BRADLEY University

EMG-Based Human Machine Interface

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EMG Explained

- Electromyography Signals (EMG)
  - Electrical signals produced by muscle activation
- Surface EMG (sEMG):
  - A technique for acquiring EMG signals by using electrodes placed on the skin of the body, directly above the desired muscle

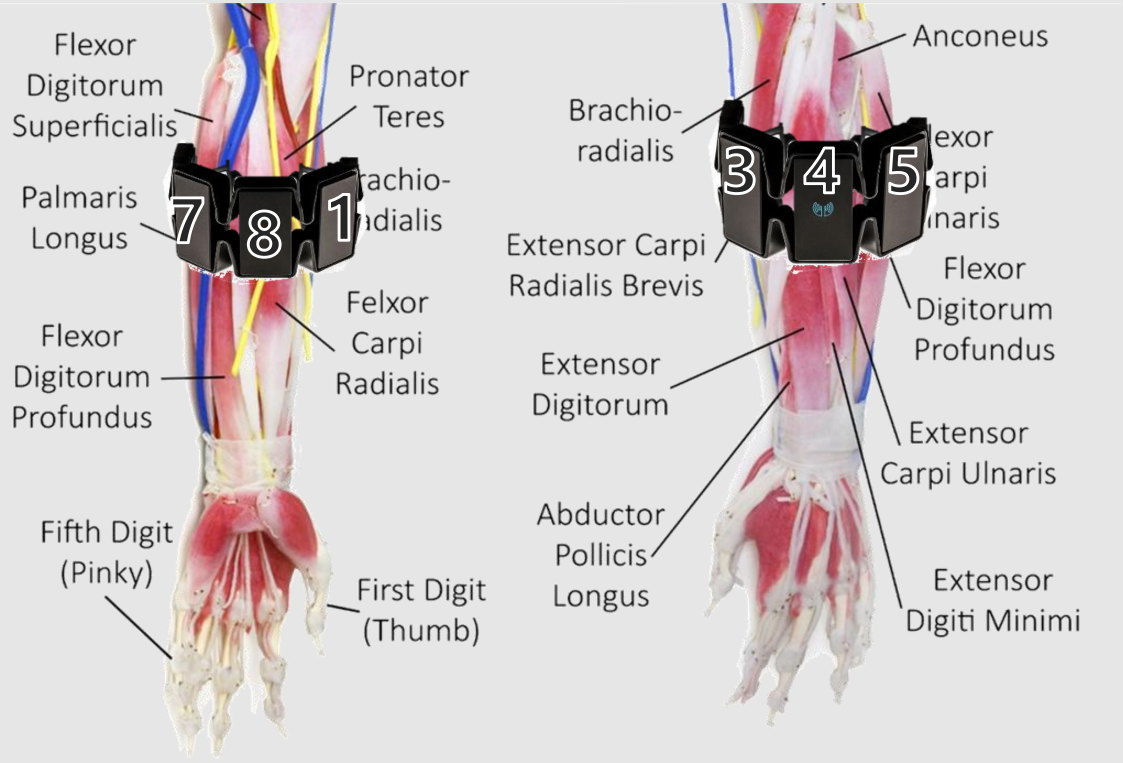

Diagram of forearm muscles [1]

Uses of EMG

- Primarily for medical purposes
  - Diagnosing and testing for muscle and nerve injuries
- Control of prosthetic limbs
- Gesture control
  - Drones
  - Computers
  - TV

Background

Applicable Literature

- Study of Virtual Control of a Robotic Arm via a Myo Armband for the Self-Manipulation of a Hand Amputee

