Force-Based Controller for Myoelectric Prosthesis

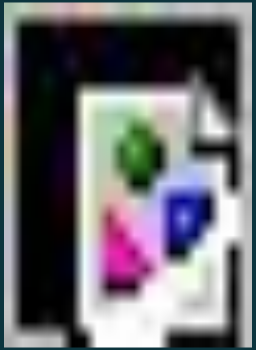
Oral Report 1

BME-5
Kaitlyn Ayers, Rebecca Jones, Allyson King,
Shaan Ramaprasad, Christian Stano

Overview

1. Advising Team
2. Background
3. Problem Space
4. Needs Assessment
5. Project Approach
6. Literature Review
7. Project Planning and Timeline
8. Initial Design Considerations

Advising Team



Dustin Tyler, PhD

Kent H. Smith II Professor of Biomedical Engineering

Principal Investigator, Functional Neural Interface Lab

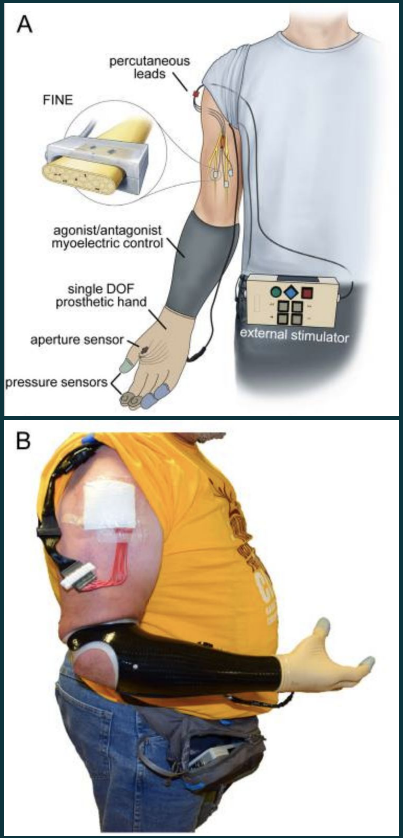
Expertise: Neural Interfacing and Neural Prostheses

Emily Graczyk, PhD

Postdoctoral Researcher, Case Western Reserve University

Expertise: Neuropsychology, Psychometrics and Electrical Engineering

Background



Traditional Prosthesis → **FINE** → **Sensory Feedback**

Traditional Prosthesis

Widespread dissatisfaction among users due to lack of fine motor control and psychosocial repercussions

FINE

Flat Interface Nerve Electrodes (FINE) implanted on median nerves

Successfully production of natural tactile sensation without paresthesia

Sensory Feedback

Integration of FINE system with a single DOF myoelectric prosthesis allows subjects to “feel”

Phase 2: in-home trials launched

Problem Space

Sensory Feedback Prosthesis System
The primary research team has developed a device and method to provide amputees with sensory restoration and motor control

Desire for Biomimetic Prosthetic Control
Current velocity-based prosthetics cannot properly emulate human muscle contraction (force-based).

Transition to In-Home Trials
Transition to testing functionality for everyday use.

Problem Statement: Velocity based commercially available myoelectric prostheses are not controlled in the same manner as an intact musculature system and cannot be used as a fully accurate comparison for motor control functionality of these systems.

Needs Assessment: Patient

- Comfortable with no extra adjustments needed for the socket
  - Easily adapted to the patient's already customized socket
- Adjustable for different patients
  - Brand/type of prosthetic
  - Amputation type
  - Muscle capabilities
- Ease of Use
  - Minimal learning curve
- Easily donned and doffed
  - Electrode placement and wearable components should be as broad and simple as possible
  - The user should be able to apply and remove the system by themselves
- Psychological Effect
  - Consider psychological effects of using a removable device

Needs Assessment: Patient

- Wearable
  - Processor either in sleeve above the prosthesis or incorporated into the prosthesis itself
  - Must be tolerable weight for daily use
- Safety
  - Must be designed and built according to quality standards to ensure there are no safety hazards from the mechanical or electrical components
  - Must integrate ability to turn off in emergency situations
- Cost-Effective
  - Components used should be cost-effective to create an inexpensive and easily accessed solution for all users

Needs Assessment: Clinician/Researchers

- Easy access for parameter manipulation
  - If the design requires manual manipulation of electrode setting given amputation or manipulation of muscle activity parameters, a user friendly interface should be created.
- Speed of EMG to prosthesis actuation
  - Should optimize the translation of a captured EMG signal to corresponding prosthesis posture to provide accurate modeling of an intact hand
- Motor control testing functionality
  - Easy integration into lab testing environment with common motor control experiments
- Software and Design Documentation
  - Research Auditing
  - Data and results from the clinical experiments being run can be published
- Clinical Trial Regulations
  - Data output and patient regulations must be considered since device is to be used in clinical trial setting

