Passive and Active Loading Exosuit

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Manufacturing Process

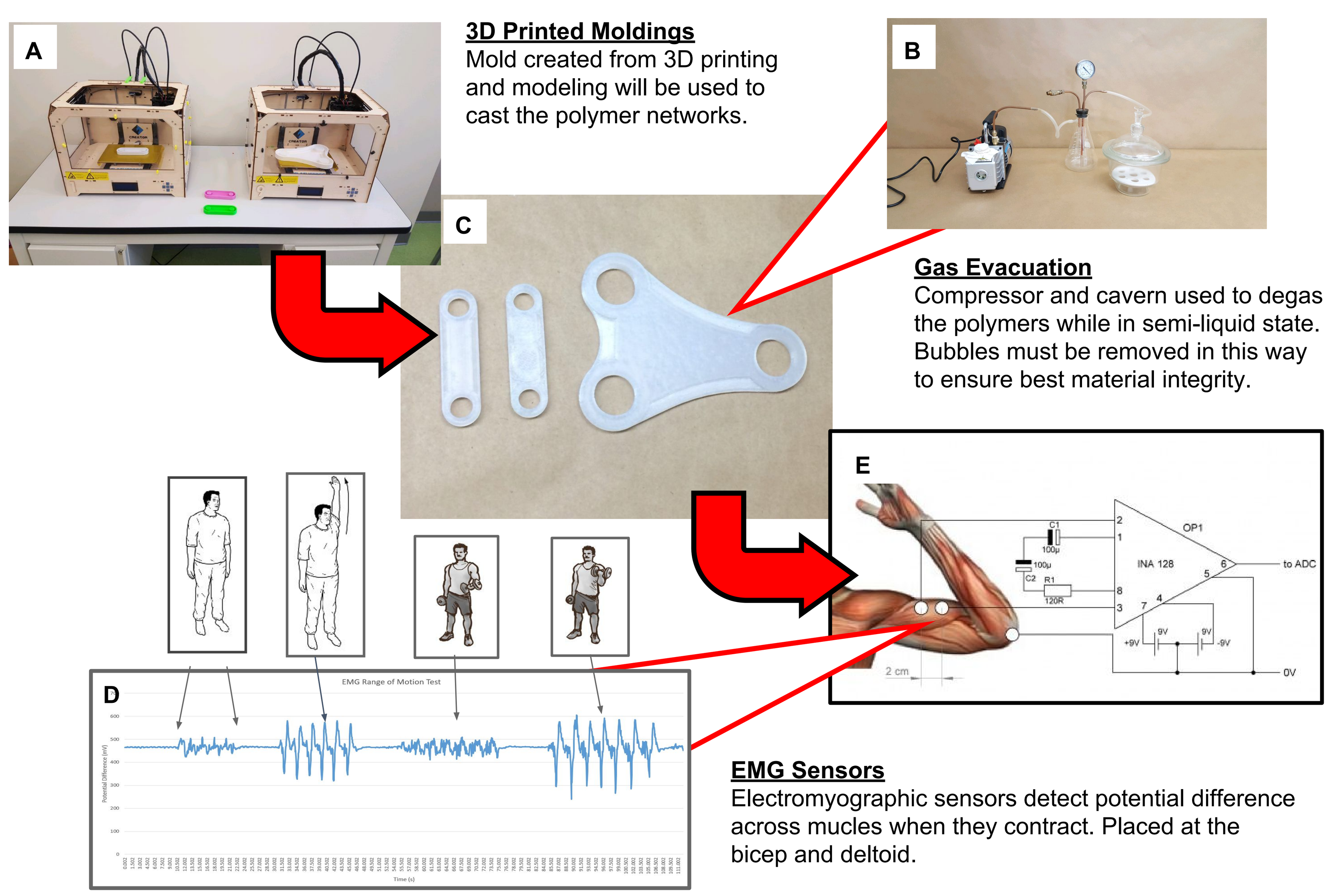

Figure 1: Diagram representing the manufacturing process for A) 3D printing molds, B) gas evacuation the polymers, C) the polymers themselves, and D) the EMG integration and E) placement