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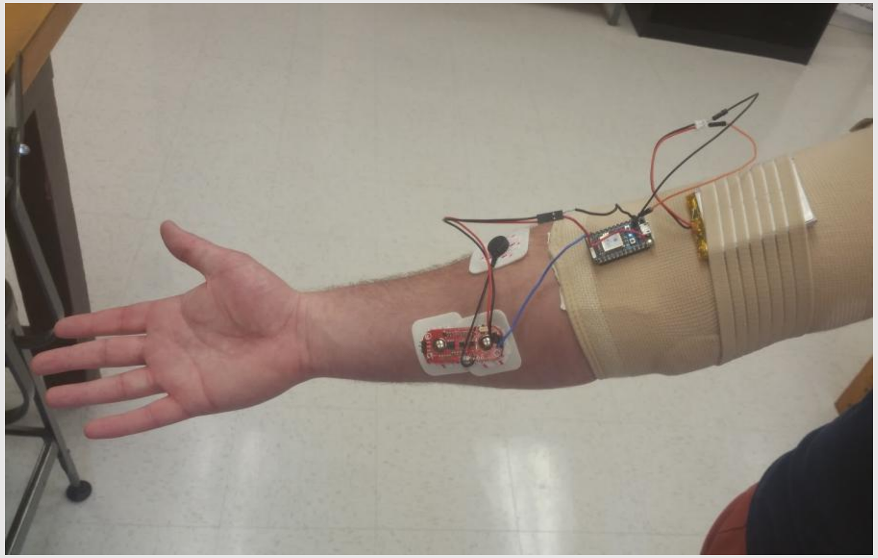
2016-2017 Senior Capstone Project

- Developed an EMG-based HMI for a mobile robot
- Used a neural network to detect user motion

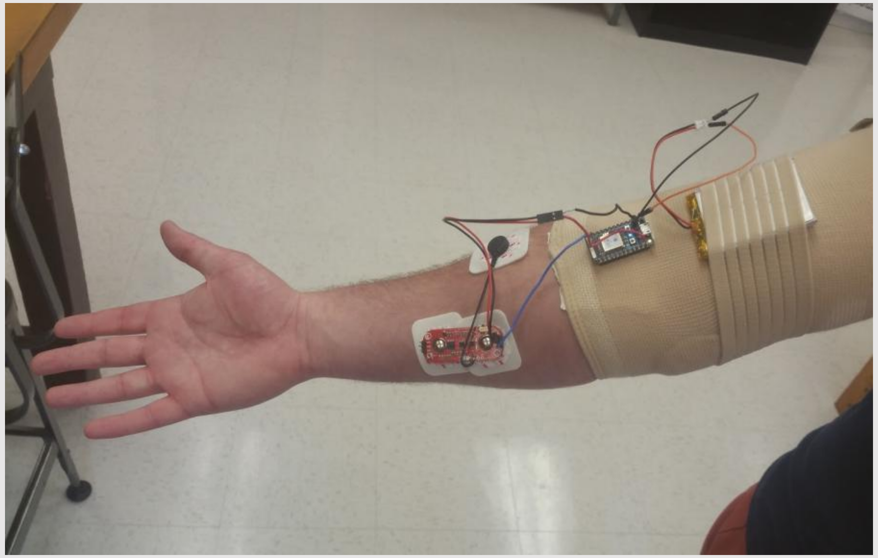


2016-2017 EMG System

2016-2017 Senior Capstone Project

Limitations:

- Uncomfortable
- Short battery life
- One sensor – limited information



2016-2017 EMG System

2016-2017 Senior Capstone Project

Improvements:

