Force-Based Controller for Myoelectric Prosthesis
Oral Report 2

BME-5
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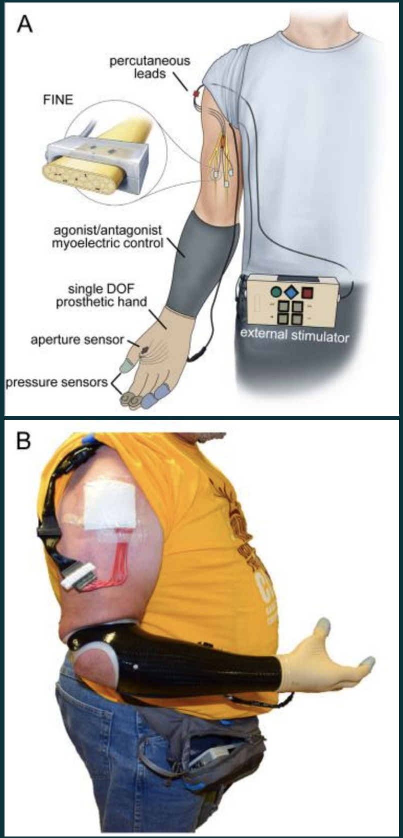
Overview

1. Background
2. Our Role
3. Needs Assessment
4. Design Approach
5. Progress Overview
6. Conclusion

Background



Traditional Prosthesis

Dissatisfaction due to lack of fine motor control and psychosocial repercussions

FINE

Flat Interface Nerve Electrodes (FINE)

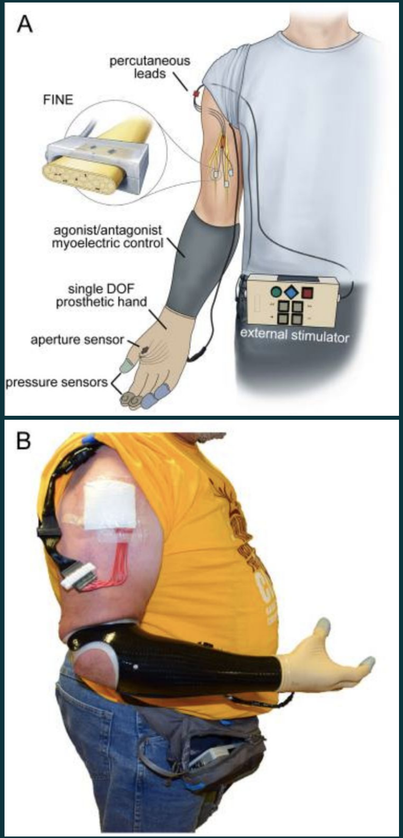
Production of natural tactile sensation without paresthesia