Polymer Integration

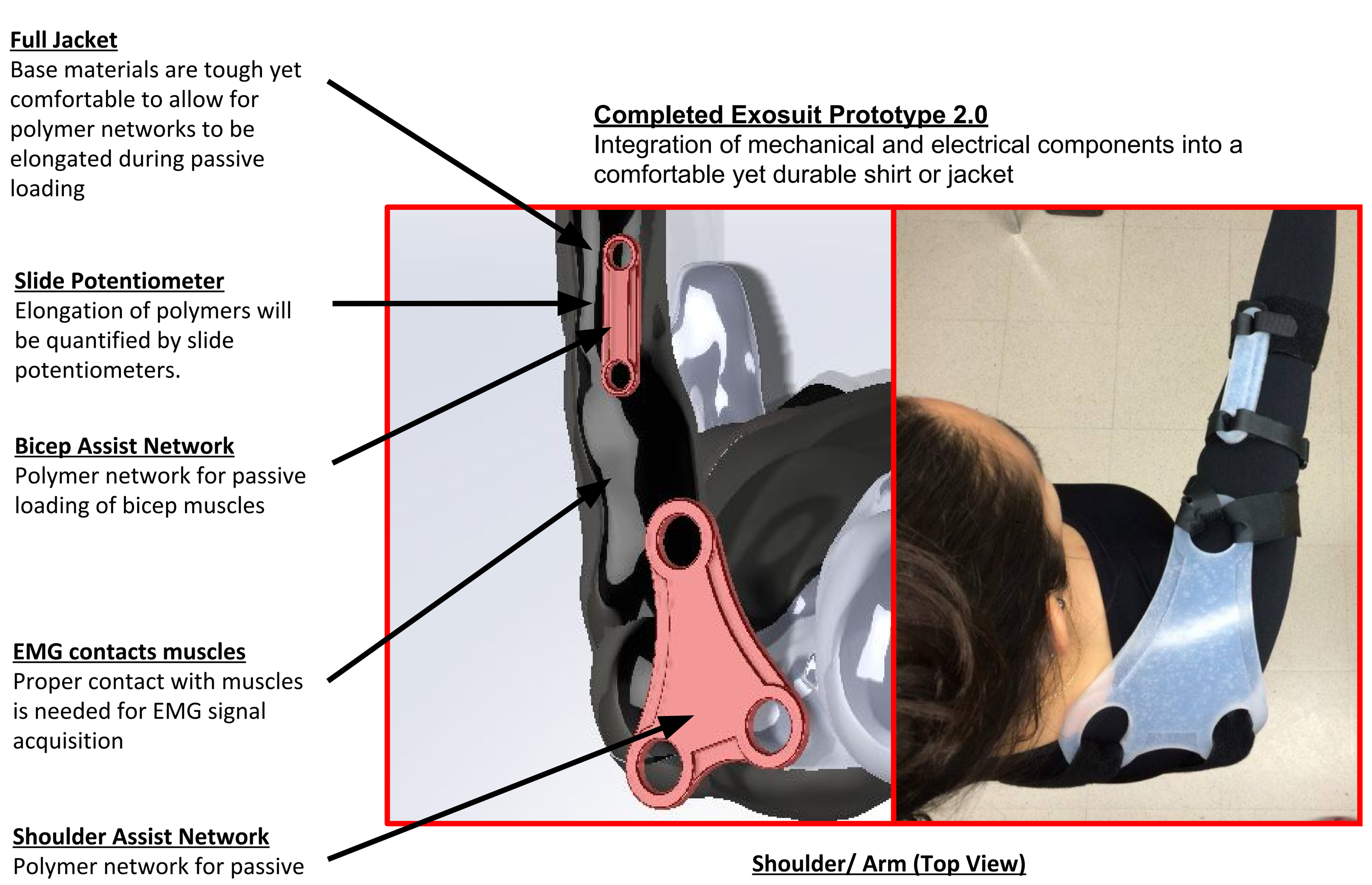

Figure 2: Diagram comparing design specifications and actual exosuit polymer placements at both shoulder and bicep

Abstract

According to the American Academy of Orthopaedic Surgeons (AAOS), in 2006, approximately 7.5 million individuals have suffered an upper body injury. Exosuit engineering is a project which aims to create a rehabilitative wearable which can mitigate load away from handicapped elbows and shoulder joints. The exosuit project is a soft robotic wearable which consists of two distinct parts. The first part is a passive loading exosuit consisting of polymers and fabric which is aimed at rehabilitation. The second component includes a motor controlled cable capable of lifting the wearer's arm through a range of motion aimed at industry. Together, the passive loading and active lifting components combine into a single wearable known as the Exosuit.