- Armband design - easy to slide on/off
- Extended battery life
- 8 sensors

Myo Armband

Project Overview

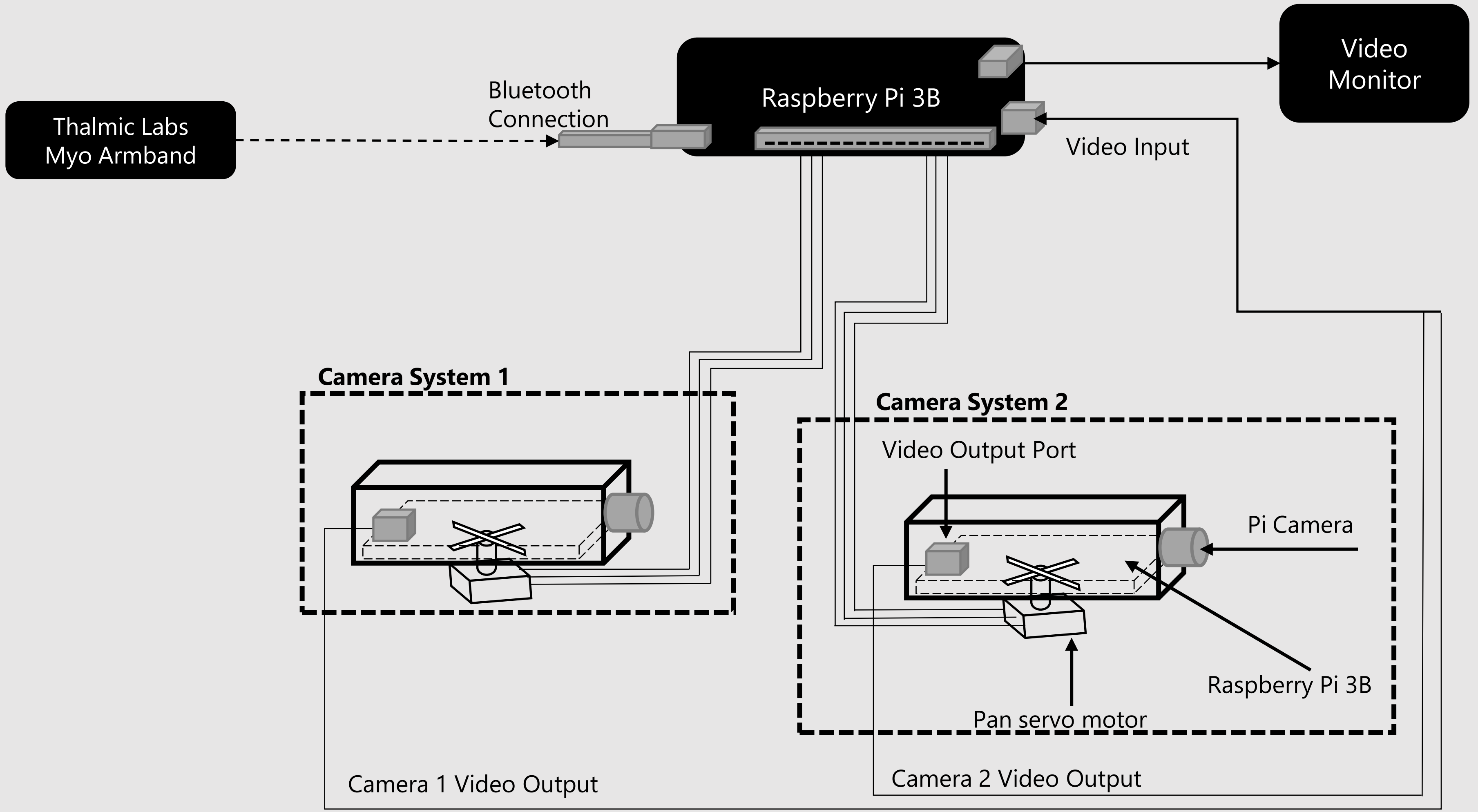
Problem Statement

- Current market for gesture control of security systems is limited
  - Based on image recognition
- Security monitoring can be tedious
- Solution: gesture-based control of cameras

Project Goals

1. Collect and analyze sEMG data
2. Develop pattern recognition algorithms
3. Control security camera system with hand gestures