Needs Assessment: System

- Durable
  - Daily use will require durability in different environmental conditions and during general activity
- Integration
  - Must integrate seamlessly with implanted neuromodulated sensory feedback system in users
  - Should minimize noise interference with implanted neuromodulated sensory feedback system and other devices
- Scalable
  - Solution should be applicable to any commercial OttoBock myoelectric prosthesis with minimal modification required
- Biomimetic
  - Natural hand-posturing created by overriding required velocity-based prosthetic inputs

Project Approach

EMG

- Develop adapter that converts EMG signals from surface electrodes to commands
- Incorporate new algorithm

Force

- Convert velocity-based prosthetic controller into a force-based system
- Better mimic natural hand posture, motion, and function
- Directly relate the amplitude of muscle contraction to the position of the hand

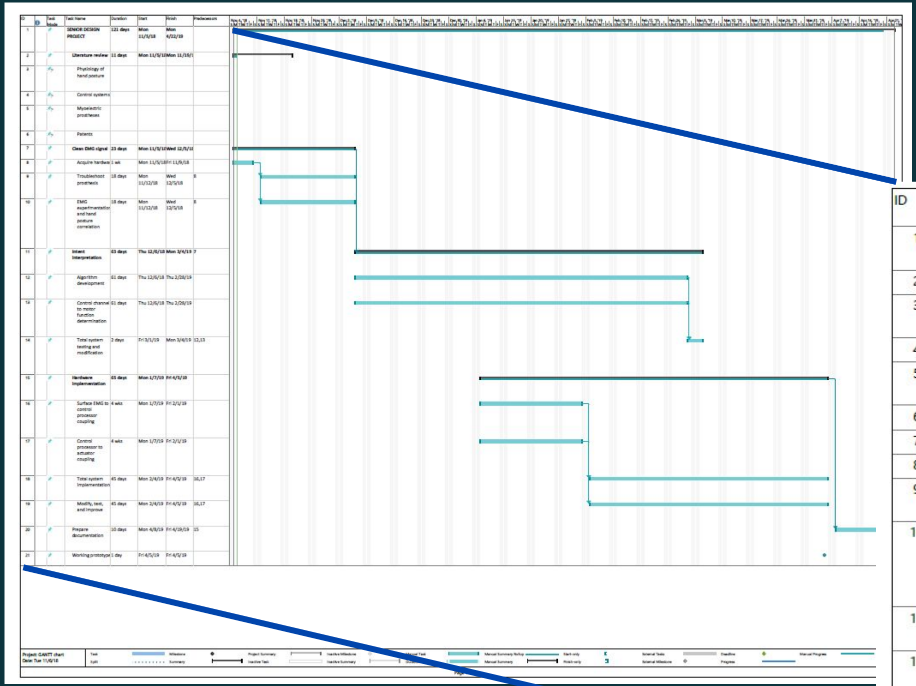
Integration

- Analog signal translation interfaced with existing prosthetic equipment
- Adaptable across prosthesis types and brands

Literature/Subject Review

- Myoelectric Prosthesis
  - A general understanding of the system we are going to be adding to and manipulating, current practices regarding its use, and ground-breaking additions to the system
  - Potential Contacts
    - Dr. Goldfarb
    - Dr. Withrow
- Hand Posturing
  - Natural muscle activation and its relationship to normal hand posturing in relaxed and activated modes need to be identified
  - Experimental Process Identification
- Control Systems
  - Understanding the relationship between algorithm development and functional instrumentation as it relates to prosthesis development
- Patent Search
  - Searched approximately 300 patents to identify related material and the current design space and avoid infringement in those areas

