Kent Denver Innovative Scholars Program
Spring 2022

Rollins Institute of Technology and Design
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Biomechatronics and Prosthetic Design

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OVERVIEW

For my independent study, I chose to research the design and implementation of prosthetic limbs. I am planning on majoring in Biomedical Engineering and haven't been able to delve very deeply into that area of study during my high school studies. Because prosthetics are such a perfect mesh of mechanical design and the field of medicine, I decided to spend my final four months of high school getting to know this area of study as well as I could.

RESEARCH

I started with general design research, learning about the manufacturing and design process. From this, I ended up delving into the economics of the prosthetics industry. This interest stemmed from the fact that the world of prosthetics is far from just, as only families with deep pockets are capable of purchasing and maintaining a prosthetic limb.

Due to the constant use and strain that these artificial limbs go through on a daily basis, they require maintenance and must be replaced every three to five years. With limbs costing anywhere from $5,000 dollars for a purely cosmetic prosthetic, to upwards of $70,000 for a functioning myoelectric prosthetic arm, it is nearly impossible for the majority of families to afford the 'luxury' of a functional limb.

Unfortunately, insurance companies do little to help as most have increased restrictions and caps starting in the early 2000s. These limit patients to a budget of $1-5,000 or to one limb per lifetime which is hardly reasonable considering the fact that as people grow older, they need to replace their limbs to fit their new size and needs.

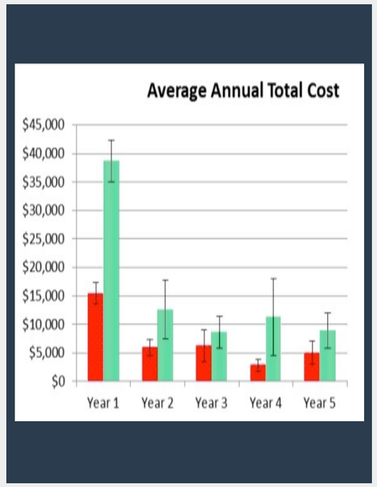

FIGURE 1: Avg. Annual Total Cost of a body-powered (red) vs. Myoelectric(green) Prosthetic

ALTERNATIVE DESIGNS

Unfortunately, because a small number of companies have such a stronghold on the production and distribution of prosthetics, it has made new, more affordable designs much more difficult to get out to the general public. There are already some incredibly effective and affordable designs which have been developed by researchers and mainly college students. The goal now is to get these designs into mainstream production.

FIGURE 2: The object detecting prosthetic designed by Hikaro Shimada, a student in Tokyo, Japan.

Innovative designs are coming into the picture across the world. Scientists from the Israel Institute of Technology have created a scanning/ imagery setup for under $40 and a highschooler in Tokyo has designed a prosthetic arm that uses AI to detect and pick up objects.

There are countless other designs that can be produced efficiently and for far less than the average minimum price of $5000 per prosthetic. This is due mostly to the use of 3D printing parts which allows not only for the precision necessary for prosthetics, but also gives room for rapid customization and implementation of new designs.

ANALYSIS/RESULTS

In an attempt to reduce the price not only of the production of the prosthetic but also the countless doctor's visits involved, I have opted to design an adjustable prosthetic arm. This would allow the user to adjust their own limb and lessen the need for significant involvement from a medical professional.

Dials similar to that on a bike helmet would be placed at various places along the forearm to allow for a tight and customizable mount for the limb.

My design focuses on treating those with transradial amputations and wrist disarticulation. Due to this, the electrodes I plan to use in order to intake electromyography data, can be placed on the front and back of the upper forearm. These electrodes will take in data from muscle movement, send it to a microcontroller and translate that data into directions which will actuate the prosthetic.

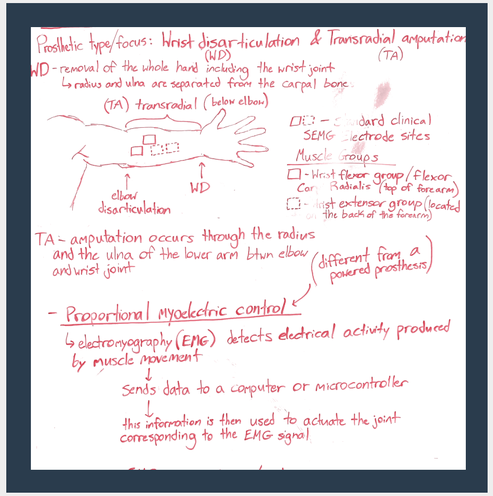

FIGURE 3: Anatomical and Myoelectric Research

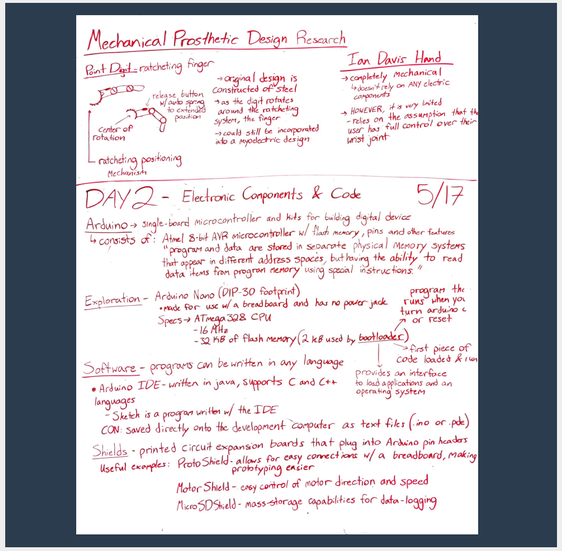

FIGURE 4: Mechanical and Electrical Research from Week of 5/16

NEXT STEPS

I am taking the research and design ideas from this independent study and implementing them into an actual prototype for my Senior Project. Over the past week I have been doing research into transradial amputation and the different mechanical designs currently in use. I am also teaching myself how to use a microcontroller (specifically, an Arduino Nano) which I will use to control the prosthetic.

While the first week has been focused on familiarizing myself with the details of the anatomical and technical knowledge of this topic, I am excited to use computer-aided design (CAD) to design and 3D-print my project. I will then be able to put my new understanding of Arduinos and past code experience into the prosthetic to bring the design to life.

CONCLUSION

While I previously had a great interest in Biomedical Engineering, this independent study and the work I am continuing to delve into throughout my senior project has greatly increased my passion and excitement for the field of study. There is so much to learn in just prosthetics, so I cannot wait to dive into the depths of what biomed has to offer. This project has shown me that there are so many areas for growth and I look forward to joining the great minds already working to create better, more ethical, and affordable medical devices and implants.