# Voice-Activated Bionic Hand

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# Voice-Controlled Bionic Hand

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## Abstract

The goal of this project was to design and build an inexpensive, voice-controlled prosthetic hand. Because precise electromyographic technology - technology that reads electrical signals from muscle movements - is often costly, our design utilizes speech recognition to move all five fingers of our bionic hand independently. This allows the user to command multiple different grips without the cumbersome and expensive equipment needed to detect individual finger movements from muscle contractions. This entire system is designed with both cost and precision in mind. All components are inexpensive and easily replaceable, providing the user with an affordable prosthetic hand. However, while the parts are inexpensive, the system accurately detects voice commands in a consistent manner. In addition, the user interface is designed to be intuitive, allowing any individual to easily train and use his or her own bionic hand for basic tasks around the house.

## Objectives

To achieve our goal, we must meet the following requirements:

1. The system must be able to detect three key voice commands and translate them into a desired hand motion.
2. The hand must not break when attempting to grasp an object.
3. The system must cost under $500.
4. The system must be fully mobile.
5. The system must display pertinent information to the user via an OLED screen.

## Control Method Considerations

Initially, we had considered using electromyography to control the system, as the previous bionic hand senior design team had done. However, one of our primary goals was to move individual fingers at the user's prompting. Because individuals without a hand or an arm have varying degrees of muscle atrophy, it becomes difficult to read individual finger motions via sensors on the skin. Sweat and dirt on the arm can also contribute to inaccurate data. Thus, given our limited budget, we decided to explore other options.

After much research, we decided to use speech recognition to control our bionic hand. Not only does it allow us to move all five fingers independently despite muscle degeneration, but it also eliminates the need for a neural network. Training the speech module with one's voice takes significantly less time and software than training sensitive electromyographic equipment to detect signals from certain muscles. In fact, our entire bionic hand system is ready for use after one five to ten minute training session. It can also be easily re-trained by the user to respond to different words if desired.

## Hardware

Speech recognition is carried out by a hardware module, which can detect up to five unique voice commands at a time. To eliminate the chance of an inaccurately identified command, we installed an easy-access power button. In addition, an OLED (a digital screen) displays pertinent information about voice command sets and steps the user through re-training the speech module. Various buttons are installed to allow user input for this process. The bionic hand is controlled by an STM32 Blue Pill, which receives translated voice commands from the speech hardware module. Figure 1 shows a hardware diagram of our system, while Figure 2 shows our circuit setup for this semester.

