Pinky: The Robotic Hand

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Introduction

Objective

The goal of this project is to create a robotic hand that mimics the motion of the human operator. This robotic hand will rely on mechanisms similar to those of the human body in order to move.

Background

In the human hand, flexor tendons are responsible for finger motion, with attachments at each phalanx responsible for bending at the three finger joints. These tendons undergo flexion and extension via the contraction and relaxation of muscles.

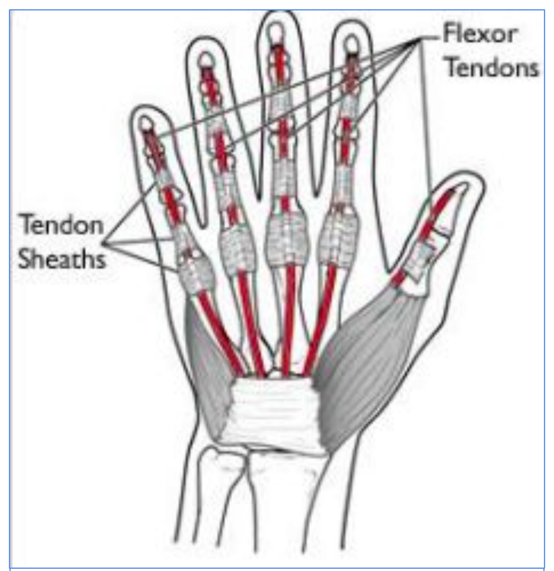

Figure 1: Tendon Anatomy
Flexor and extensor tendons stretch down each finger. They have bundled connection points at the top of each of the phalanges.

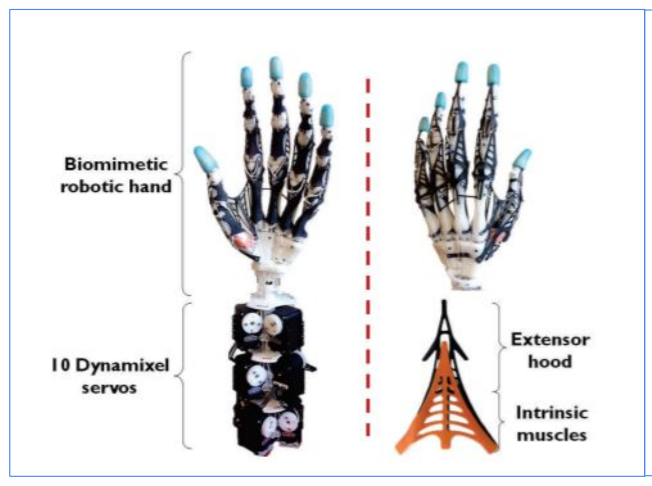

Figure 2: Biomimetic Models
Previous hand models sought to model muscle contraction and relaxation using a servo-driven tendon system with the anatomically accurate skeletal structure of the human hand.

This project mimics muscle contractions and their corresponding tendon movements in order to model human motion on a robotic hand. In this experiment, muscle contractions were simulated through the motion of high-voltage servo motors. Fishing-line "tendons" attached to the phalanges would move in response to servo motion to induce finger flexion and extension.

Results

Early Prototypes

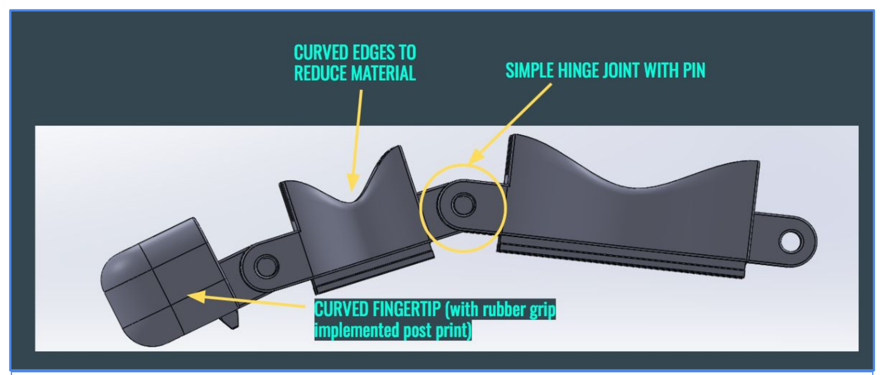

Figure 3.1: First Prototype Model
This CAD model aimed to mimic some of the natural constraints to motion that are present in the human finger

Figure 3.2: First 3-D Printed Model:
This prototype used elastic bands to maintain finger tension. A servo flexed the finger from its neutral position.