Sensory Feedback

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

Phase 2: in-home trials launched

Background



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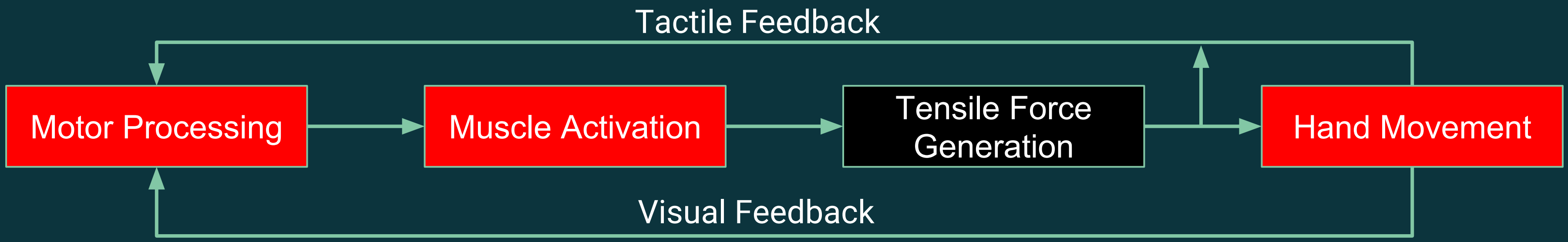
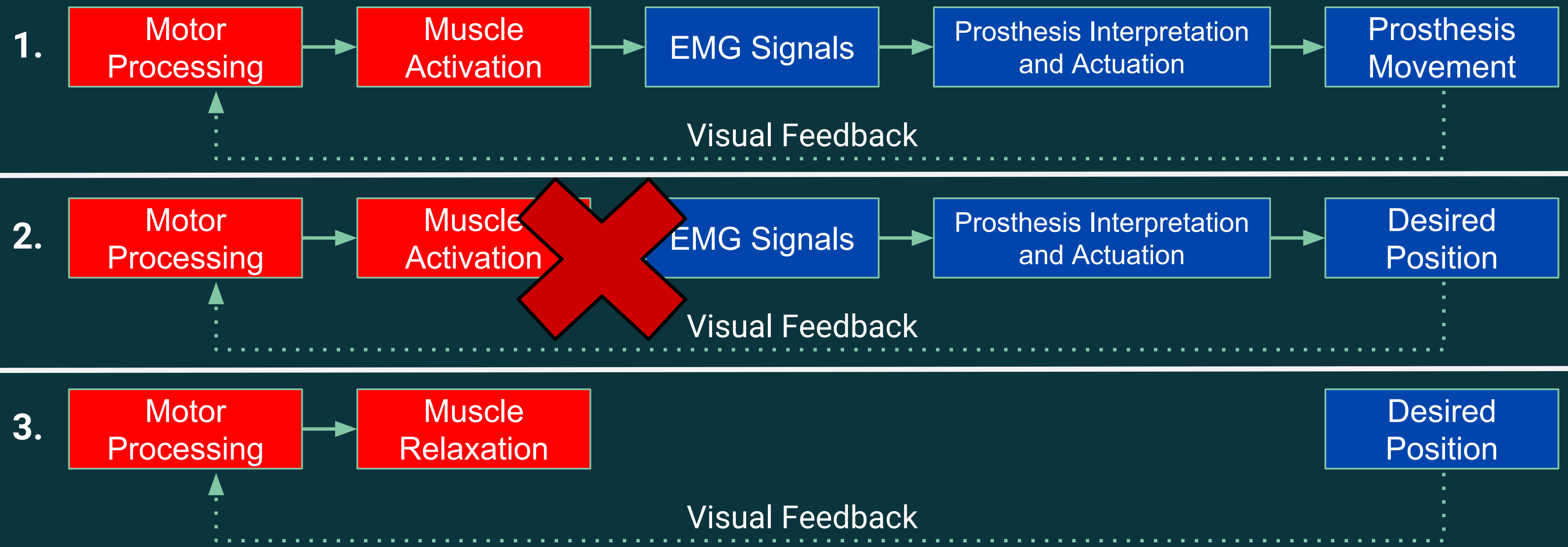
Natural Muscle Control

Key Features:

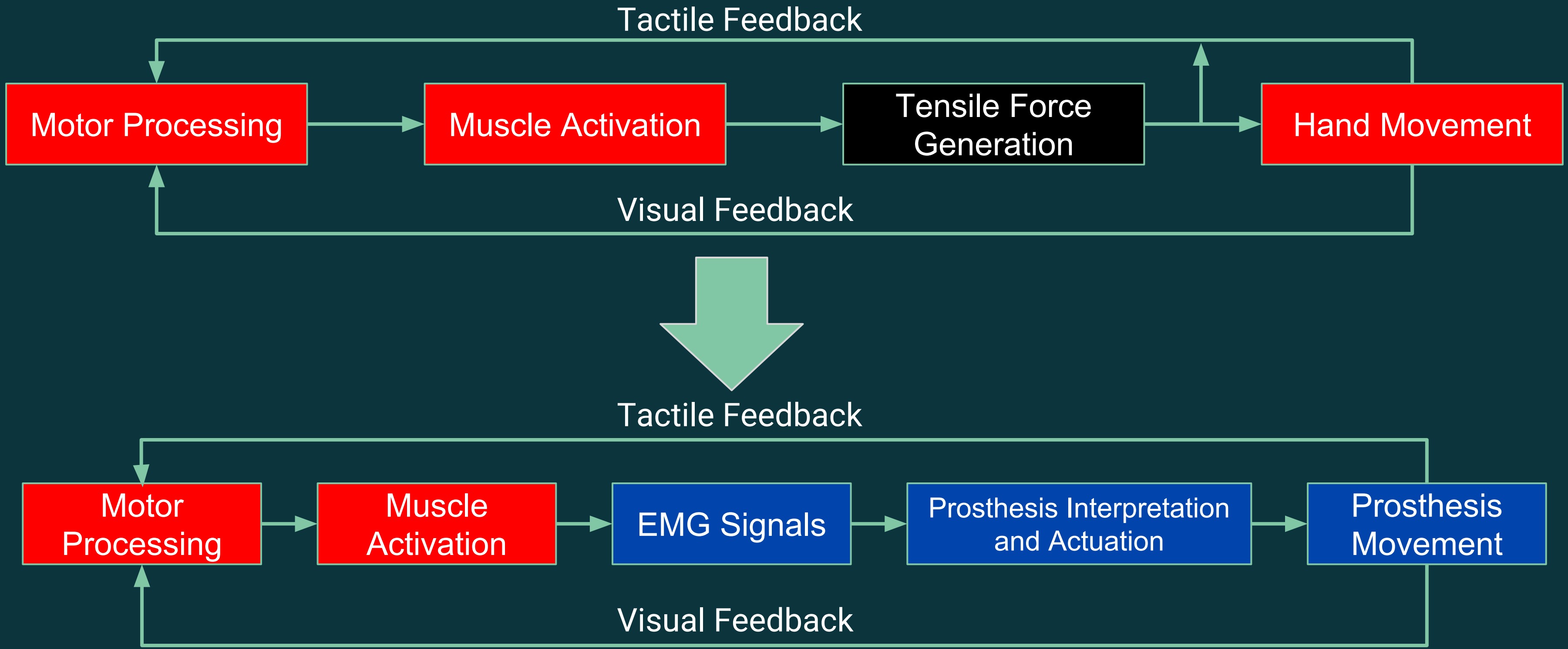
1. Continuous sensory-motor control
2. Tactile + visual afferent feedback
3. Constant motor processing and hand movement coupling