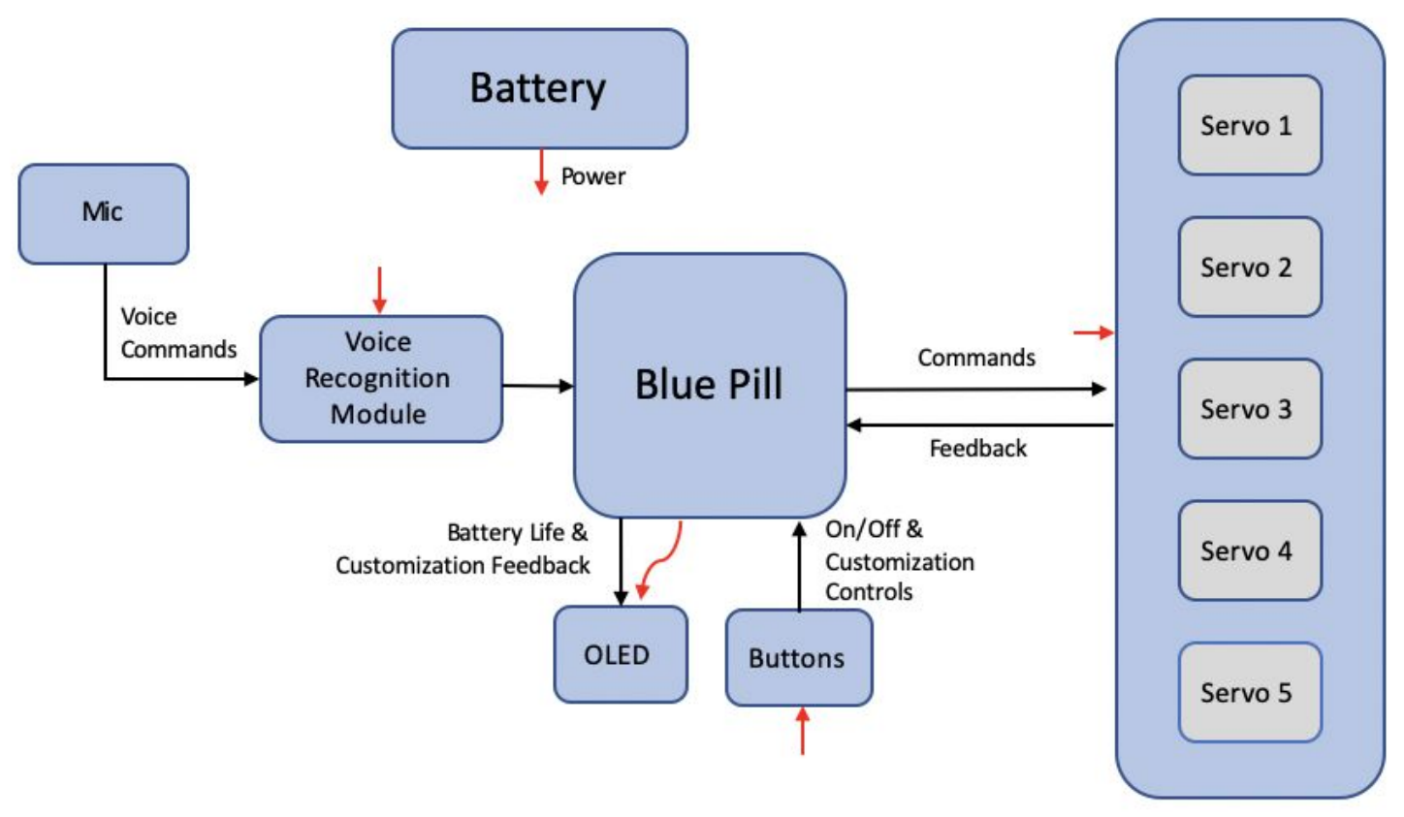


Figure 1: Top-Level Hardware Diagram

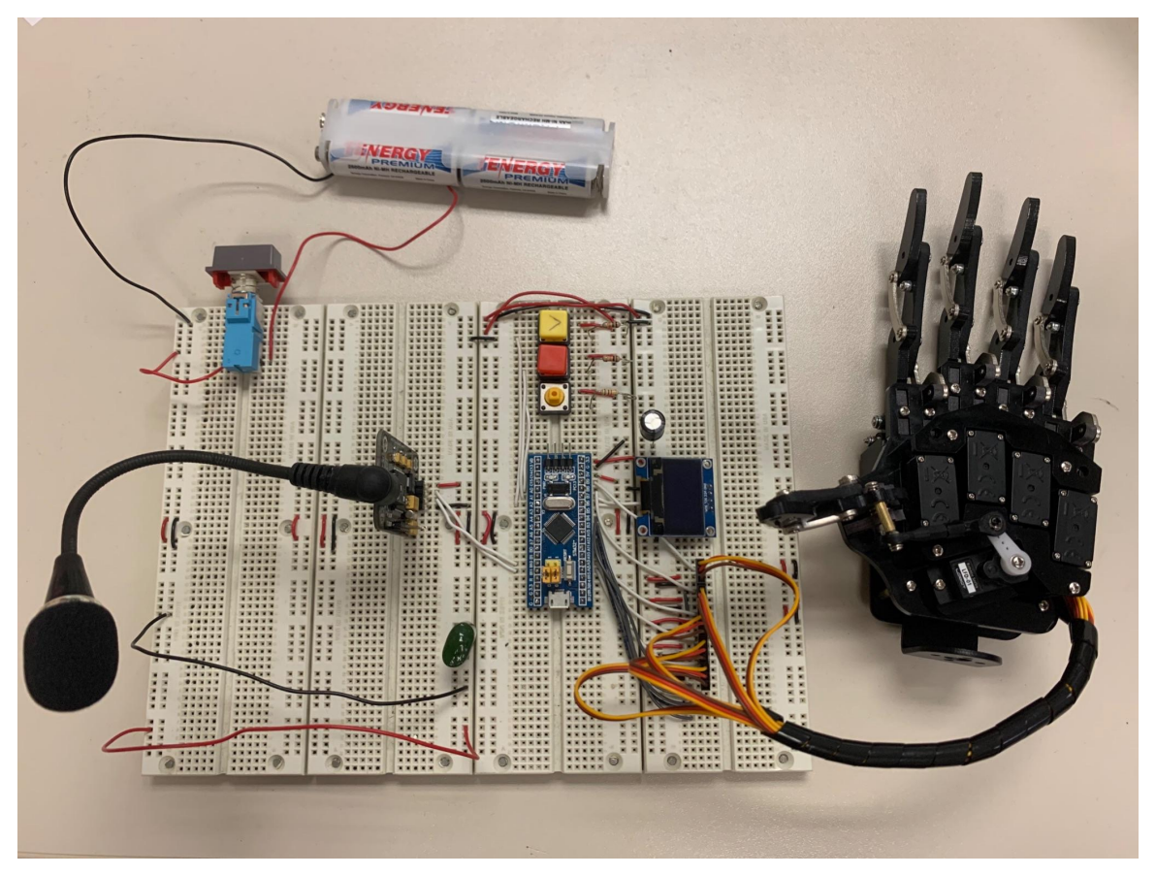


Figure 2: Spring Semester Circuit

## Software

The majority of our software on the Blue Pill is written to control the servos and to operate the user interface. The speech hardware module completes any speech recognition itself, so the Blue Pill simply communicates with it and then sends appropriate commands to the hand. A software diagram of the motor controls is shown below in Figure 3. In short, the Blue Pill listens to the speech module in a loop until the speech module sends information. When this information is received, the Blue Pill picks the correct hand motion and sends that command to the servos. The servos are activated by pulse width modulation (PWM), a means of controlling an analog device (in a range of numbers) with a digital signal (just 1s and 0s).

The user interface is designed to interact with the wearer in an intuitive manner. Software is written for the OLED screen, which steps the user through training and using the system. It also provides a low power mode option, in which the system saves power by still responding to voice commands while the screen is off.