Initially, 9 g servos were used to flex the fingers from their neutral position. However, these motors proved too weak to overcome the elastic force of the rubber bands. The servos were replaced with larger, stronger 20 Kg servos. While they have performed better, the new servos have problems with instability an inconsistency from electromagnetic interference.

Figure 4: Basic Setup of the Robotic Hand
The hand was oriented on its side with control servos placed behind the hand in the anatomical position of the forearm. Each side of the servo arm was attached to three sets of strings. The other side of each string was attached to the corresponding position on the top and bottom of each phalanx on the finger. As the servo arm rotates, the strings are tensioned and relaxed, actuating flexion and extension in the fingers. The servo motors were wrapped in aluminum foil to minimize interference.

Current Model

Figure 5: The Base of the Thumb
To mimic human motion, the base of the thumb must be able to rotate orthogonally to the plane of the palm. This is achieved by using two helical gears with 45 ° pitch angles. One gear is placed within the palm and controlled by a belt connected to an external servo. The second gear is integrated into the base of the thumb.

Figure 6: Current Palm Design
The latest iteration of the palm has notable differences from previous designs. The new palm has a series of partially covered tunnels that allow for easy threading of fishing line to the fingers. There is also a set of grooves near the fingers that allows for the insertion of joints, allowing for modularity and ease of installation. These joint inserts serve to limit the range of motion of the fingers, mimicking human anatomy.

Figure 7: Controlling the Robotic Hand
The robotic hand moves in response to user motion detected by flex sensors sewn onto a glove, When the user flexes their finger in the glove, the servo arms rotate accordingly, leading to flexion and extension of the fingers.

Future Research

Alternative Sensors

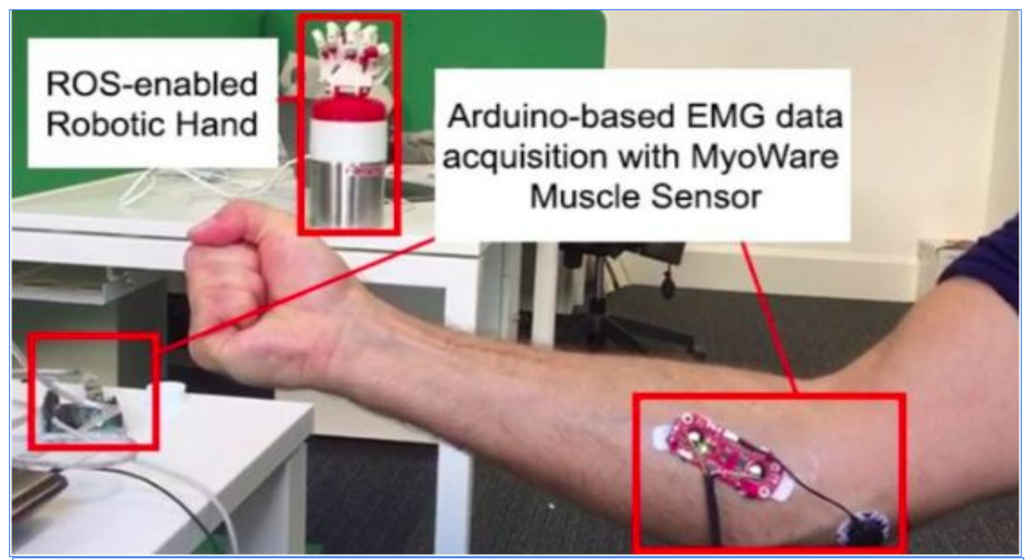

Figure 8: Electromyogram Control
While the flex sensor model allows for the user to wear an intuitive sensor glove, there was great difficulty integrating the flex sensors into the design without damaging the relatively expensive devices. To avoid this issue, user movement can be sensed using an Arduino-base electromyogram. In this system, muscle contractions will be directly translated to robotic hand movement, serving as a pseudo-prosthetic.

Wireless Modifications

To allow for greater user mobility when using the device, the servo motors can be controlled via a smaller Arduino Nano within the servo enclosure rather than a larger, external Arduino Uno. In addition, the Arduino Nano does not require a direct connection to a laptop running the script, allowing for more practical use of the device.

References

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Robotic Hand Project Team

From left to right: Aidan Montiel, Thamira Skandakumar, Anya Bekhtel, Bhrugu Mallajosyula, and Sruthi Mukkamala.