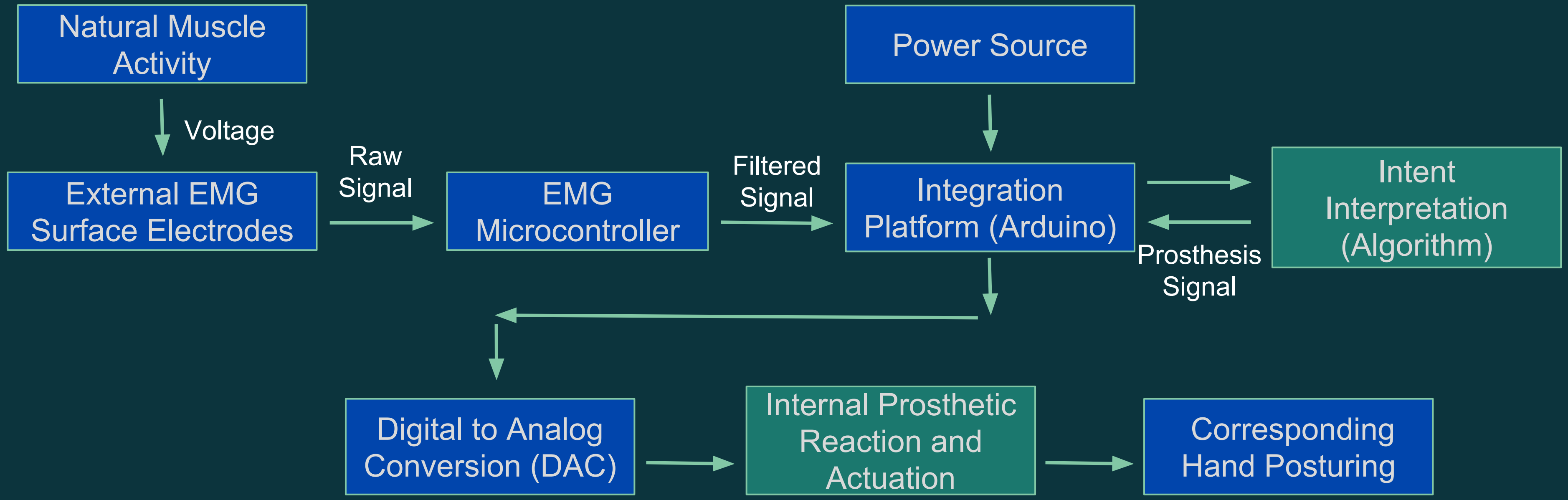
Project/Design Timeline



- Experimenter Specialization
- Adaptation
- Approval

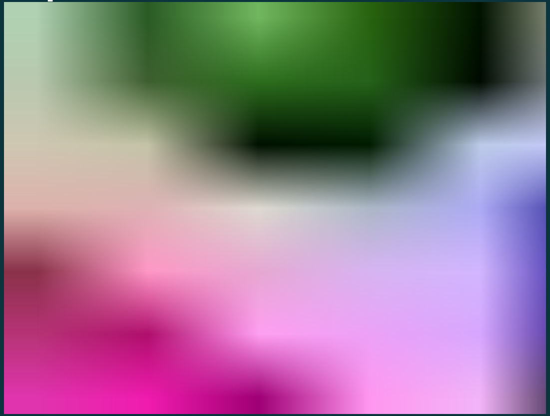
ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**SENIOR DESIGN PROJECT**	**121 days**	**Mon 11/5/18**	**Mon 4/22/19**	
2			**Literature review**	**11 days**	**Mon 11/5/18**	**Mon 11/19/1**	
3			Physiology of hand posture				
4			Control systems				
5			Myoelectric prostheses				
6			Patents				
7			**Clean EMG signal**	**23 days**	**Mon 11/5/18**	**Wed 12/5/18**	
8			Acquire hardwar	1 wk	Mon 11/5/18	Fri 11/9/18	
9			Troubleshoot prosthesis	18 days	Mon 11/12/18	Wed 12/5/18	8
10			EMG experimentation and hand posture	18 days	Mon 11/12/18	Wed 12/5/18	8
11			**Intent interpretation**	**63 days**	**Thu 12/6/18**	**Mon 3/4/19**	**7**
12			Algorithm development	61 days	Thu 12/6/18	Thu 2/28/19	
13			Control channel to motor function	61 days	Thu 12/6/18	Thu 2/28/19	

Initial Design/Brainstorming



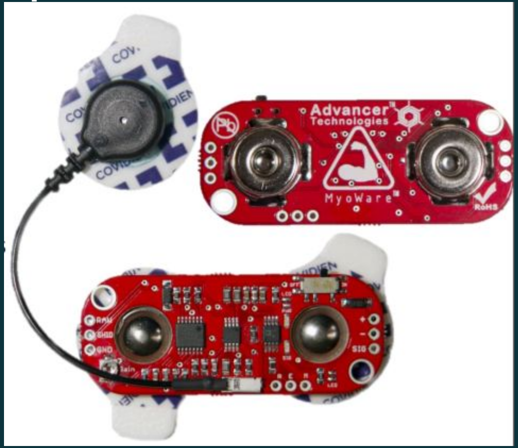
Hardware Brainstorming

Options for Microcontrollers



- Arduino
  - Ease of Software and EMG controller integration
- Arduino MKR1000
  - Small Size
  - WiFi connectivity for easy access to internal code
  - Built in rechargeable energy source

