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Dept. of Electrical and Computer Engineering
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Wearable Biomimetic Appendage

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Abstract

The Wearable Biomimetic Appendage (WBA) can mimic a user's hand and finger movements to aid in basic tasks. A control glove using Hall sensors and magnets was designed for precise finger tracking, a calibration program visualized with a virtual reality (VR) environment was constructed with Unity, and a robotic hand was developed to mimic a user's movements. These achievements showcase the project's potential for diverse virtual- and real-world applications.

Introduction

This Capstone Design project intends to create a device that can overcome the conditions which may hinder one's ability to carry out tasks effectively or safely. Modern 3D printing has enabled consumer prosthetic creation, and the expansion of virtual reality has sparked the need for hand tracking devices. These technologies are a synergy of VR and robotics that inspired the WBA.

Deliverables

- Design a control glove that can detect both MCP and PIP joint rotation in all 5 fingers
- Program a calibration procedure that yields accurate results seen in WBA and VR usage
- Develop an easy-to-use graphical user interface (GUI) application for calibration and usage of the glove in a VR environment
- Design a robotic hand and forearm mount that can actuate with 3 degrees of freedom (DOF) per finger and hold objects

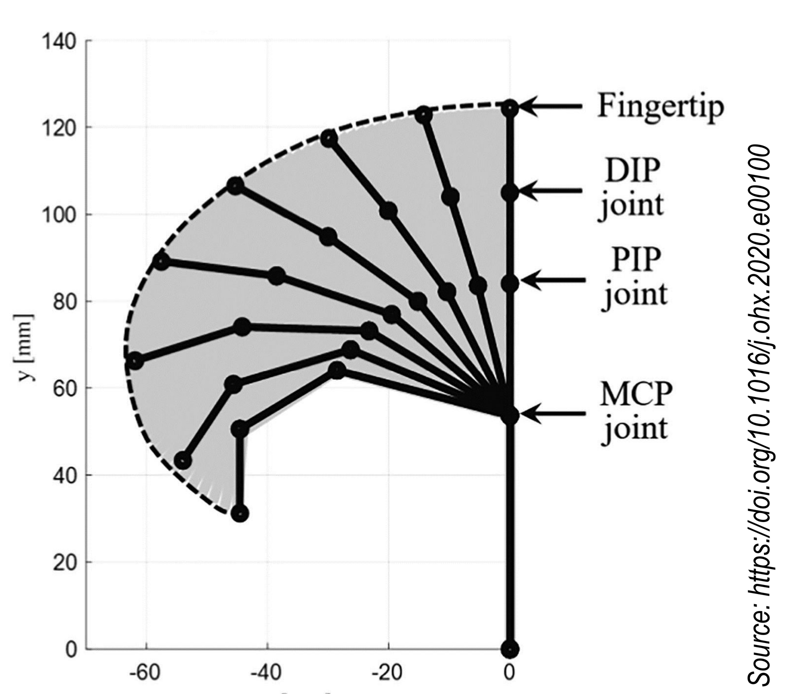

Figure 1: Finger range of motion

Experimental Results

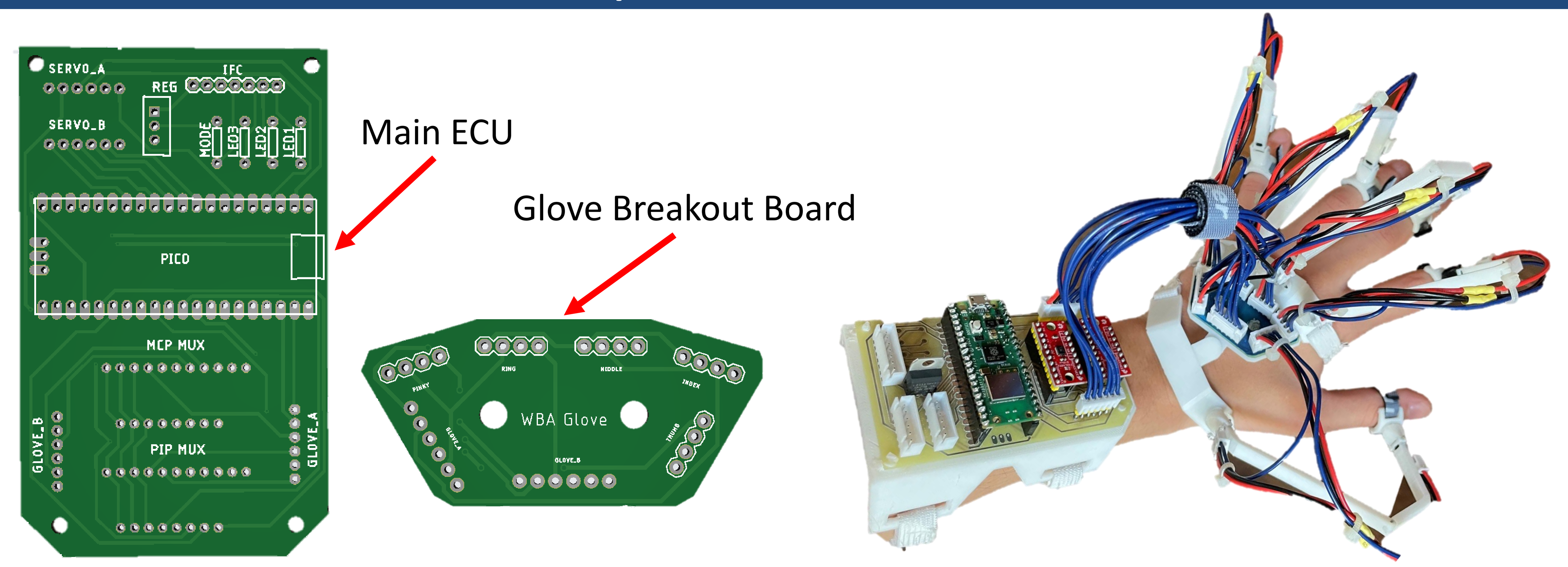

Figure 2: Glove ECUs (left) and full prototype (right)

A **Control Glove** was designed to host Hall sensor-neodymium magnet pairs measuring 2 DOF per finger. An onboard MCU polls incoming data from the sensors and uses a 12-bit ADC and a dynamic calibration model to convert the measurements (in mV) to relevant angles (in degrees).

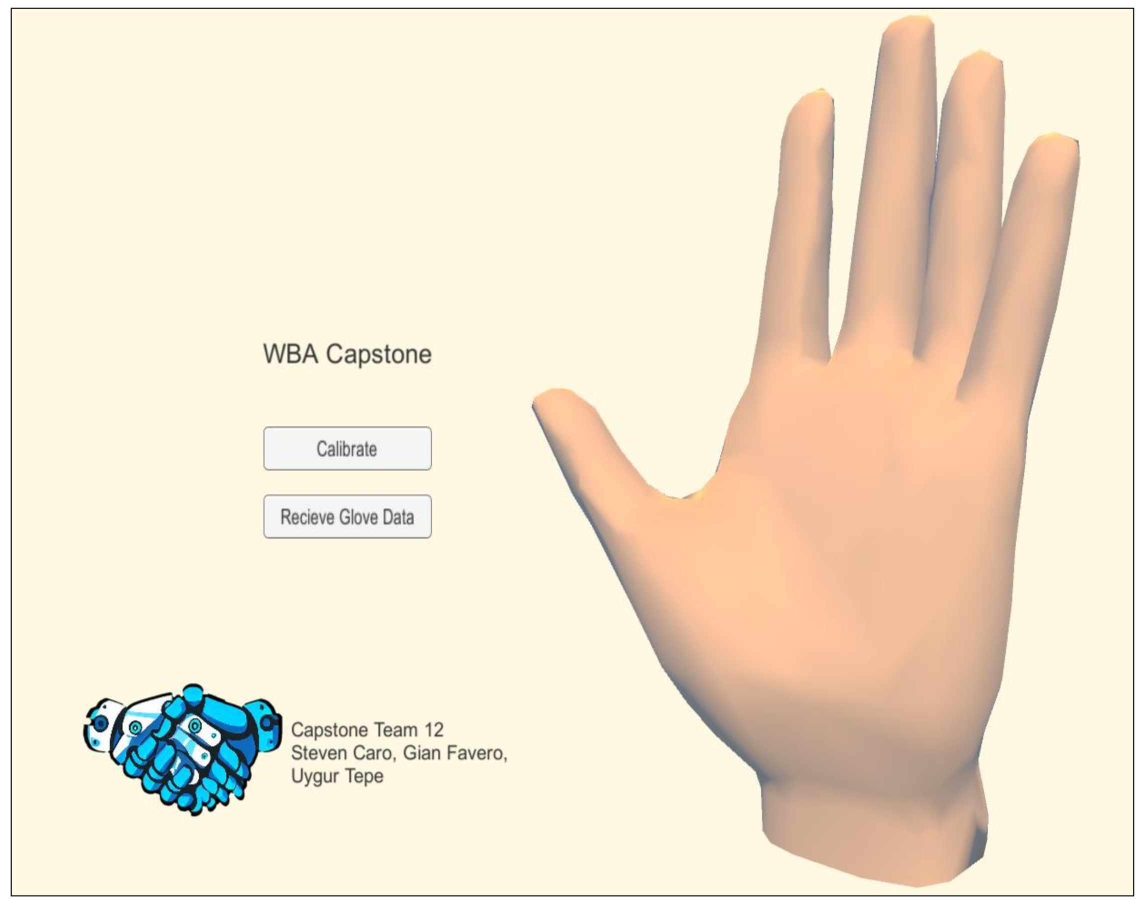

Figure 3: Unity GUI application

Unity GUI and VR Functionality
- Unity was utilized as a GUI and calibration medium for the control glove in VR settings.
- The software provided step-by-step guidance for calibration, ensuring the creation of an accurate dynamic model.
- Unity's integration as a GUI allowed for easier visualization of calibration accuracy.
- The glove's compatibility with VR environments enhanced its multifunctionality, boosting usability and performance.