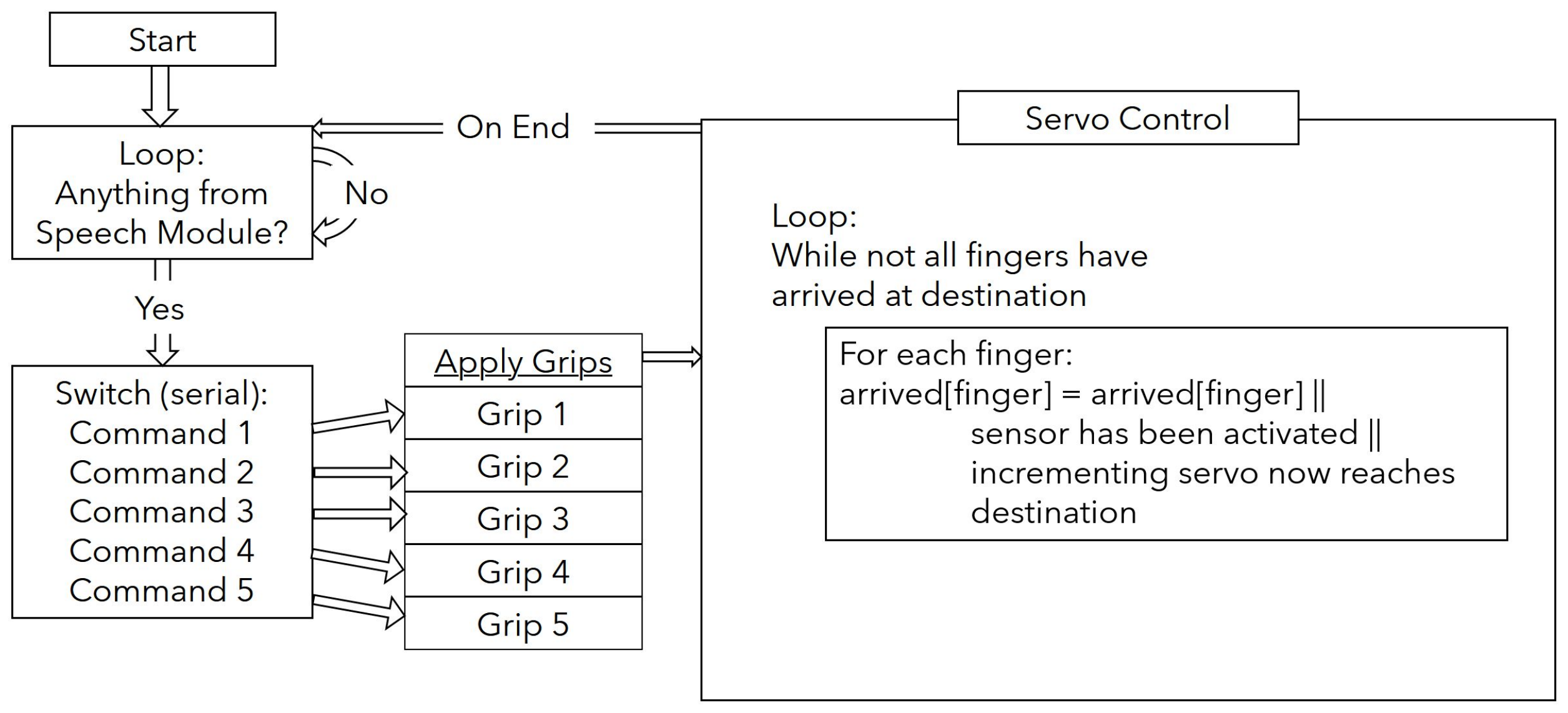


Figure 3: Software Diagram

## Sensors and Socket

To prevent servo damage when an object is grasped, pressure sensors are attached to each finger on the prosthetic. These are made from a pressure-sensitive material that drops in resistance when a force is applied. Because the bionic hand fingertips are fairly small in width, the sensors are mounted onto 3D printed fingertips, which both widen and flatten the fingertip surface.

Figure 4: Pressure Sensors

In addition, because our end goal is to give this hand to a particular amputee, we designed and 3D printed a socket. The bionic hand and all circuit components are attached to this socket, which can be molded to fit each user's arm.

