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Improved Lower-Arm Prosthesis

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IMPROVED LOWER-ARM PROSTHESIS

CAPSTONE DESIGN EXPO 2015

PURPOSE

Upper limb amputees face a challenging decision when choosing a prosthesis option. Approximately 35% of these amputees choose not to use a prosthesis due to complaints of difficult operation, comfort, and cost. In order to bridge the gap that exists between functionality and usability in such solutions, we have developed a user-friendly low-cost lower arm prosthesis. This prosthesis is intended to encourage patient adoption and retention by emphasizing ease-of-access and cohesion over technical precision.

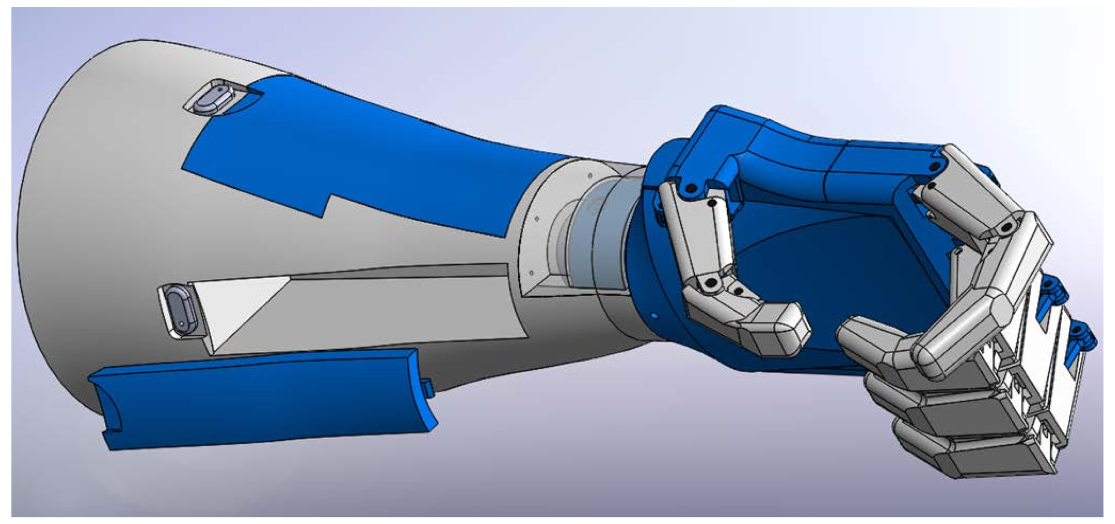

Figure 1: Prosthetic hand and forearm

DESIGN APPROACH

The improved lower arm prosthesis is a robotic prosthetic solution designed to provide the user with:

- Simplified Usage
- Minimized Cost
- Consistent comfort

As shown in Figure 2, this device has the capability to emulate three common hand grips: a pinch, a full fist, and an index point. This prosthesis is designed to be operated in combination with a signal processor unit. This signal processor should take in myoelectric signals from the user's muscles, and use them to issue commands to the prosthesis controller.

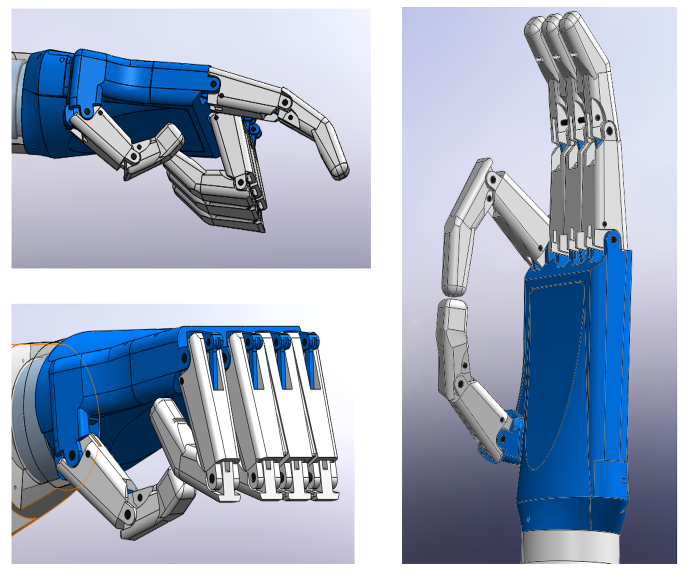

Figure 2: Three prosthesis hand grips

Mechanical Hardware

The structure of the prosthesis is composed of 3D printed ABS plastic that attaches to the body with the use of an elbow brace to distribute weight off of the insertion point. The joints and dog bone linkages are crafted from steel and aluminum, respectively. Actuation of the prosthesis' digits are performed by three hybrid linear actuator stepper motors that are connected to a four-bar mechanical linkage shown in Figure 3. The wrist rotation is performed by a DC bi-directional motor with an encoder attached to measure movement distance.