Current Velocity-Based Myoelectric Control



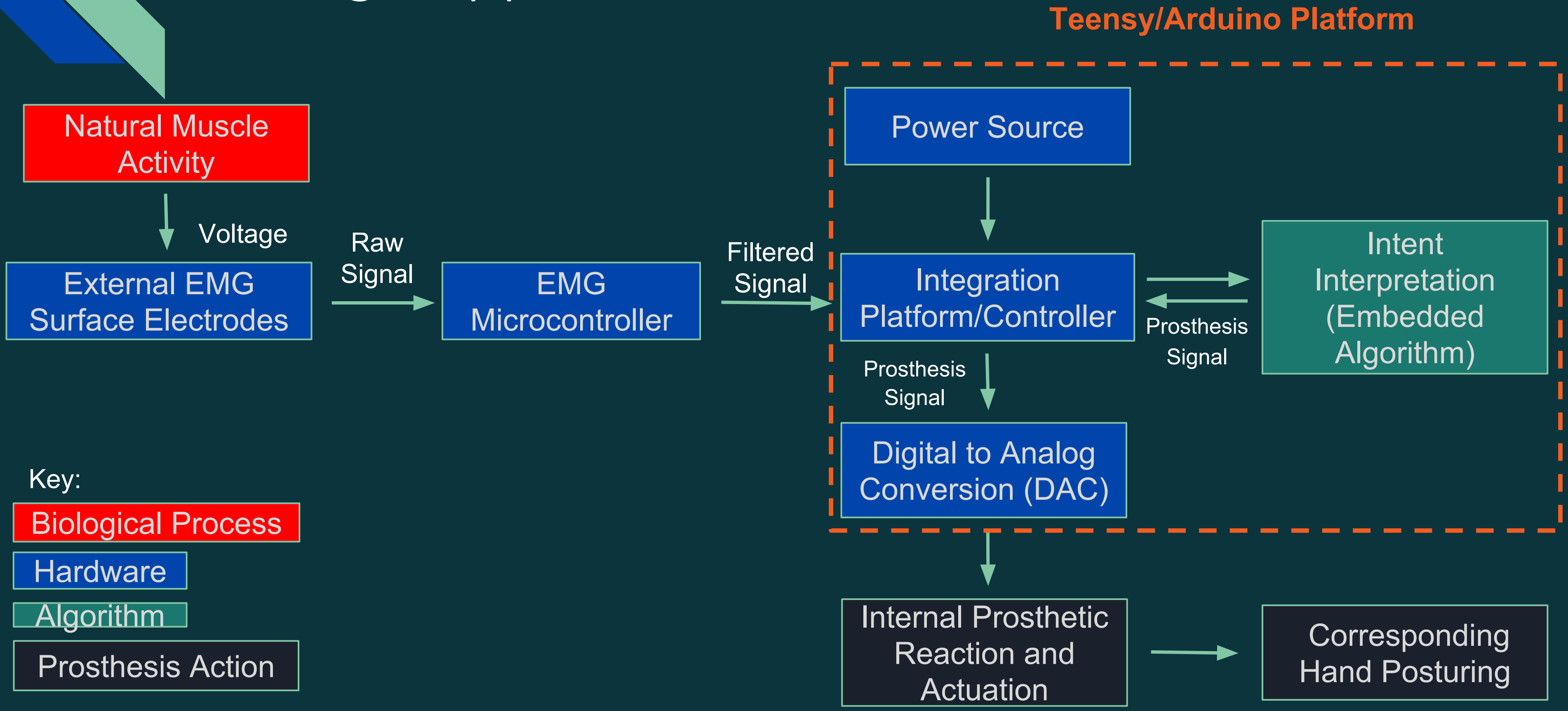
Our Role: Bridging a Gap



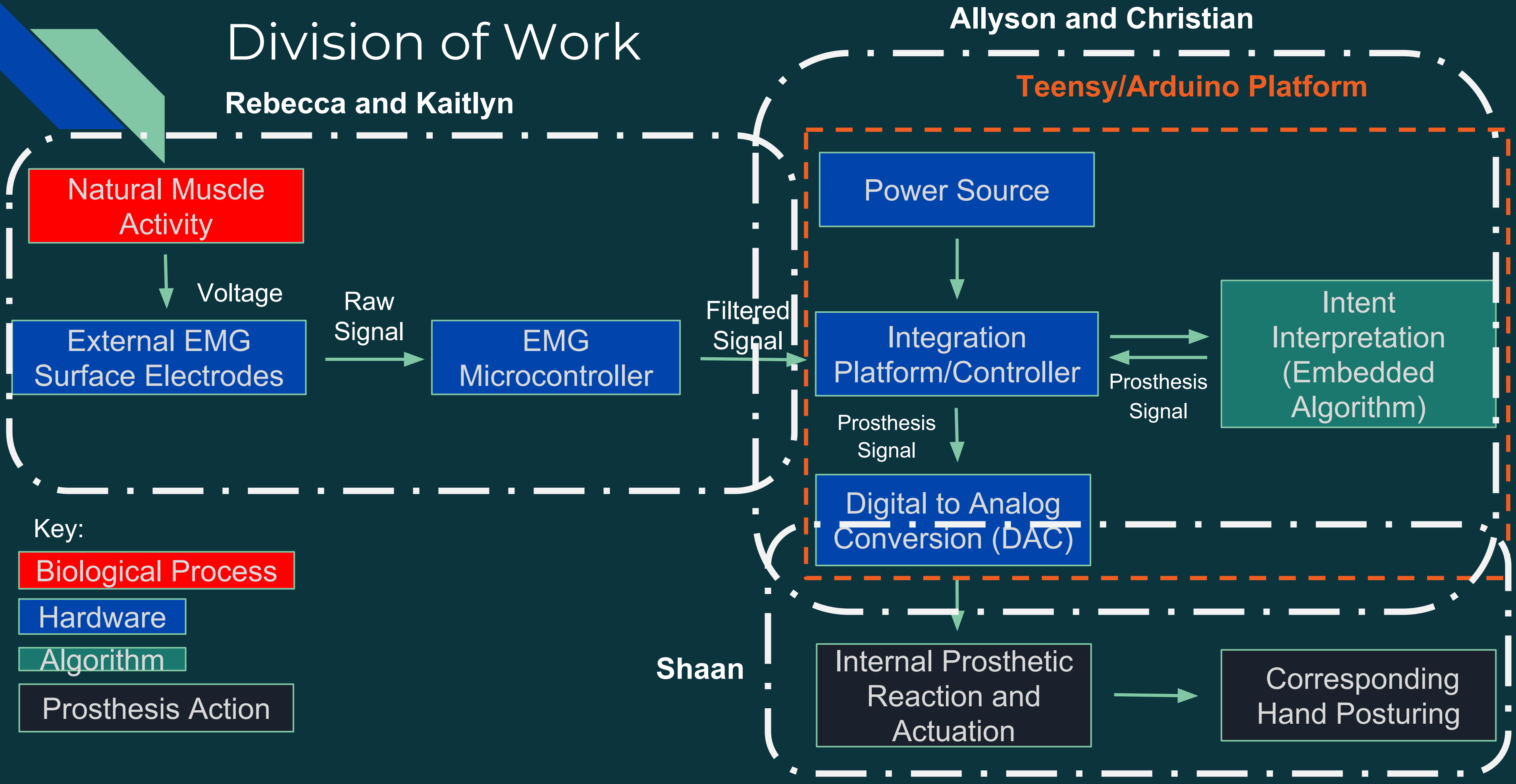
Highlights of Needs Assessment

- Adjustable to different
    - Patient Capabilities
    - Amputation types
- **Wearable**
- **Durable**
- **Safe** and Easy to Use
    - Patient Use
    - **Prosthetist/Lab Technician parameter manipulation**
- **Cost Effective**
- Software and Design Documentation
- Efficient EMG to prosthesis actuation

