Adaptive Soft Robotic Finger

Clint Middlemist, Dr. Jianguo Zhao, Jiefeng Sun

Department of Mechanical Engineering

Colorado State University, Fort Collins, CO, USA

WALTER SCOTT, JR.
COLLEGE OF ENGINEERING
COLORADO STATE UNIVERSITY

Introduction

Research was conducted on the use of robotics consisting of a small DC motor, encoder, and Arduino to control and flex a soft silicone finger. This research, which is highly useful for the field of prosthetics, is simply a gateway to a new world of adaptive robots that can “reconfigure their shapes, structures, or functionalities to fulfill multiple tasks in diverse environments” [1]. The movement of the robotic finger can be reconfigured to suit many different fields, such as a robotic fish.

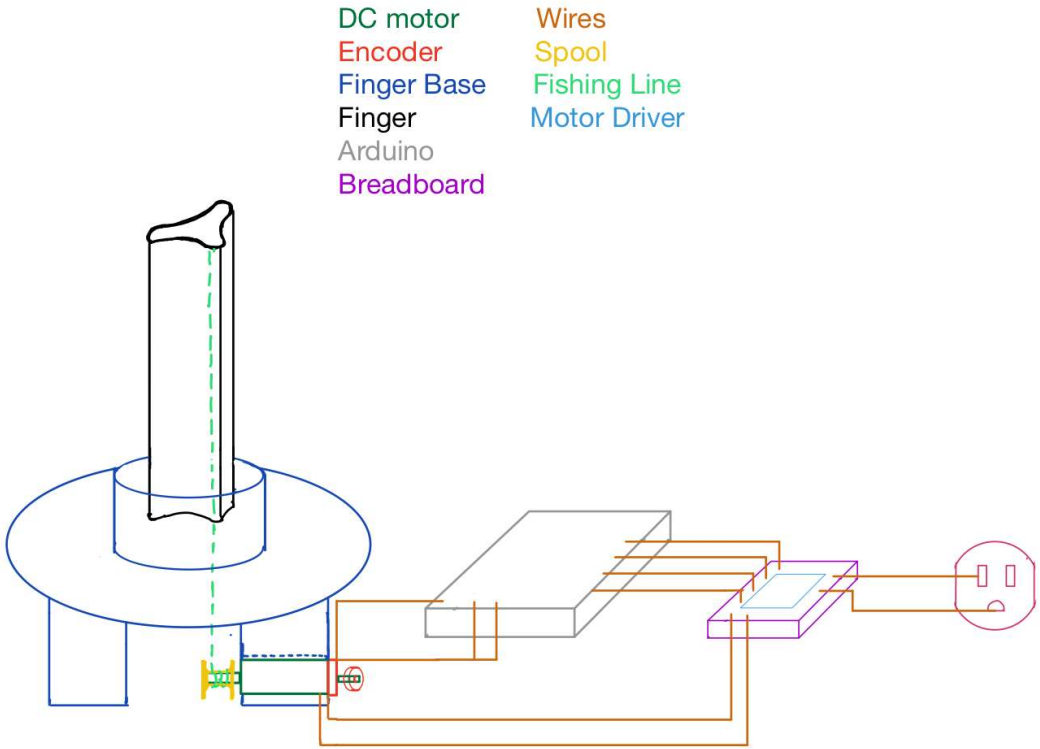


Figure 1. Schematic Diagram of Finger Setup

Methods/Experimental Setup

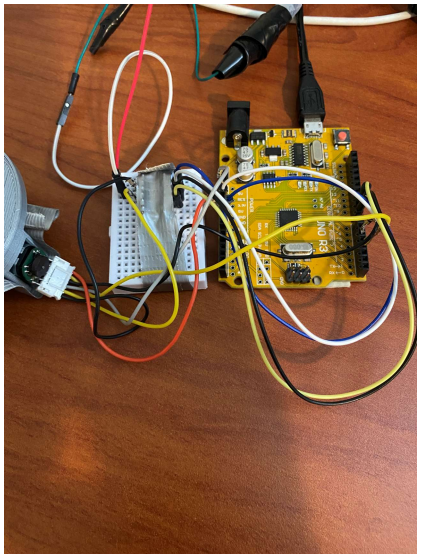


Figure 2. Wiring Diagram of dc motor, encoder, motor driver, and Arduino

Figure 3. Picture of DC motor with spool of fishing line and magnetic encoder attached.

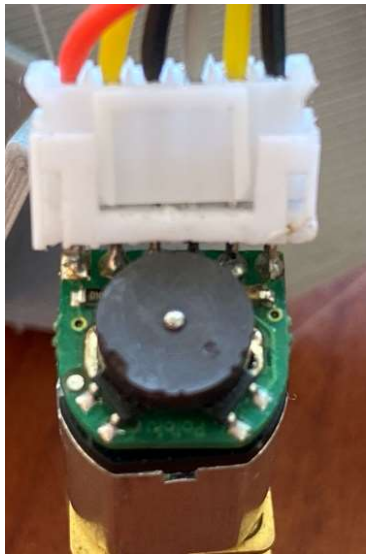


Figure 4. Magnet (Black) rotates with motor and is tracked by the encoder (Green) to count the number of rotations

Prior to developing the finger, it was imperative to understand how to control the finger. To do this, a magnetic encoder was used in conjunction with Proportional Integral Derivative (PID) control to always control the position and velocity of the motor.

