the Raptor hand is more affordable, lighter, and easier to maintain. Other benefits of Raptor hands are that they are customizable to an individual, they can be scaled for children or adults, and they can be produced and assembled on site in a single day.

I determined that the original Raptor hand was largely ornamental. The two main limitations were that the tension could not easily be adjusted in individual tendons, and that the design did not feature an opposable thumb. These limitations inspired my work to modify the Raptor hand. Many functional improvements came out of this work including: a variable tension tuning peg rack, reminiscent of a guitar headstock; a strategically placed rubber band that greatly improved gripping function; rubber-like finger grips, which also improved gripping ability; and an opposable thumb assembly. The opposable thumb assembly introduced a new degree of freedom to the thumb, allowing it to twist towards the fingers and grip objects with opposing forces. A tuning peg was strategically mounted on the thumb to allow the angle between thumb and index finger to be adjusted manually. All of these modifications improved the usefulness of the Raptor hand substantially, though many required the use of one's other hand.

Material strength tests were developed and implemented to assess the short-term viability of some of the various materials involved. Five different tendon materials were subjected to tests involving hanging masses. Fishing line rated for 50 pounds (~220 Newtons) of tension was the strongest in terms of tensile strength. The average flexing strength was found to be equivalent to the weight of a 1.5 kg mass, or approximately 15 Newtons. This was significantly less than the maximum weight endured by the fishing line, which suggests that the fishing line would be resilient enough to withstand the forces applied with daily use of a Raptor hand.

My work has led to me to develop many additional ideas for functional and aesthetic improvements to the Raptor hand design, mostly focused on anthropomorphization. Future research into the choice of materials will also be useful in improving 3D printed prostheses. Methods for customizing the fit of such devices include 3D laser scanning one's own limb and reshaping plastic components through a process known as "thermoforming." With continued expansion of the 3D printing industry and growing access to the internet all around the world, support for e-NABLE's mission continues to grow. Crowd-sourcing the production and iterative design of 3D printable prosthetic hands allows for the free exchange of ideas between users and designers as people come together to "lend a hand".

Works Cited

[1] e-NABLE. About Us. Available at *http://enablingthefuture.org/about/* (June 2016).

[2] P. Ventimiglia. Design of a Human Hand Prosthesis. Worcester, Massachusetts, 2012. Technical report. Available at *https://web.wpi.edu/Pubs/E-project/Available/E-project-042612-145912/unrestricted/MQP_PaulV_Complete_Final_3.pdf* (August 2016).