Design of a Muscle Activated Prosthetic Hand

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Problem Statement

- Across the United States there are over a million people living with a residual limb.
- Many American veterans are just some of the thousands of people who have lost a limb, but cannot afford the cost associated with a prosthetic.
- Our local prosthetist partner, Eric Shoemaker, has many such patients who would benefit from a myoelectric (muscle activated) prosthetic.
- A commercial device that utilizes such mechanisms can cost anywhere from $20,000 to $100,000 for most amputees.

Specifications

- ***Weight***: less than 500 grams
- ***Grip Force***: 60 N for cylindrical grip, 6-12 N in extended fingers.
- ***Grasp Speed***: fully close/open in less than 1.2 seconds
- ***Compliance***: we want our hand to bend when it encounters unexpected forces to prevent it breaking.
- ***Feedback***: we want our hand to be aware when it encounters resistance, to avoid accidentally crushing something.
- ***Life of Daily Use***: 1-2 hours of continual use; 9-10 hours of idle use
- ***Lifetime***: ~3.5 years
- ***Cost***: less than $1,000

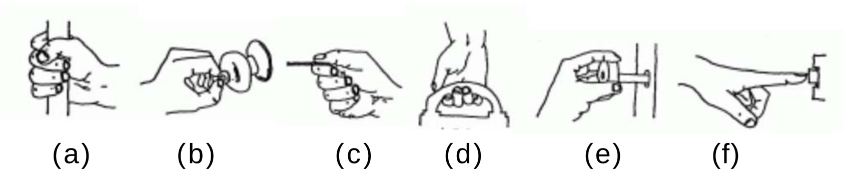

Figure 1: Depiction of grip patterns utilized to achieve ADLs - (a) power/cylindrical (b) precision pinch (c) lateral/key (d) hook (e) tripod (f) finger point.

Mechanical Design:

- 1 motor controls the 1st and 2nd digits, 1 motor controls the 3rd and 4th digits, and 1 motor will control the thumb
- The motor rotates a shaft connected to a worm gear, which in turn rotates a spur gear connected to a cross axle
- As a cross axle rotates, two proximal phalanges rotate concurrently
- A link pinned to the holder and distal phalanx achieves the motion of a finger closing
- Parts to be 3-D printed: proximal phalanx, distal phalanx, and holder
- Use of non-backdrivable worm gears allow a static force to be applied without the motor continuously running

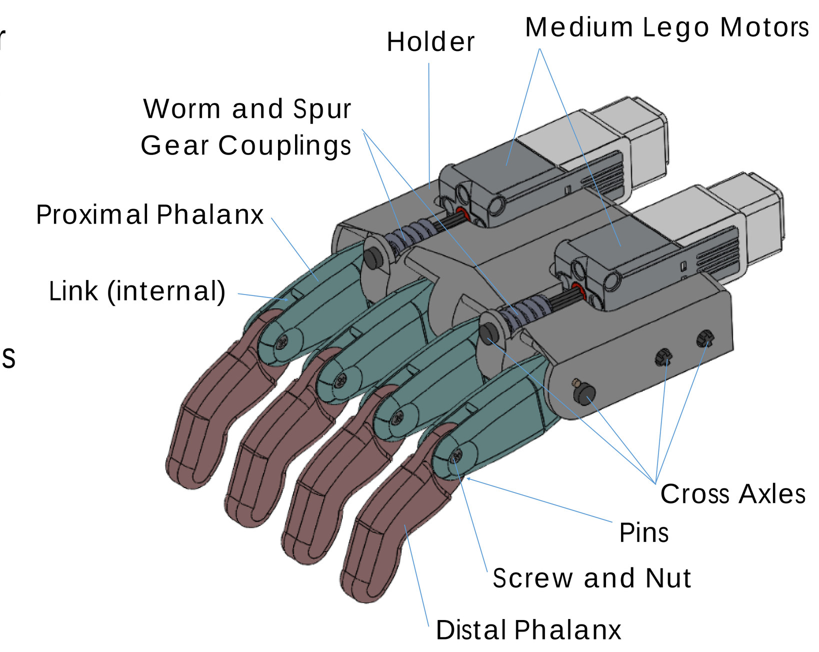

Figure 2: Isometric view of current parts of prosthesis

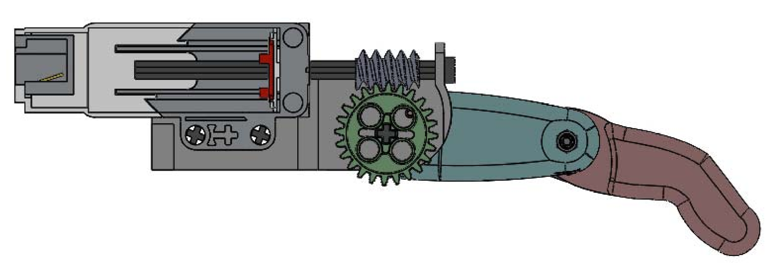

Figure 3: Section view depicting the interaction of the gears

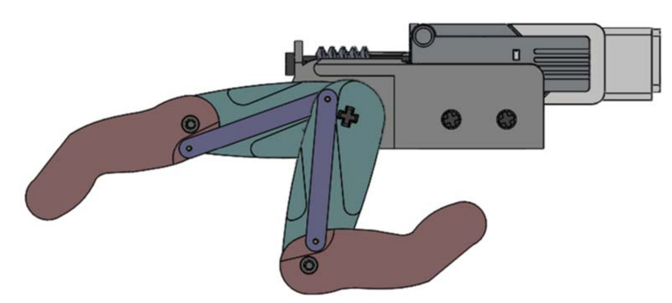

Figure 4: Section view showing the link mechanism and its accompanying motion

Electrical Design:

- The Electrical Team decided to approach the problem from a ground-up design philosophy.
- We started using only a single sensor, and designed a computer program that would switch between two positions.
- Next we began to experiment with more complex programs that could remember different positions. This was deemed unreliable with the signal from a single sensor.
- In the next year we plan to implement additional sensors to give us a more precise signal to read from.