Approach

Having completed a physical prototype for the passive loading component of the exosuit, placement and strain tests have been completed to create an ergonomic and functional wearable. Strain tests have been recorded to show how a wearer's arm elevation reacts to differing loads – unweighted as compared to weighted. The polymers which are being used to alleviate the stress from the wearer's joints have been manufactured using a two part polymer mixture and 3D printed molds. The polymer undergoes a gas evacuation process while it is still in its liquid form to create a more reliable and solid structure. The results are a quick and versatile manufacturing process capable of producing a product in less than a day. In addition to the passive loading component of the exosuit, sensor integration has been conducted with electromyography (EMG) and pressure loading cells. Wearable EMG sensors have shown that Arduino feedback can identify the user's range of motion and holding a variety of positions. Pressure loading cells concealed in a lightweight glove can detect when the user is carrying an object and when their hands are empty. These two sensors can be integrated to relay feedback to a motor controller and spin a motor cable of driving a collection of cables.

Acknowledgements

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References

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- Menguc Y, Park Y-L, Martinez-Villalpando E, Aubin P, Zisook M, Stirling L, Wood RJ, Walsh CJ. Soft Wearable Motion Sensing Suit for Lower Limb Biomechanics Measurements, in 2013 IEEE International Conference on Robotics and Automation (ICRA).

Methodology

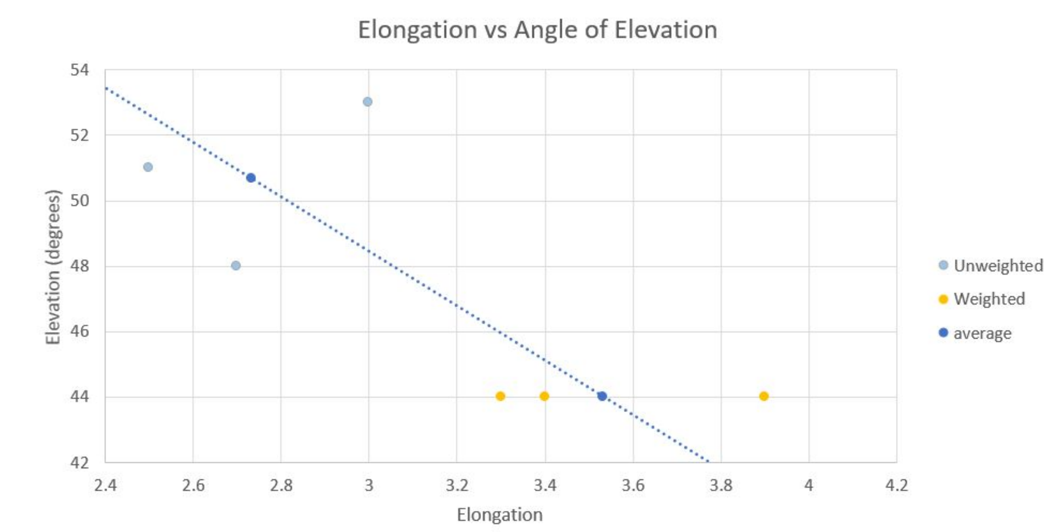

Figure 3: Graph representing the strain of the polymers through a range of motion both weighted with a 2.7 lb weight and including the arm unweighted

Elongation at Position Testing:

- Tested with shoulder in full lateral flexion, then allowed the arm to drop while measuring elongation.
- The initial and final strain and shoulder position angles are then recorded.

Position Feasibility of Polymers Testing:

- Placement of polymers on wearer's front and back for comparison
- All elongation vs angle testing done both weighted and unweighted on both positions
- Analyzing elongation, friction, posture, and impact of leverages.