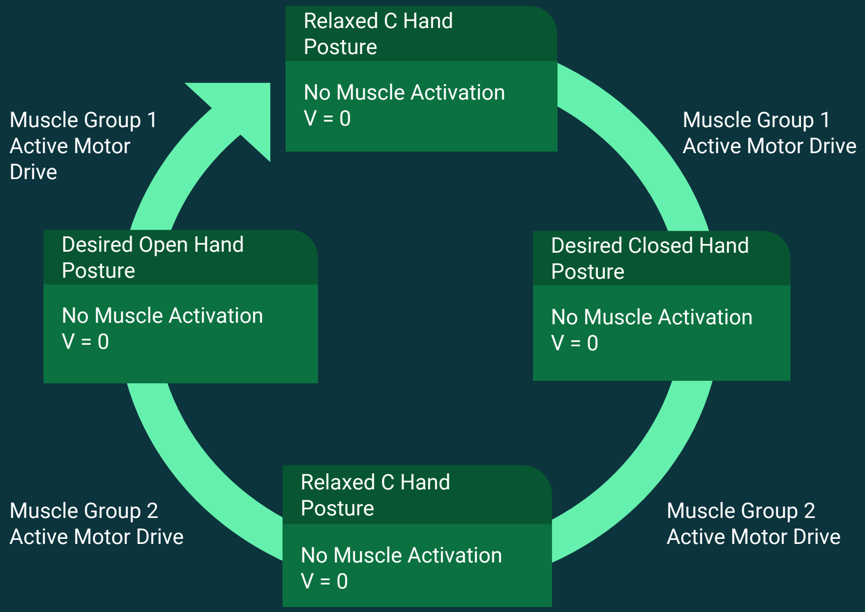
Options for EMG Controllers



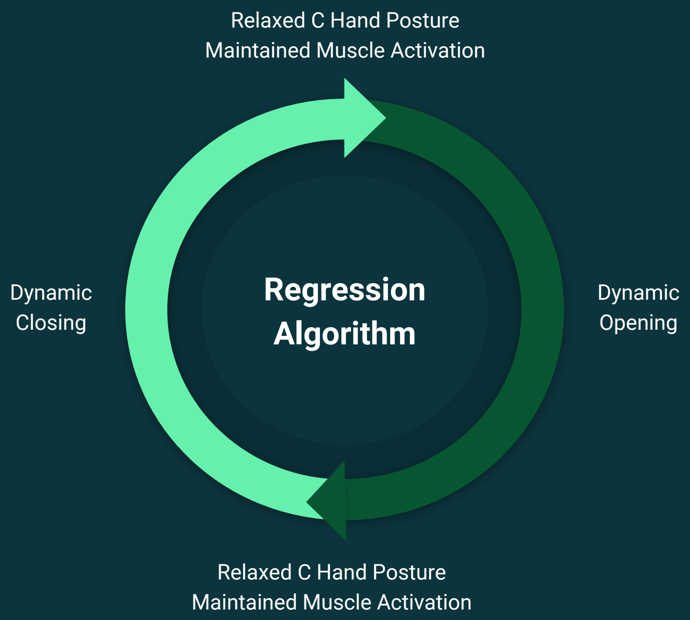
- Compact with limited interference from implanted electrodes
- Myoware Muscle Sensor
  - Easily integrated into arduino platform
  - Compact with only one extended electrode
  - Common for this function

Intent Interpretation- Algorithm

Finite State Machine (Current)



Pattern Recognition (Future)



Where We Are and Where We Are Going

Define the Problem	Needs Assessment	Generate/Evaluate Possible Solutions	Make and Test Model	Modify and Improve Design	Communicate
Velocity-based prostheses not controlled in same manner as intact control system	**Patient, Clinicians/ Researchers, System**	**EMG Interfacing,** Intent Interpretation, Hardware Interfacing **Literature Review, Timeline, Hardware Collection, Non-Functional Prototype**	Integrate System Components	Ensure System is Functional, Safe, Scalable, and Meets Expectation	Design Day

What Questions Do You Have?

References

Slide 3 Figure A and B: Graczyk, Emily L et al. “Home Use of a Neural-connected Sensory Prosthesis Provides the Functional and Psychosocial Experience of Having a Hand Again” Scientific reports vol. 8,1 9866. 29 Jun. 2018, doi:10.1038/s41598-018-26952-x

Slide 14:

Arduino:

- https://store.arduino.cc/usa/arduino-mkr1000

Myoware sensor:

- https://cdn.sparkfun.com/datasheets/Sensors/Biometric/MyowareUserManualAT-04-001.pdf