Passive and Active Loading Exosuit

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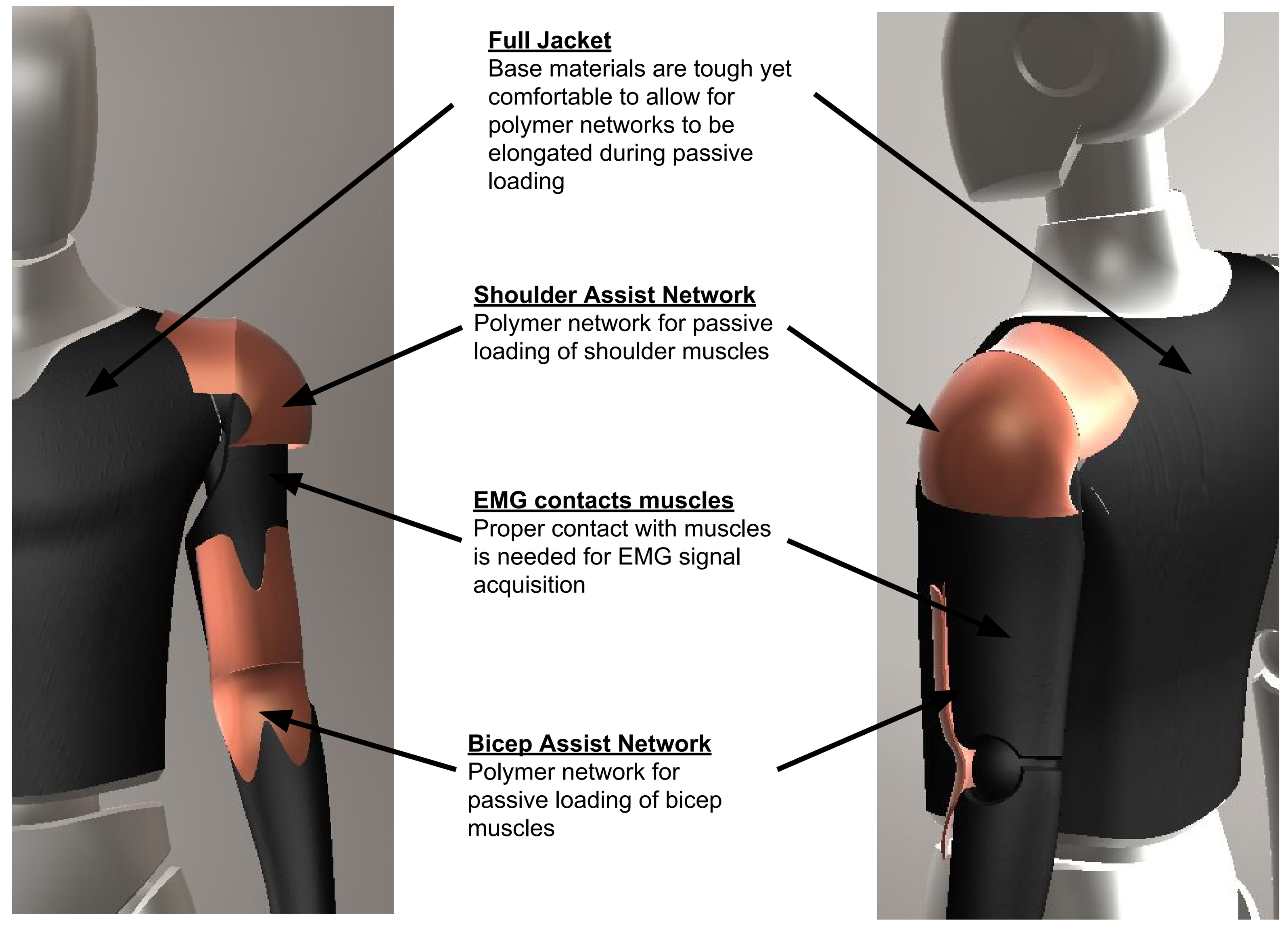
Introduction

The purpose of this exosuit is to create a rehabilitative wearable which can mitigate the load from the subject's elbow and shoulder joints, thus reducing fatigue and enabling a range of motion the wearer would not normally be able to complete. The exosuit will consist of a two part wearable. The first part is a passive loading exosuit consisting of elastomers, polymers, and fabric. The second will include a motor and motor driver capable of moving the wearer's arm using a lightweight battery. These two systems work in unison to create a passive loading and motion amplification exosuit.