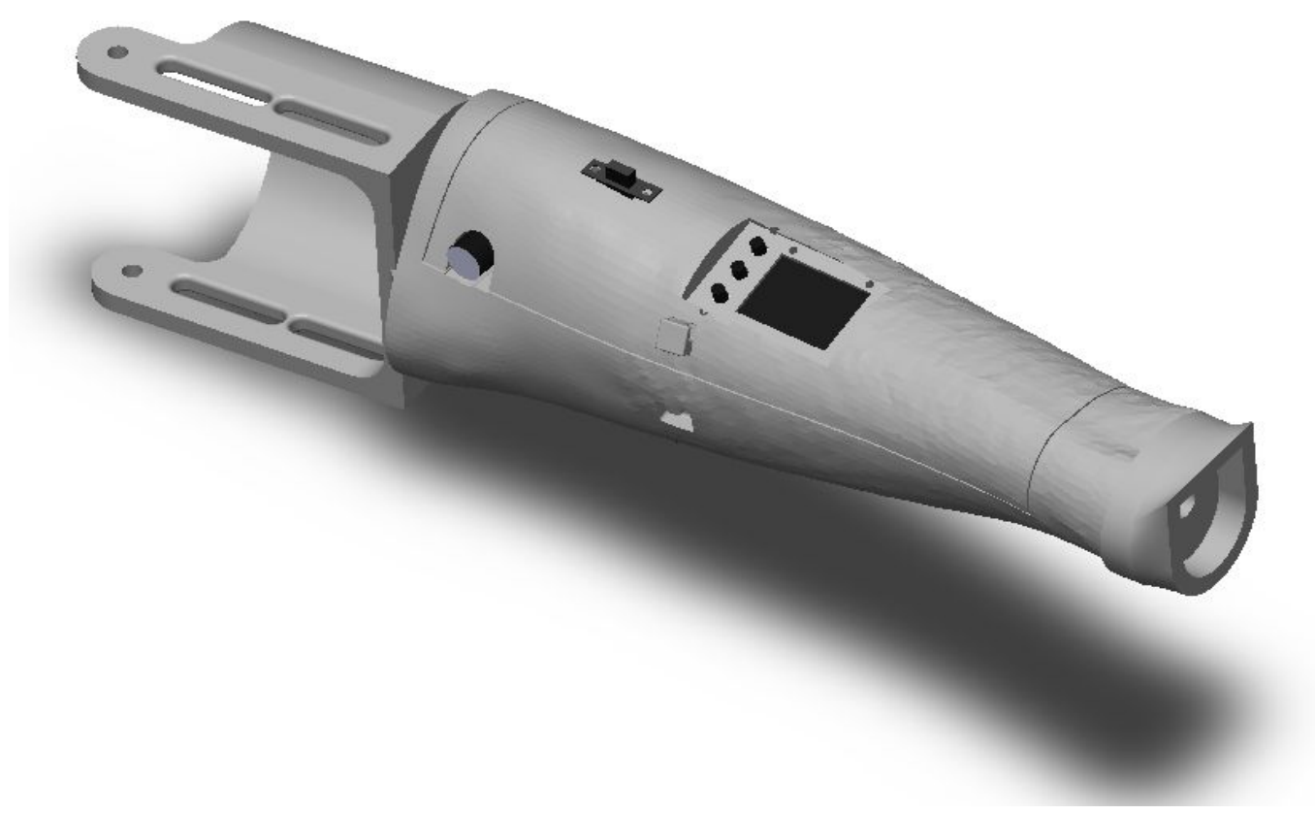
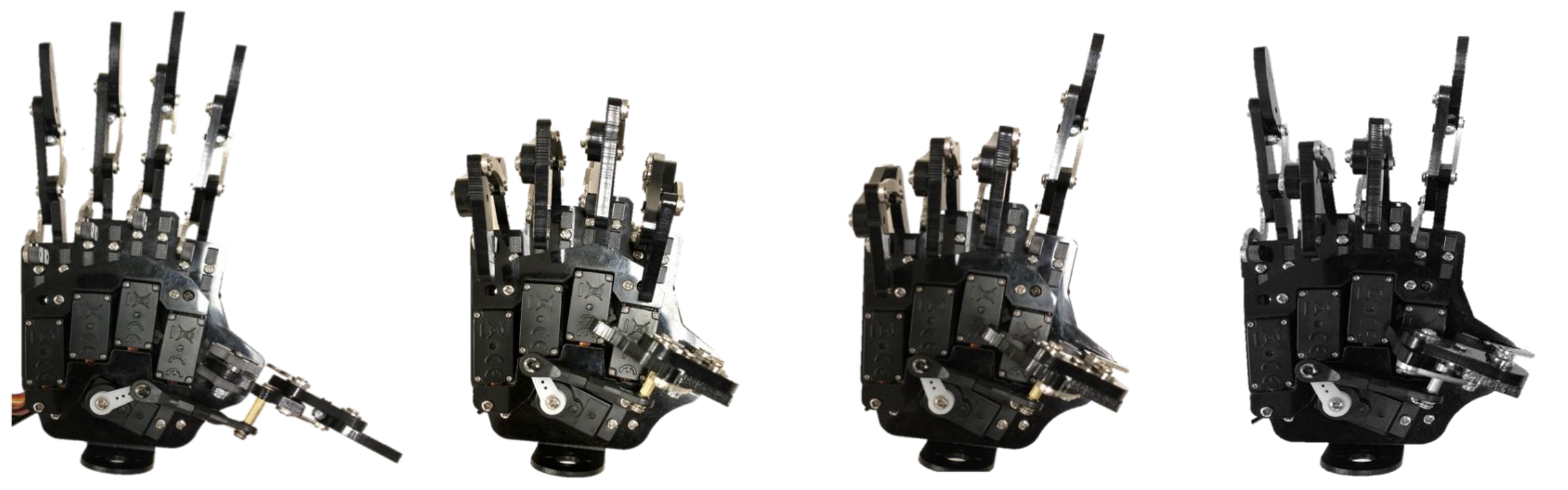


Figure 5: Socket Model

## Results

As of the beginning of April, our bionic hand correctly responds to five separate voice commands. Four hand motions are shown in the figures below. The fifth is a slower version of "Grasp." In addition, all five fingers stop when a force is applied to the pressure sensors. We have reached or will reach all of our goals for this project by the end of the semester, producing a fully-functioning voice-controlled prosthesis ready for training and operation.



"Release" "Grasp" "Point" "Rock On"

## Conclusion

While this system is not ready for production on a significant level, substantial steps were made toward researching and creating a voice-controlled prosthetic hand. We successfully demonstrated that speech recognition can be used to translate user input to bionic hand motions. Not only does our system eliminate much of the expense and training time associated with electromyographic devices, but it also allows a large amount of variation in hand movements even with muscle deterioration. In the future, a different hand and/or a different speech module is recommended to improve weight limit or to increase the number of voice commands.

## Significance

This research project has provided an inexpensive and effective means of controlling a prosthetic hand.