Design Approach

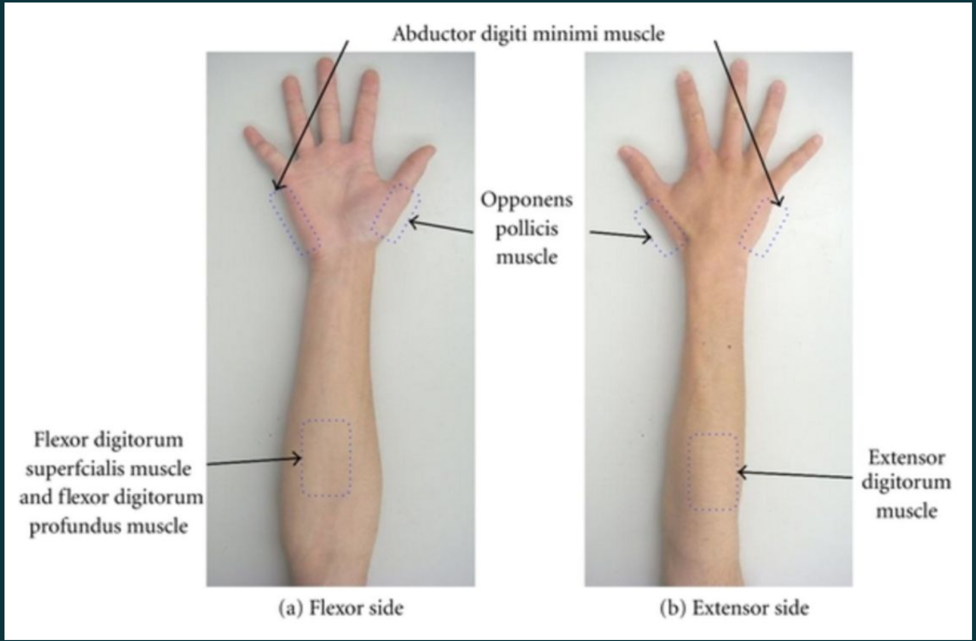


Division of Work



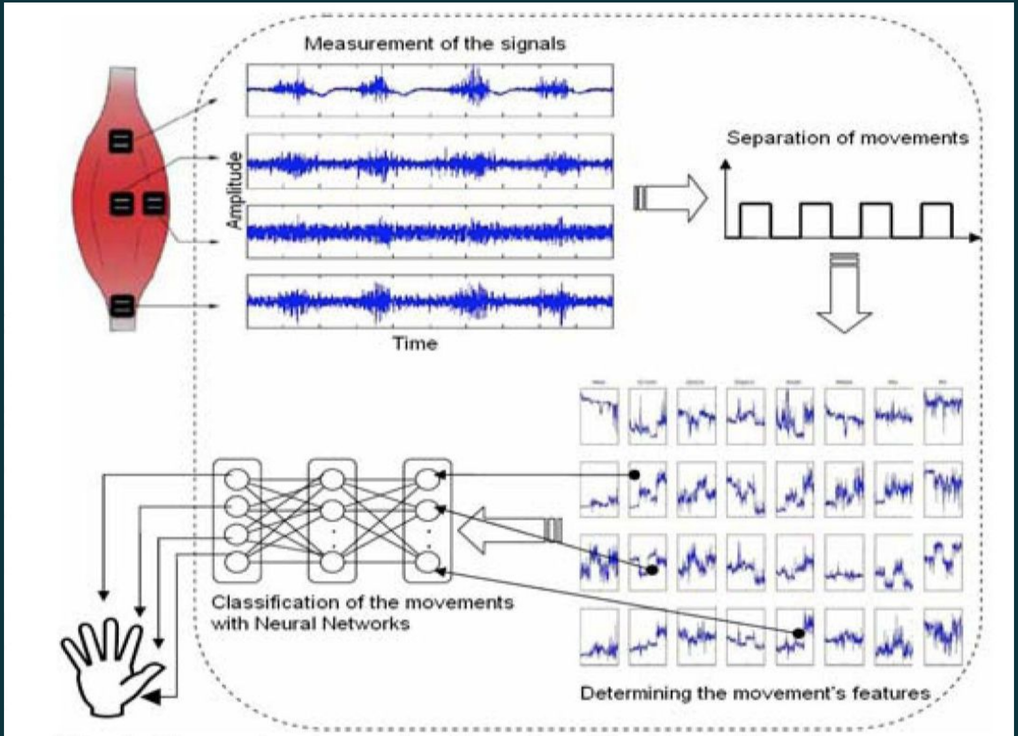
EMG Acquisition

- Signal will be obtained from EMG signals placed on the Extensor Digitorum and Flexor Digitorum
- Phantom testing designed with human subject
  - Motion will be limited where appropriate for correct signal acquisition



EMG Signal Interpretation

- Each movement should have a different EMG signal pattern
- Through analysis of known EMG patterns and customization for test subject, we hope to be able to classify different signals as different movements