System Diagram



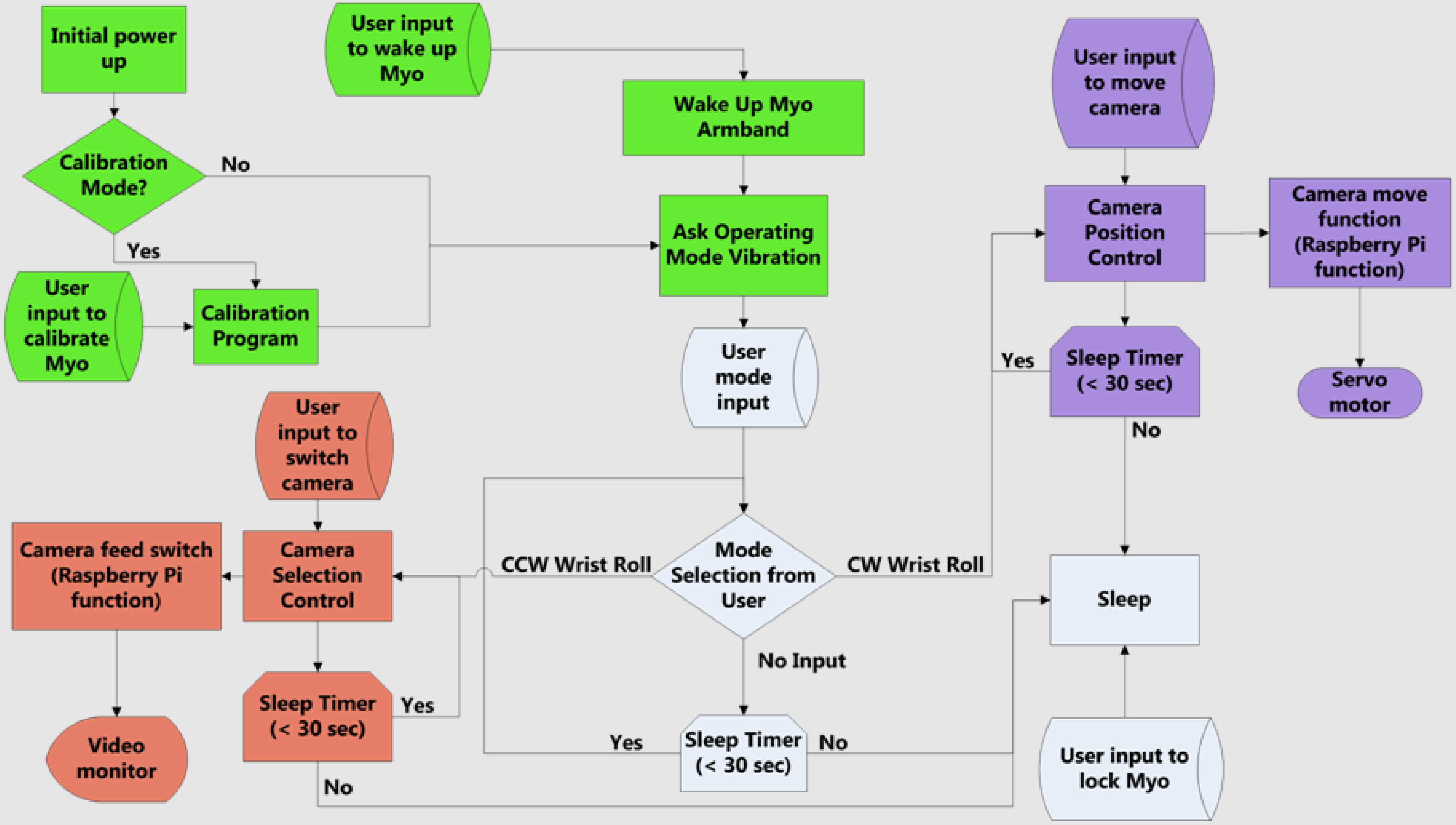
Functional Requirements

- Myo armband worn on right forearm
- Bluetooth connection between Myo and Pi
- Calibration process executed by Pi
  - Based on machine learning
- Generate PWM signals for pan action
- Display camera video feed on monitor
- User controls
  - Myo armband sleep/wake up
  - Calibration
  - Camera selection
  - Pan camera view

