The AI Rock Paper Scissors 3D Printed Hand

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Project Objectives and Goals

The main objective of the project is to produce an open-source, low cost, and accessible bionic hand that can be trained to recognize and react to chosen objects through neural network processing.

The first milestone was to create a generation one bionic hand. To do this, we designed a model through computer-aided design (CAD), constructed the 3D printed hand, implemented servo control, and trained an existing neural network to recognize the gestures of rock, paper, and scissor of real people in real time.

Background

Loss of the hand is the second most common loss of a body part, with half a million people affected in the U.S alone[1]. However, less than 50% of affected patients use a prosthetic attachment in any form[2].

To produce an easily accessible and customizable hand, we designed a 3D printable model and added one servo motor for each finger, allowing each finger to be controlled independently.

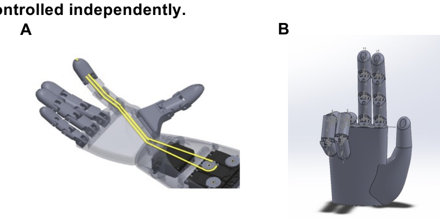


Figure 1: Internal image of a servo motor attached to the pointer finger[3] (**A**). Image of our designed hand in solid works with the strings attached to the servo motors on display (**B**)

To improve the user experience, we are working on developing a neural network (NN) for object detection that will train the hand to be able to react to external stimuli.

As the initial deliverable, we trained the hand to play the game rock, paper, scissor, against real opponents to test the capability of the NN to recognize complex gestures. Multiple hand shapes, sizes, and colors were used to create a more robust training set.

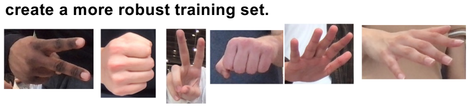
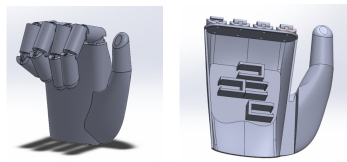


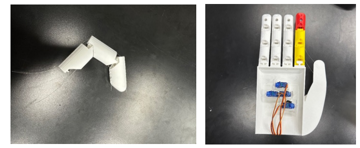
Figure 2: Sample of our training set images for the Neural Network

QR Code to our website to can see the hand in action and learn more about our team and project

Experimental Setup

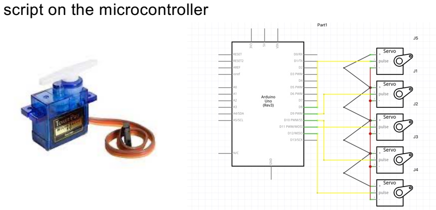


Step 1: Design a realistic-looking hand using CAD

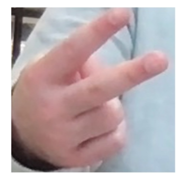


Step 2: 3D print and construct a prototype with the integrated sensors

- Various iterations of the model were 3D-printed to optimize the ideal motor placement and smooth movement of each finger
- The positions of each finger at closing and opening were mapped to an angle range of the respective servo motor within the script on the microcontroller



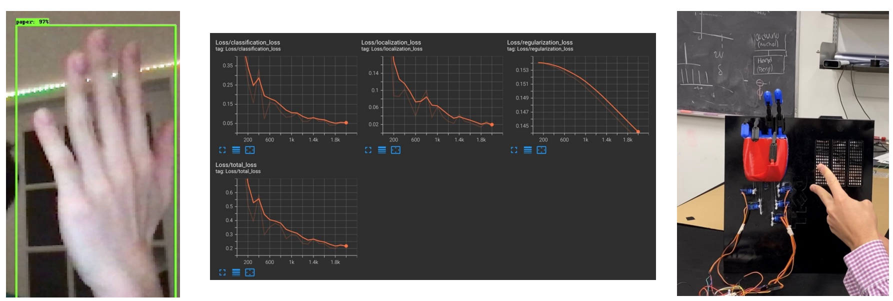
Step 3: Implement servo control for each finger using a microcontroller



Step 4: Collect hand images for the IRB approved Neural Network

- The microcontroller was programmed to actuate the servo motors to form the gesture of rock, paper, or scissor
- To collect training images for the NN, we received CITI biomedical research certificates and submitted an Institutional Review Board (IRB) application to use volunteer hands in the training set

Data and Results



Step 5: Process the images and train the Neural Network to recognize the gestures rock, paper, and scissor through a camera

- Various iterations of the model were able to be successfully controlled with servo motors and form the gestures: rock, paper, and scissor
- The IRB application was approved and images of the hands of various members of the Cooper Union community forming rock, paper, or scissors were collected
- The images were processed to uniform dimensions and labeled
- The NN was trained successfully
- The hand was able to successfully play against real opponents in real-time

Conclusions

The initial milestone of producing a bionic hand that can use object detection to play the game, rock, paper, scissor, with opponents in real-time has been a success. However, just opening and closing the fingers is not enough for practical use, so the physical complexity of the model must be improved.

Furthermore, the confidence of the NN can be improved by adding more training images to the database. In order to increase reactivity against various stimuli, the NN can be trained with images of other objects. By expanding the NN training set, the response against such stimuli can be hard-coded into the microcontroller. Thus, an advancement in the fluidity of the hand, as well as a larger database of objects for the NN, will complement one another to result in a more applicable bionic hand.

Future Studies / Recommendations

Based on the conclusions, the physical complexity and the database of the NN must be improved.

The physical complexity can be advanced by designing the thumb to be able to rotate about the palm. This thumb redesign will allow for more complex gestures. A current proposal for the thumb is to integrate a gear system into the hand. Similarly, the joints of each finger can be controlled individually if a motor is integrated at each joint. However, the tradeoff will be more weight to the overall hand.

As for the NN, images of various objects can be captured and used to train the NN. The responses against those objects can be hard-coded to improve speed of response.

Acknowledgments

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References

1. Ziegler-Graham, K., MacKenzie, E. J., Ephraim, P. L., Travison, T. G., & Brookmeyer, R. (2008). *Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050. Archives of Physical Medicine and Rehabilitation, 89(3), 422–429.* doi:10.1016/j.apmr.2007.11.005
2. Raichle KA, Hanley MA, Molton I, Kadel NJ, Campbell K, Phelps E, Ehde D, Smith DG. Prosthesis use in persons with lower- and upper-limb amputation. J Rehabil Res Dev. 2008;45(7):961-72. doi: 10.1682/jrrd.2007.09.0151. PMID: 19165686; PMCID: PMC2743731.
3. Hussein, M 2014, 3D Printed Myoelectric Prosthetic Arm, Bachelors Thesis, AMME, Sydney.