Hardware: Prosthesis

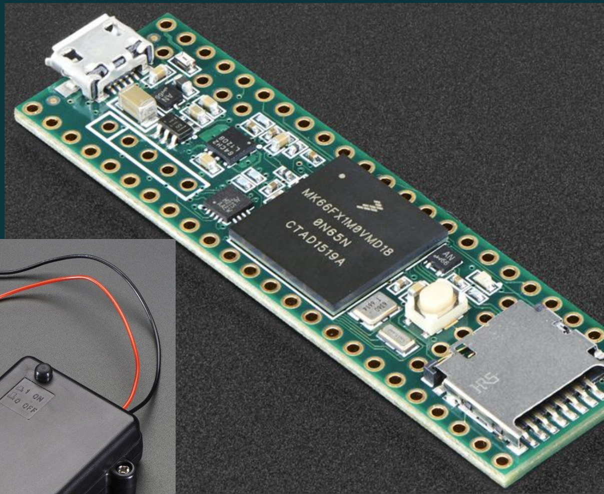
Ottobock Transcarpal Hand (8E44)

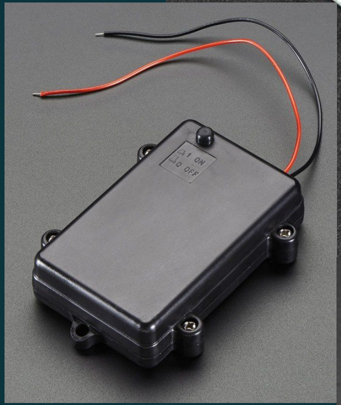
- Variable grip speed (force)
- Motor operates using PWM
- Issue: motor not moving with EMG input
  - Gain adjustments
  - Mechanical isolation
- Next Step: have prosthesis serviced by Ottobock

https://professionals.ottobockus.com/Prosthetics/Upper-Limb-Prosthetics/Myo-Hands-and-Components/Myo-Terminal-Devices/Transcarpal-Hand-DMC-plus/p/8E44~56-R8%201~24