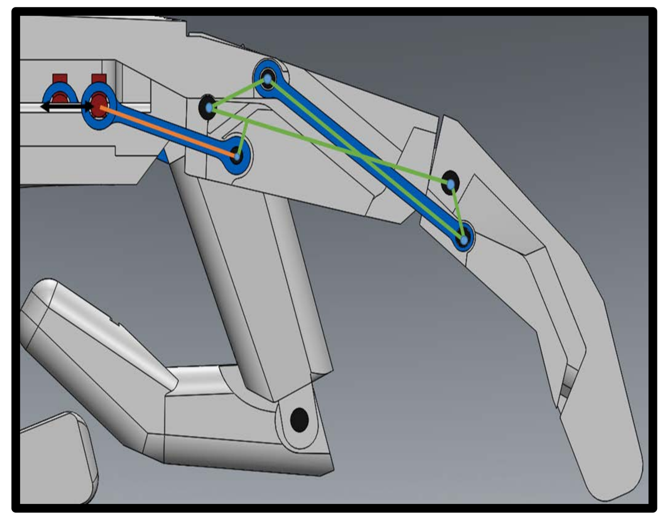

Figure 3: Intra-digital linkage system

Electrical Hardware

Power for the prosthesis is provided by a 2200 mAh lithium polymer battery and distributed to the various system components through a specially designed power distribution circuit. The prosthesis controller is implemented on a Zynq-7000 devleopment board. Figure 4 shows an overview of the prosthesis' electrical system.

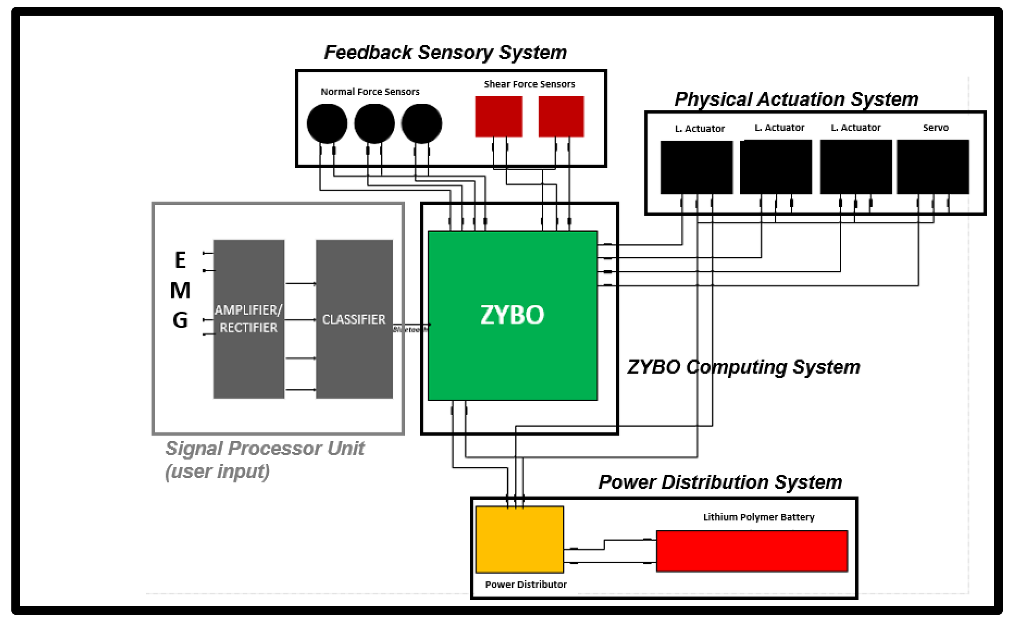

Figure 4: Overview of system interface

Software

The software design for the prosthesis controller is depicted through the state diagram shown below. The hand starts at a rest state and, depending on the grip desired, will transition to a new state to begin performing one of the requested grip. The following states then utilize function calls and analog-to-digital conversion to continuously monitor force sensors on the surface of the hand.

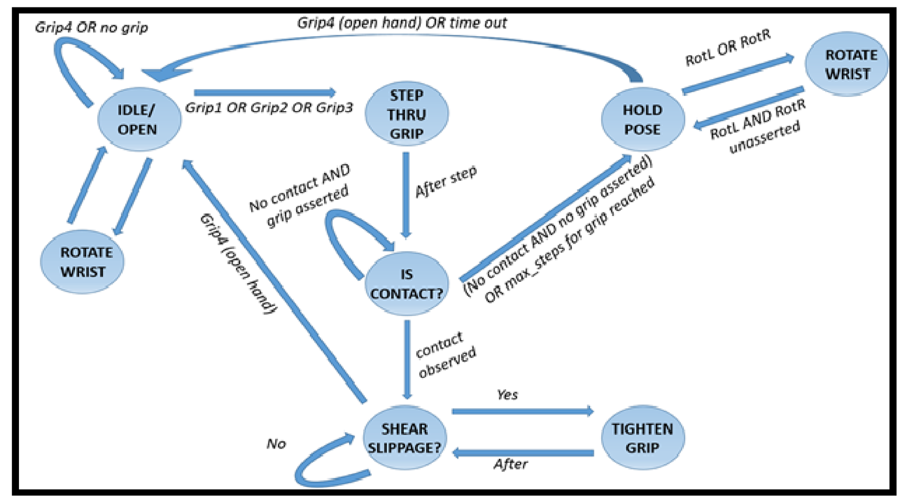

Figure 5: State Machine executed in prosthesis controller

These states are then used to automatically manipulate the motors based on sensor inputs, allowing the prosthesis to "sense" physical objects in the real-world.

CONCLUSION

Overall the primary principles of our design were preserved throughout the completion of the project. However, a number of adjustments and alternatives were considered to address a few unexpected issues. After our initial design phase, we determined that a linkage-based movement scheme may be preferable to a string/spring-based concept. This strategy provides increased structural integrity, which should result in less maintenance and cost. While evaluating the structure of our software, we chose to include hardware interrupt signals to manage the parallelization of the sensor interfacing and motor control. This strategy was chosen due to the more precise timing capabilities available, as well as the advantage of not being required to implement a full operating system on the computing platform.

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Make it real.

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