Humanoid Robotic Hand

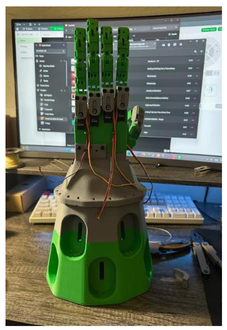
Semester: Fall 2025

Noah Enlow, Tyler LeBeau, Joseph Maresh, David Lutz, Justin Alonzo, Markus Steinebrunner

College of Engineering, Northern Arizona University, Flagstaff, AZ 86011

Abstract

The goal of this project is to design a highly dexterous robotic hand to serve as a testbed for NAU's research labs exploring prosthetics. The design maximizes degrees of freedom while maintaining proportions like an average adult human hand, scaled up 1.5 times to accommodate sensors and motors. The final design features 15 degrees of freedom, motion repeatability fast enough to play the piano, dexterity to catch a ball,



and grip strength to hold a 10-pound weight. Meeting these requirements will provide the labs with a versatile platform for testing and advancing prosthetic research—marking an important first step in future development and applications.

Figure 1: Initial Prototype

Requirements

Table 1: Project Requirements

Engineering Requirements
Grip Force of 45-50 N
Time from full extension to full closure 200-250ms
Within 1-1.5 scale of average person's hand and forearm
Approximately 3-4kg
Cost of manufacturing <$1500
15 degrees of freedom
Operates with 1-3 120V plugs
At high operating load, no component exceeds 75 degrees Celsius
Each joint operable near 10k motions
Able to predict finger placement within +/-5mm based on sensor data

Methods

Materials:

- 3D-printed components made from Onyx and PLA
- Tendons: high-strength fishing line
- Bowden tubes: used for tendon routing and to prevent fraying
- Electronics for control and sensing

Testing Parameters:

- Grip strength
- Actuation speed
- Durability
- Weight and size measurements
- Sensor accuracy
- Power draw and thermal performance

Purpose: Testing ensured the hand met design requirements and is suitable for use in research labs.

Testing

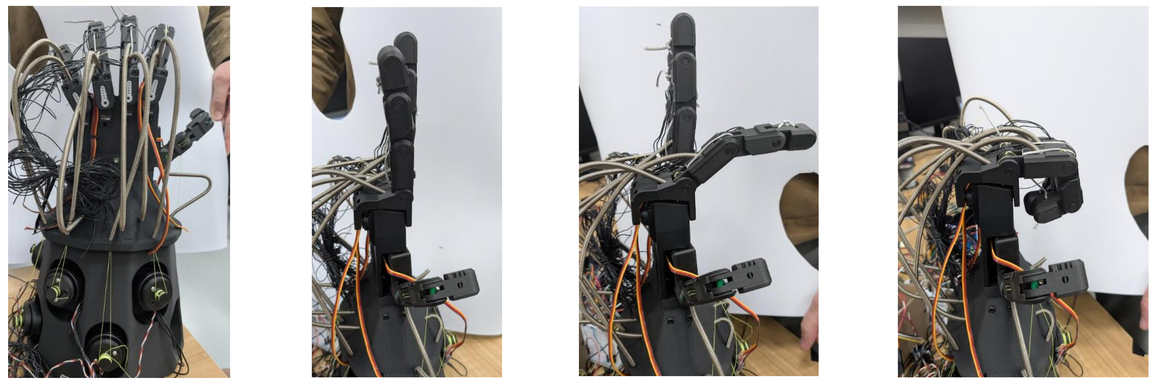


Figure 2: Finger Actuation

Design

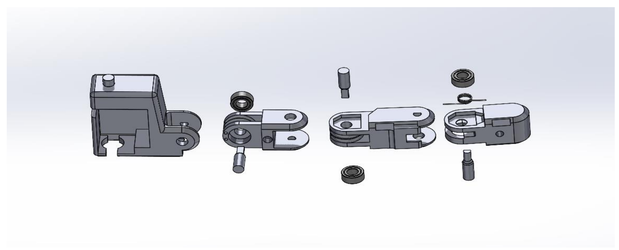


Figure 3: Thumb Exploded View

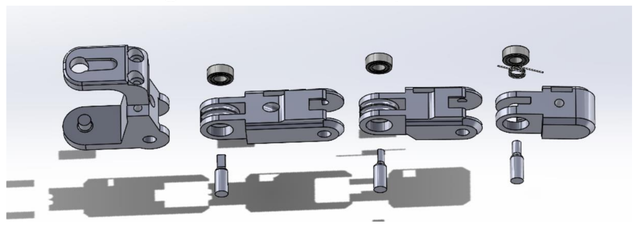


Figure 4: Finger Exploded view

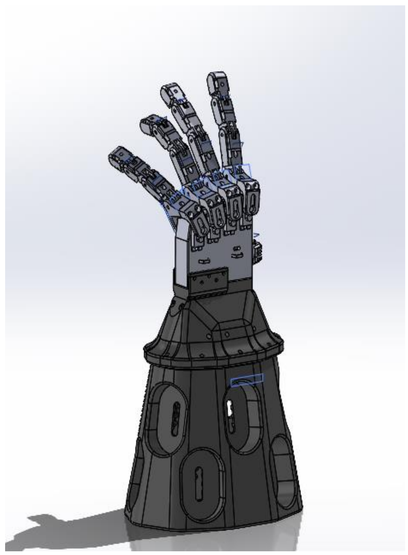


Figure 5: Final Assembly

- Each joint in the fingers and thumb are pinned together with a bearing for reduced friction
- Each joint has a cutout for an angle sensing potentiometer.
- Base joints of the thumb and finger are designed to house a servo for splaying motion
- Holes on the back of the finger are for tendon routing
- Loops on the back of the palm are for improved wire routing
- Holes and slots in the forearm are for the 10 motors that actuate the flexion and extension of the fingers and thumb.

Conclusion

- This project developed a highly dexterous robotic hand to advance prosthetic research at NAU. Its importance lies in improving human–machine interaction and expanding assistive technology capabilities.
- The design achieved 15 degrees of freedom, realistic proportions, and performance sufficient for piano playing, ball catching, and lifting 10 lbs, providing a versatile research platform.
- While simpler designs are easier to build, this model's complexity and realism make it far more valuable for advanced prosthetic studies.
- Future work will focus on refined control, enhanced sensing, and component miniaturization to further replicate natural human motion.

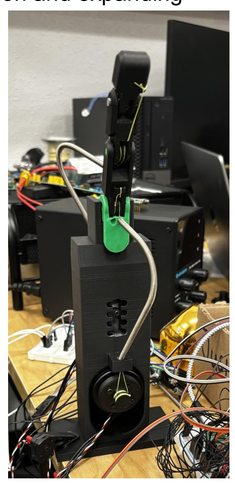


Figure 6: Test Apparatus

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Acknowledgements

Our Team would like to thank the following:

- Our Clients: Professor Zachary Lerner and Professor Reza Razavian
- Northern Arizona CEIAS
- Our Instructor: Professor Carson Pete