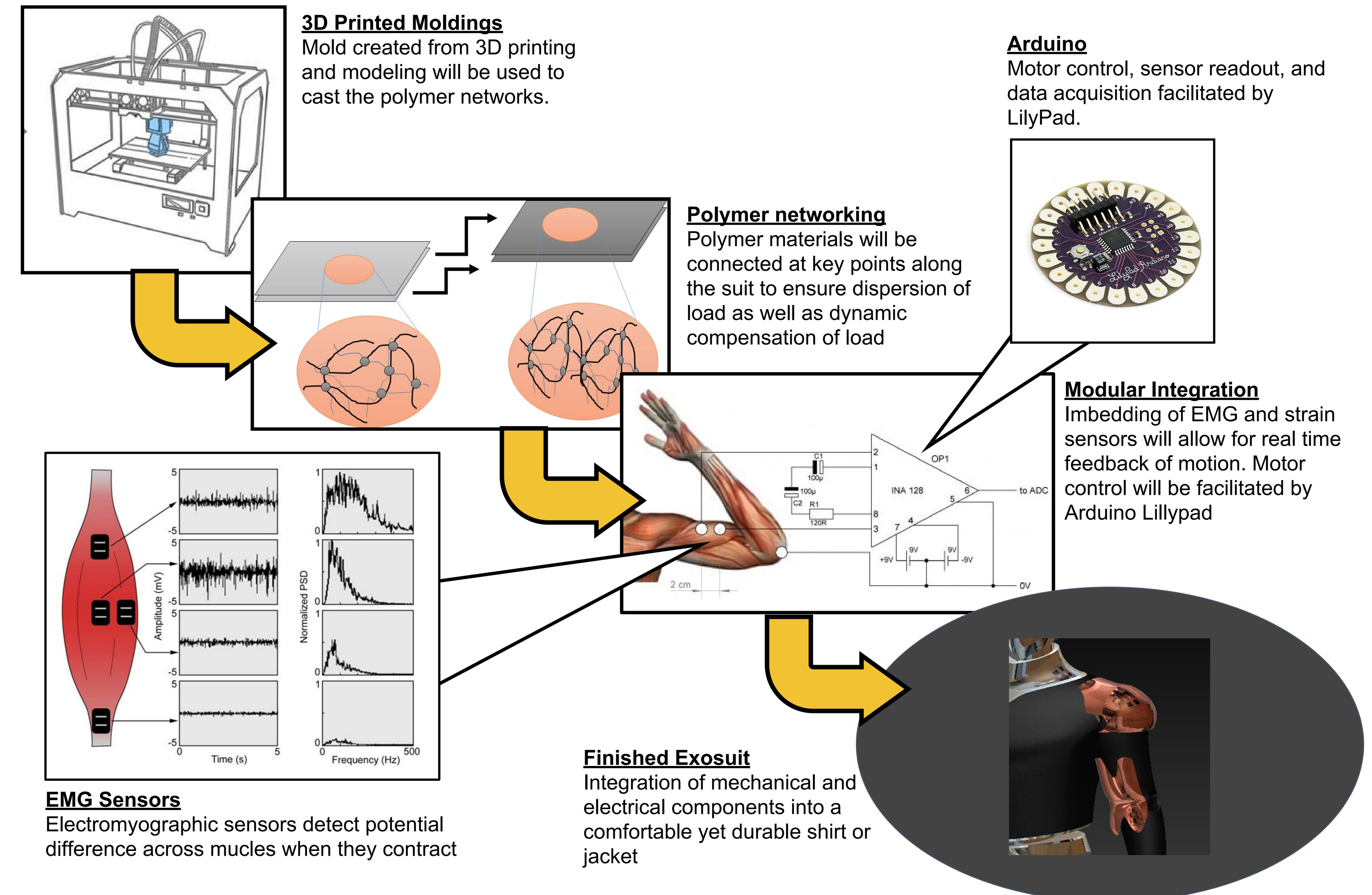
Approach

Using a virtual prototype developed in SOLIDWORKS 2015, the project's functionality and safety factors will be analyzed through simulation tests. The results provided from the simulation will be used to determine the exosuit's components as well as its limiting factors. For the passive loading, a physical prototype will be manufactured using a combination of elastomers, polymers, and fabric along different sections of the arm. The elastomers will be easily detachable and have varying stiffness to accommodate the wearer's limited capabilities. Sensors will be embedded within the suit to target specific sections along the arm which will communicate through a microcontroller for data acquisition, and in turn be used to track the wearer's progression over time. For the active loading portion of the exosuit, a motor will be implemented using a control law which can move the wearer's arm through a designated range or motion. The information collected from the sensors in both components will be tabulated into graphs showing the the strain produced in differents sections of the arm versus the wearer's exertion in order to analyze the exosuit's effectiveness.