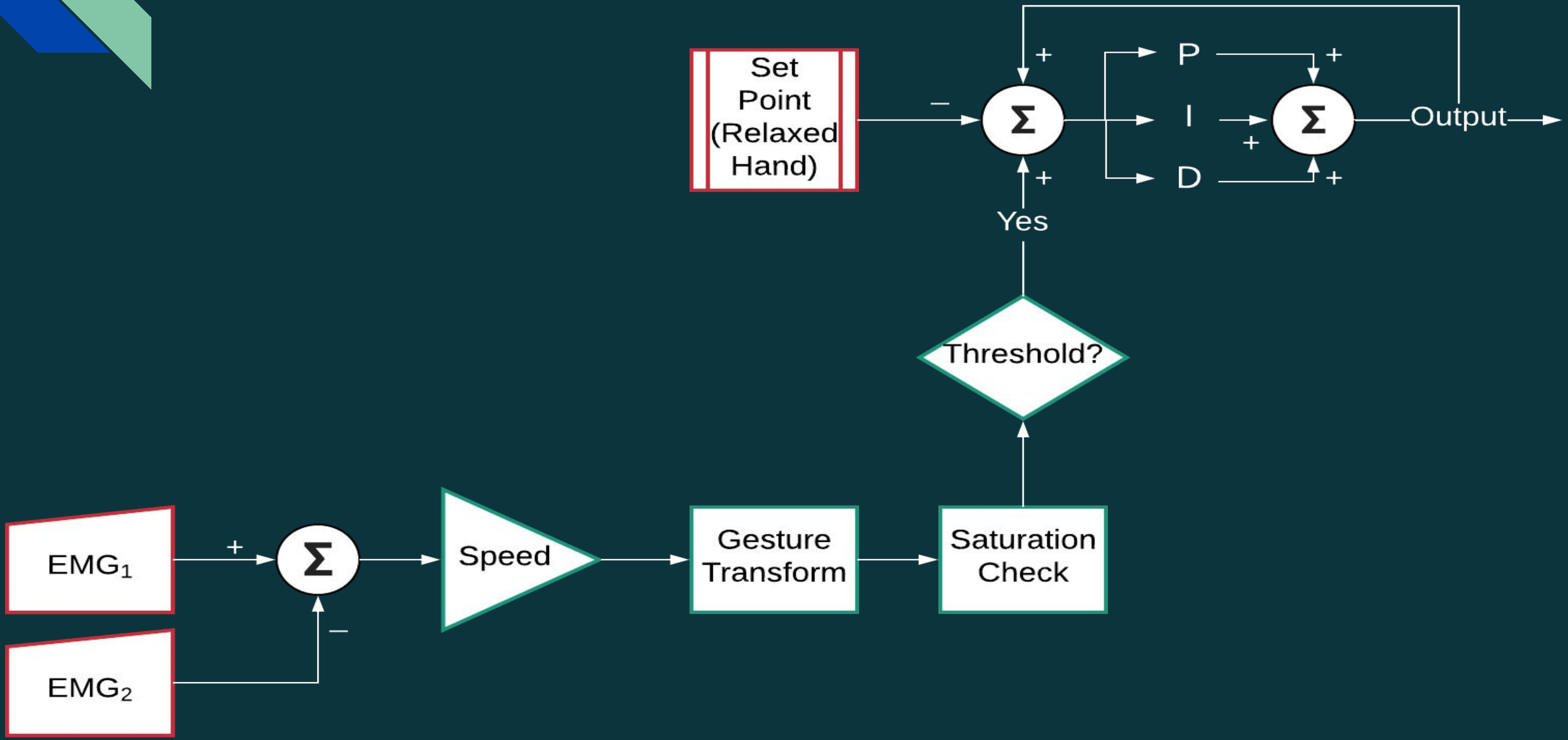
Hardware: External Processing

- Teensy Development Boards
  - Arduino platform compatible
  - Increased Bandwidth
  - Compact and lightweight
  - No on-board power capabilities
- Myoware Sensors
  - On-board signal processing
  - Compact
  - Fixed signal placement
- Total Cost: $110





Novel Control System Scheme



Where We Are and Where We Are Going

Define the Problem	Needs Assessment	Generate Solutions	Make and Test Model	Improve Design	Communicate
Velocity-based prostheses not controlled in same manner as intact control system	**Patient, Clinicians/ Researchers, System**	**EMG, Algorithm Dev, Hardware Interfacing**	**Integrate System Components**	Ensure Functional, Safe, Scalable, and Meets Expectation	Design Day

What Questions Do You Have?

References

Slide 3,4 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 10 Figure: https://www.researchgate.net/figure/The-muscles-related-to-finger-motion-The-muscle-functions-are-as-follows-the-flexor_fig6_258378736