Methods/Experimental Setup

Channel of finger as shown from above

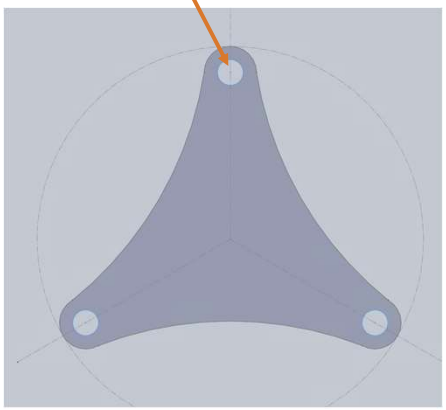
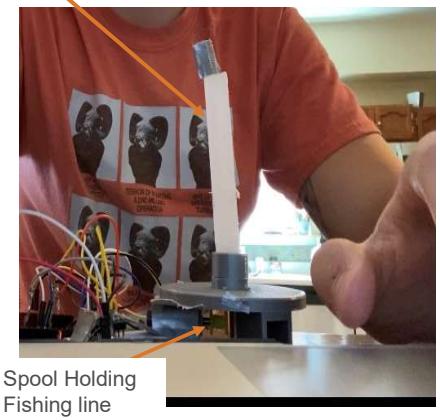


Figure 5. Cross sectional area design of finger

Figure 6. A Mold was printed to pour and create the silicone finger

Channel with fishing line running through finger



Spool Holding Fishing line

Figure 7. The finger was attached to a 3D fabricated base and has fishing line running through to a motor.

In order to fabricate the finger, a mold had to be 3D modeled and printed, and then the finger was molded with 3 channels running through to hold the fishing line.

Methods/Experimental Setup

The finger is flexed by the tightening of the fishing line contained in the channel by the motor. As the motor spools up and tightens the line, the distance between the top of the finger and the base must shrink, thus flexing the finger

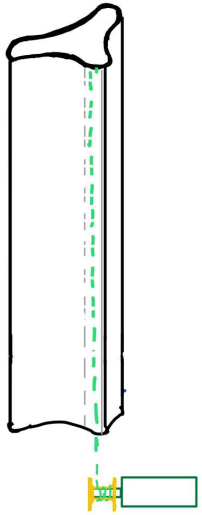


Figure 8. A set length of fishing line (green) is running through a channel contained in the finger (gray)

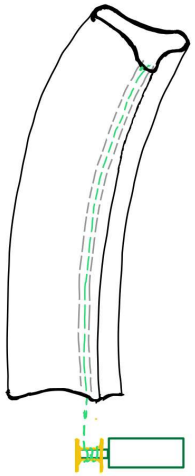


Figure 9. The fishing line is spooled by the motor, shrinking the distance of the line in the finger, forcing the finger to compress and flex

Results

There were several successful trials shown that demonstrate the ability for the finger to flex to a specific distance, directly proportional to the amount of fishing line spooled by the motor. A given input in length can be specified in the code, and once run, the motor could spin, spooling up the line and thus flexing the finger a given amount. Is these trials, the finger was flexed near 85% and 100% to show the difference.

Figure 10. Video of finger flexing approximately 85% of max

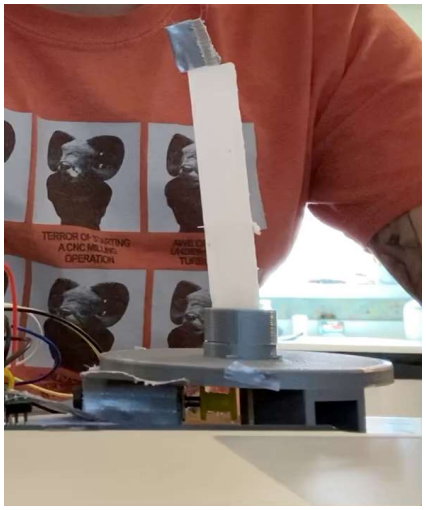


Figure 11. Finger flexing to near full distance

Next Steps

There are countless directions one could take this research. However, the first steps would be to modify the code controlling the Arduino to flex and unflex the motor with code and implement a joystick controller to flex the finger. After this is implemented two more motors can be added to allow for 360-degree motion, along with the addition of complex paths of the finger being attainable. For example, having the tip of the finger move in a circle, triangle, etc.

Once these preliminary steps are done, this framework could be implemented into many different robots, including a remote-controlled robotic fish, or a working prosthetic finger/hand.

Conclusions

Using PID control, a dc motor with an encoder, and an Arduino, one can manipulate and control a soft artificial finger. Although what I have accomplished has barely scratched the surface of what is capable with this technology, it is still fascinating to see the possibilities.

What benefits did you get from you SURE experience?

There are countless benefits I received from the SURE experience. Not only did I broaden my knowledge in the world of engineering, but I have also made amazing connections with faculty members and have had the ability to continue my research throughout the summer as well. I have also developed new problem-solving skills that come with conducting research and having perseverance. Being able to expand my knowledge into the world of Adaptive Robotics will guide me in my future in the direction of my engineering career.

References & Acknowledgements

I would like to thank both Jiefeng Sun and Dr. Zhao for all their help on this project. Although remote research was not easy, they both made the process much easier.

[1] J. Zhao, “Colorado State University,” *Adaptive Robotics Lab*. [Online]. Available: https://www.engr.colostate.edu/~zhao/. [Accessed: 21-Apr-2021].

Thank you to the Suzanne and Walter Scott Foundation, Tointon Family Foundation, The Filsinger Family, Caterpillar Inc., and Contributors to the Dean’s Innovation fund for making the SURE program possible.

Thank you

Colorado State University