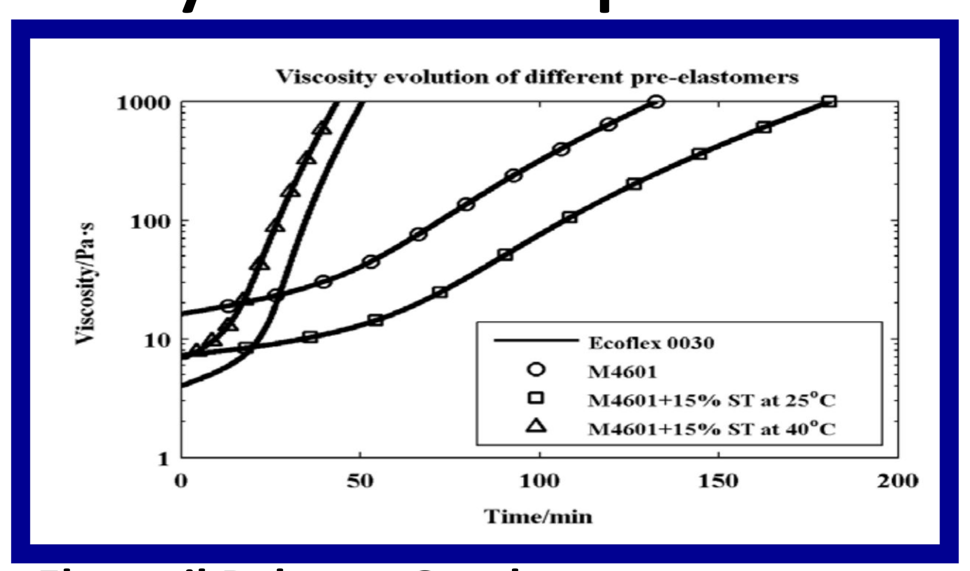
Design Schematic



Manufacturing Process

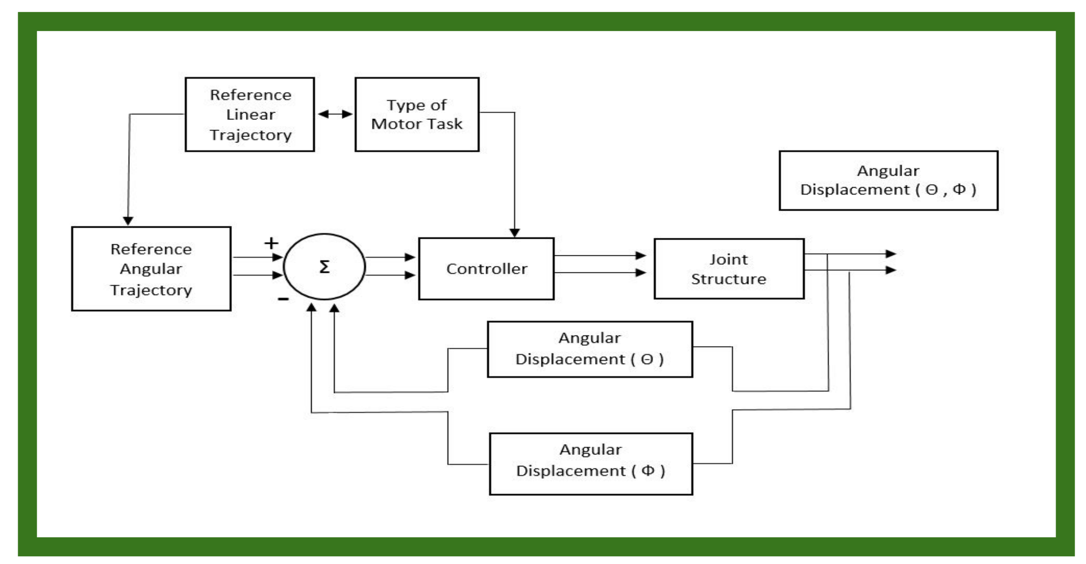


Polymer Properies



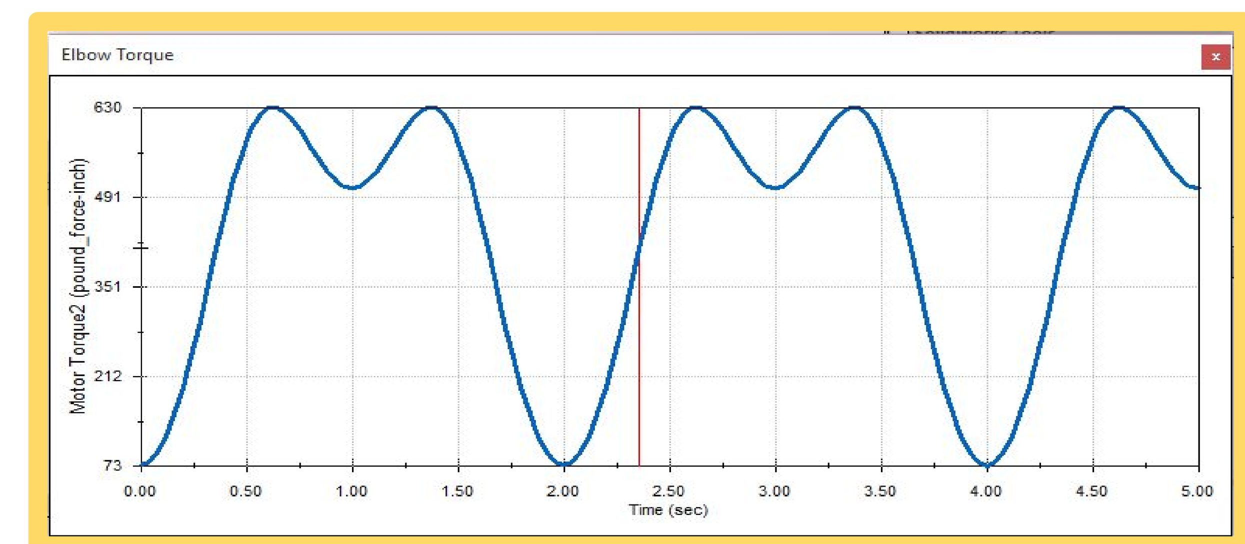
Elastosil Polymer Graph
Viscosity versus time at various temperatures for polymers produced by Elastosil (Zhao, 2014).

Motor Controller



Motor Controller Block Diagram
Closed loop feedback of motor compensation in response to wearer's arm and shoulder position.

Motion Characterization



Motor Torque vs Time
Dynamic analysis of predicted motion in second phase motor controller

Fall (Sept 24 - Dec 4)		Winter (Jan 4 - Mar 18)		Spring (Mar 23 - Jun 10)	
Prototype 1.0	Week 1-10	Prototype 2.0	Week 1-10	Prototype 3.0	Week 1-10
Design	Week 1-5	Controls	Week 1-10	Controls Check	Week 1-5
Manufacture	Week 4-10	Electronics	Week 1-10	Safety Testing	Week 4-8
WearRA Submit	Week 10	WearRA Competition	Week 6	Results & Calibration	Week 6-10
Fall Design Review	Week 10	Winter Design Review	Week 10	Spring Design Review	Week 10

Budget	Cost
Wearables	$1,488.14
Elastomers	$96.30
Sensors	$126.00
Electronics	$428.58
Tools	$498.55
Total:	$2,637.57

Acknowledgments

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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). Karlsruhe, Germany; 2013:5309-5316.
- H. Kazerooni, "Human Augmentation and Exoskeleton Systems in Berkeley", International Journal of Humanoid Research: Vol 4 No 3 Sep 07. - See more at: http://bleex.me.berkeley.edu/publications/#sthash.LrTfQgDl.dpuf