Robotic Hand
- The InMoov robot was used as the foundation for the robotic hand.
- Modifications were made to the design to enable greater range of motion, grip strength, and flexibility.
- The hand and fingers of the hand are made from PLA, a hard plastic, while the joints of the fingers made from TPU, a flexible plastic.
- Fishing line and TPU hinges serve as counteracting tensioners in the fingers to allow movement and a functional grip strength.
- Five servo motors actuate and provide 3 DOF per finger.

Figure 4: Robotic hand rendering

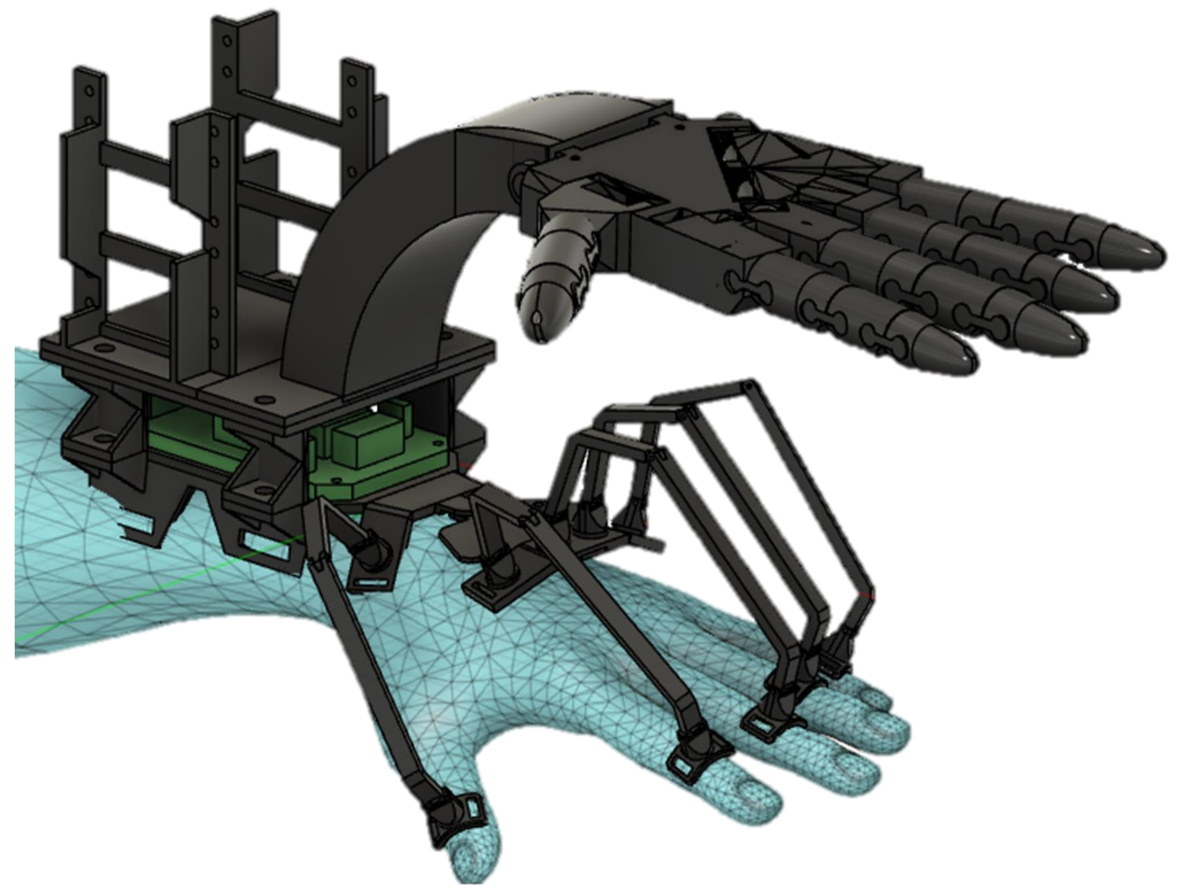

Figure 5: Rendering of complete assembly

Complete WBA Assembly
- A custom servo motor bay and forearm mount was created in order to integrate the robotic hand with the control glove.

Conclusion & Future Work

- Prototype control glove and WBA assembly successfully met performance specifications.
- Control glove demonstrated an estimated accuracy of 3 degrees.
- WBA effectively mimicked users' hand motions and demonstrated object-holding capabilities.
- Integration with simulation environment via Unity added multifunctionality to the control glove by facilitating a visualization of calibration procedure and accuracy.

Novel contributions include a control glove that uses Hall sensors and magnets to control a robotic hand, this is an overall cheaper and more reliable control glove design compared to potentiometers

Future works include switching the microcontroller and unity to communicate over serial, updating the WBA to support two motors per finger to allow individual control of two joints, using a more precise method to determine the accuracy of the control glove

Acknowledgements

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