Slide 11 Figure: G. Tsenov, A. H. Zeghbib, F. Palis, N. Shoylev and V. Mladenov, “Neural Networks for Online Classification of Hand and Finger Movements Using Surface EMG signals,” *2006 8th Seminar on Neural Network Applications in Electrical Engineering*, Belgrade, Serbia & Montenegro, 2006, pp. 167-171. doi: 10.1109/NEUREL.2006.341203

Slide 13: Battery Pack: https://www.adafruit.com/product/771?gclid=Cj0KCQiAm5viBRD4ARIsADGUT25Rn_FJLIYKc3t2rLc6H1FHcBdir39XMgxD5oLOFZC8Z59nZjuHMcMaApIDEALw_wcB Teensy Board: https://www.adafruit.com/product/3266 Myoware Sensors: https://www.adafruit.com/product/2699?gclid=Cj0KCQiAm 5viBRD4ARIsADGUT26WdiQrva9o_F5tG6X3 -FNKWbrwMby-7y-6VrE-zYzJ9XYoIqbCTy8aAmcBEALw_wcB

Appendix

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

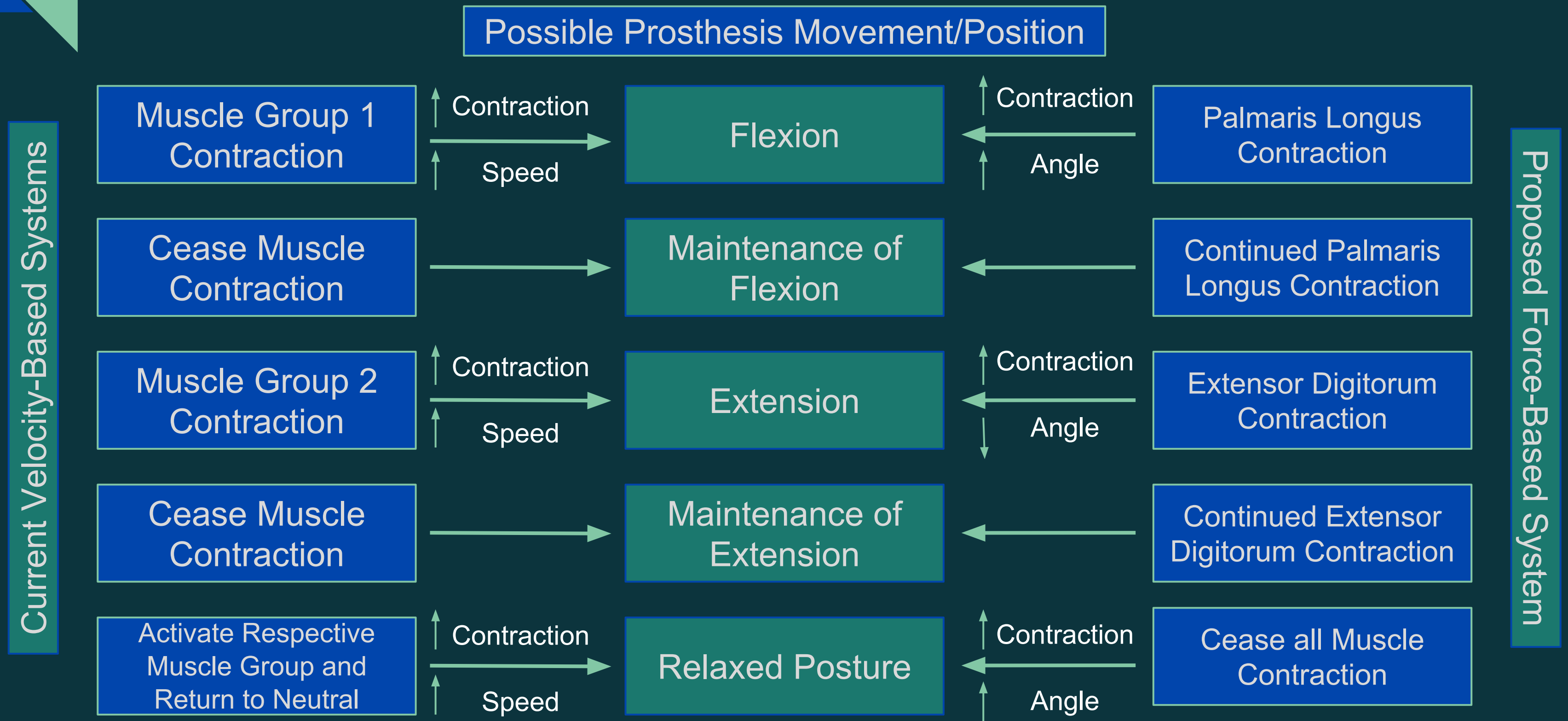
- Wearable
  - Processor either in sleeve above the prosthesis or incorporated into the prosthesis itself
  - Must be tolerable weight for daily use
- Safety
  - Must be designed and built according to quality standards to ensure there are no safety hazards from the mechanical or electrical components
  - 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