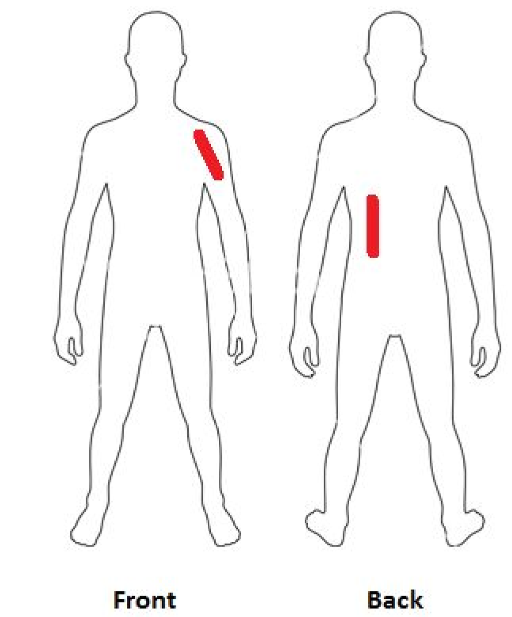

Figure 4: Diagram representing polymer placement locations front and back

Future Directions

The focus of this research project will continue into the spring quarter and aim towards integrating the polymer wearables with a motor controlled cable system. Load sensor cells and EMG detection will allow for motor activation and stabilization with PID control. Additionally, a cell phone app will be developed to gather data from the wearable so that it can be relayed to the user or a healthcare professional. Additional consideration will be taken for phone app based rehabilitation games.

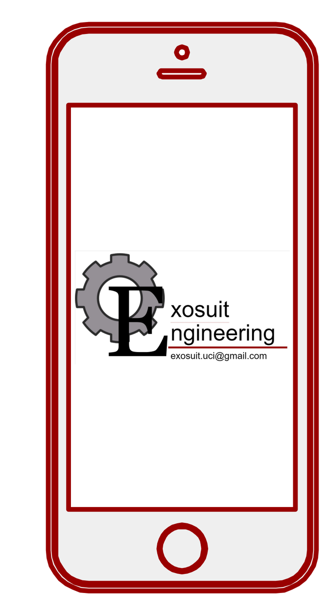

Figure 5: Diagram representing the design concept for a data reporting and user interface app for rehabilitative practices

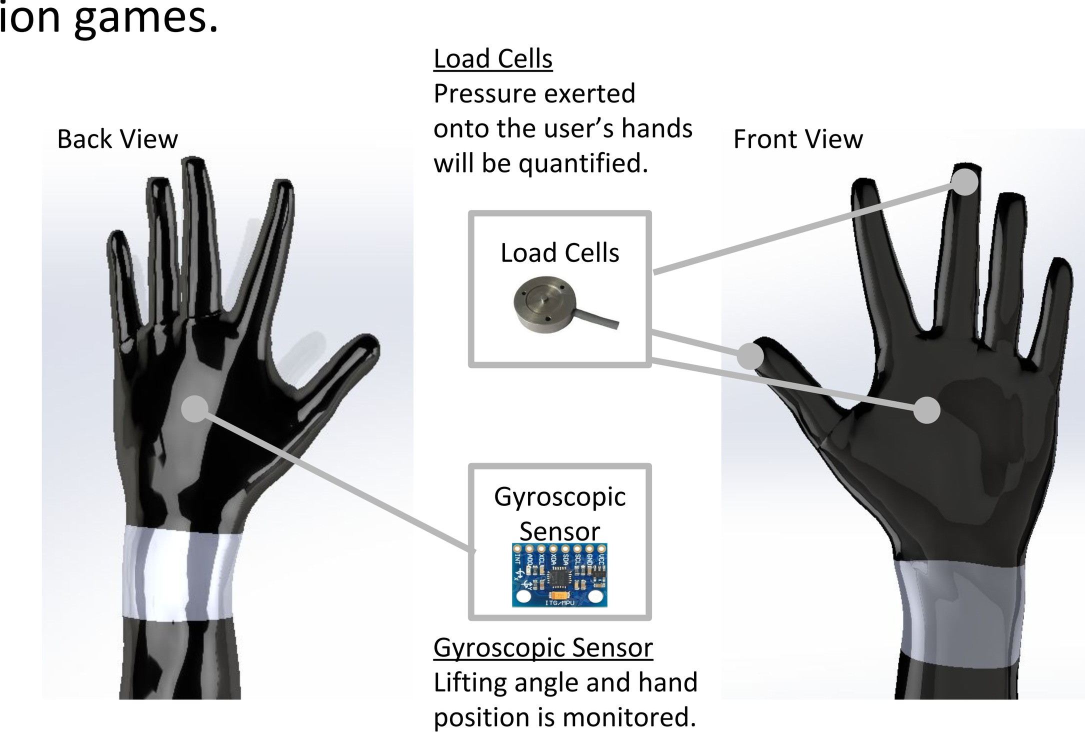

Figure 6: Diagram showing the implementation of sensors to a glove for force detection and hand orientation detection.