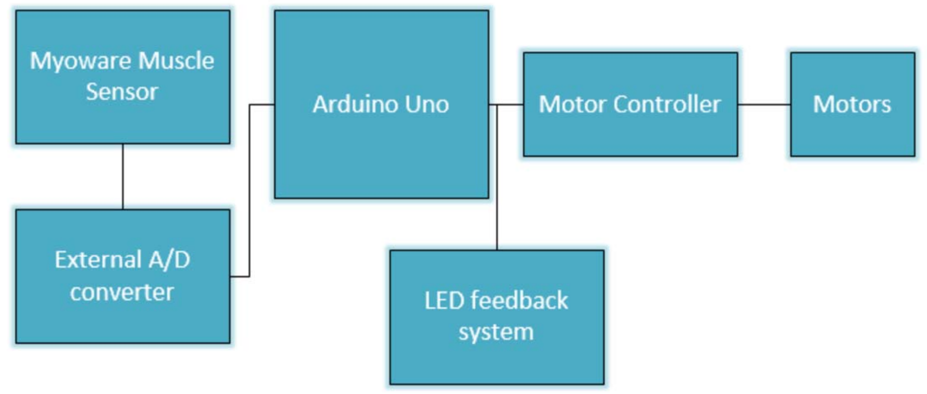

Figure 5: Flowchart of System design

Figure 6: Myoware Muscle Sensor

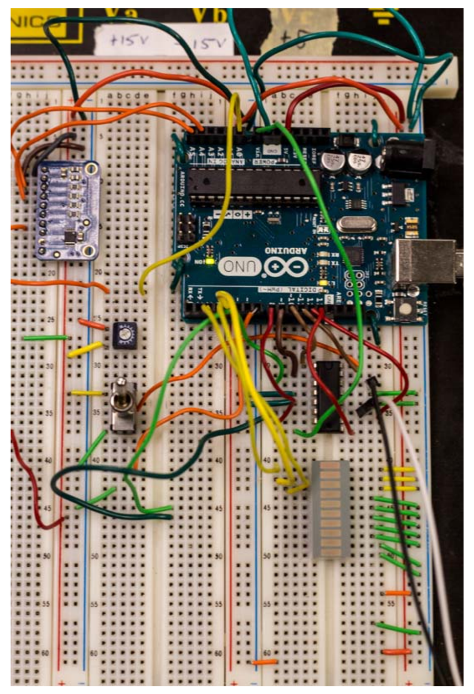

Figure 7: Circuit board

Goals

- This project aims to make the best treatment available to patients who are unable to afford the prosthetic device they need.
- The final product will comprise a custom fitted myoelectric prosthetic device for a patient who has undergone a transradial (below the elbow) amputation.
- The prosthesis will have a set number of grip patterns initiated by varying strengths and rhythms of EMG signals emitted by muscle contractions.

Methodology

- Our team decided to tackle this problem on two fronts. Because electric prostheses straddle the line between an electrical engineering and a mechanical engineering project, we elected to divide our efforts.
- Jason and Jonathon worked on the Mechanical and Biomechanical portions of the Prosthesis, creating the hand itself with 3D printing technology.
- Kieth, Erin and Alaric handled the Electrical and Computer engineering portions of the assignment.
- Several portions of the design procedure did overlap between the electrical and mechanical sides of the design project, such as understanding the power draw of the motors and what size and type of battery would be best able to sustain our current needs.
- Our research into the best solution lead the team to take a trip to Black & Decker manufacturing company, where we received valuable advice from Danny Brotto and several of the engineers who were generous enough to take the time to go over our design with us.

Conclusion

- Over the course of the last year, we have taken in research on the field of Myoelectric Prosthesis and have created from that research a working prototype for how such a hand could be designed.
- There are still several major topics to be approached, such as the construction of the forearm casing and the refinement of the controlling program.
- Despite these future challenges we are quite pleased with our progress in the year and looking forward to seeing where the next year goes.

Physical Prototype:

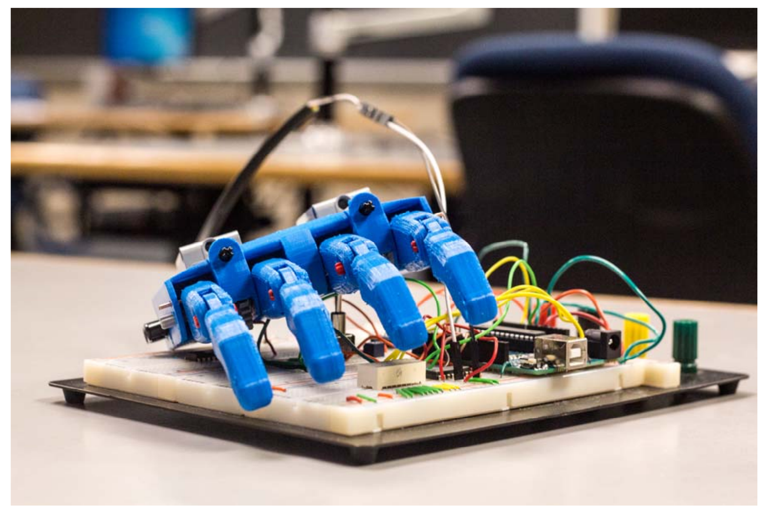

Figure 8: Physical Prototype

Acknowledgements

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Team Members

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- Keith Wei Luen Lim
- Alaric Kobzowicz
- Erin Cressman

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