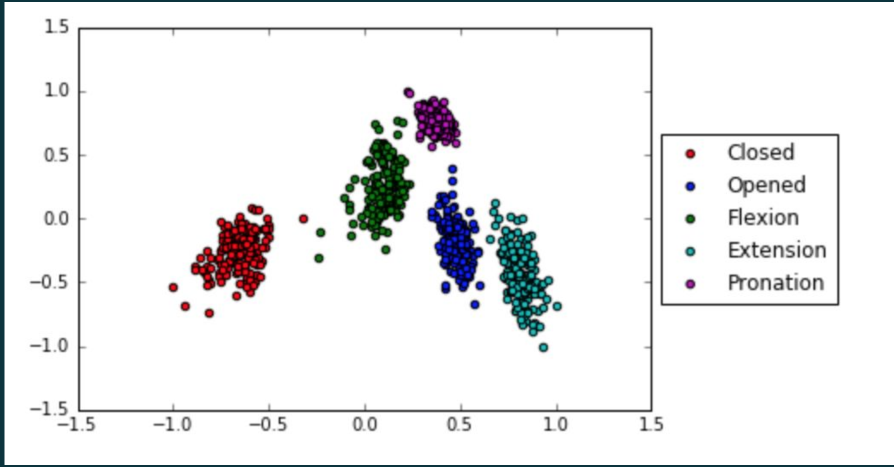
- Durable
  - Daily use will require durability in different environmental conditions and during general activity
- Integration
  - Must integrate seamlessly with implanted neuromodulated sensory feedback system in users
  - Should minimize noise interference with implanted neuromodulated sensory feedback 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



Possible Prosthesis Movement/Position
Current Velocity-Based Systems
Proposed Force-Based System
Muscle Group 1 Contraction
Contraction
Speed
Flexion
Contraction
Angle
Palmaris Longus Contraction
Cease Muscle Contraction
Maintenance of Flexion
Continued Palmaris Longus Contraction
Muscle Group 2 Contraction
Contraction
Speed
Extension
Contraction
Angle
Extensor Digitorum Contraction
Cease Muscle Contraction
Maintenance of Extension
Continued Extensor Digitorum Contraction
Activate Respective Muscle Group and Return to Neutral
Contraction
Speed
Relaxed Posture
Contraction
Angle
Cease all Muscle Contraction

EMG Signal Interpretation

- To do this, Root Mean Square calculates the mean power of the signal, mean absolute value calculates contraction level, and waveform length shows the cumulative length of the waveform



$$RMS_k = \sqrt{\frac{1}{N}\sum_{i=1}^{N} x_i^2}$$

$$MAV_k = \frac{1}{N}\sum_{i=1}^{N} |x_i|$$

$$WL_k = \sum_{i=1}^{N-1} |x_{i+1} - x_i|$$

Wearability/Durability

- Watch-like
  attachment to socket
- Cardboard Prototype
- Adjustability
  achieved with watch
  strap