Operating Modes

Function	Gesture	Haptic Feedback
Toggle armband lock/unlock	Fingers spread (hold for 2 seconds)	Vibration (3 seconds)
Calibration Mode	Make fist (hold for 2 seconds)	3 Vibrations (1 second each)
Camera Selection Control Activate	CCW circle with fist	1 Vibration (1 second)
Camera Position Control Activate	CW circle with fist	2 Vibrations (1 second each)
Next Camera	1. Start with palm facing in 2. Move wrist outward	N/A
Previous Camera	1. Start with palm facing in 2. Move wrist inward	N/A
Pan Left	1. Start with palm facing in 2. Move wrist inward	Vibrate low while moving
Pan Right	1. Start with palm facing in 2. Move wrist outward	Vibrate low while moving

System Flow Chart



Specifications – Myo Armband

- 8 EMG sensor electrode pairs
- Sampling rate = 200 Hz
- EMG data sent via Bluetooth
  - 8-bit signed integer
  - Unitless, represents muscle activation
- Compatible with:
  - Windows 7, 8, and 10
  - OSx 10.8 and up
  - Android 4.3 and up
- Battery life

Specifications – Raspberry Pi 3B

- Broadcom BCM2387 64-bit ARMv7 Quad Core Processor (1.2 GHz)
- BCM43143 WiFi
- Bluetooth (BLE 4.1)
- Boots from Micro SD
- Runs Linux or Windows 10 IoT (Internet of Things)

- Input / Output
  - 40-Pin 2.54 mm expansion header (2x20 strip)
  - CSI Camera port for Raspberry Pi Camera
  - 4 Port USB
  - HDMI
  - Ethernet

Engineering Efforts Completed

Introduction

Background
- Literature
- Previous Work

Project Overview
- Problem / Goals
- System Diagram
- System Functions
- Operating Modes
- Flow Chart
- Specifications

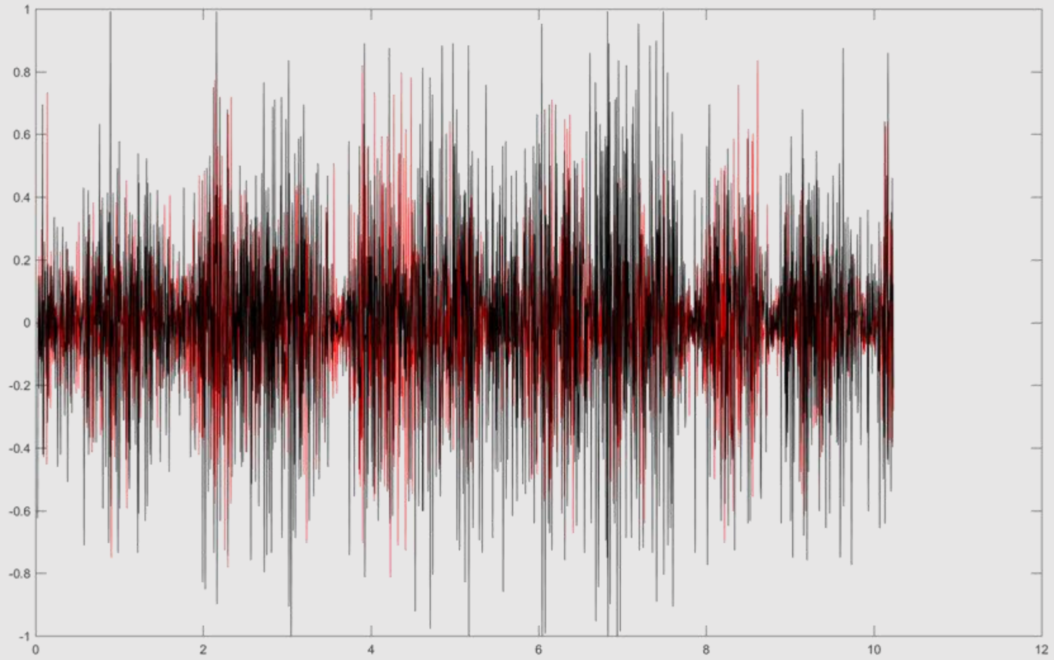
Engineering Efforts Completed
- Data collection
- Analysis

Parts List
- Submitted
- Possible Additions

Looking Forward
- Division of Labor
- Schedule

Initial Data Collection

- Use Visual Studio (C++) to record and save data
- Import the data and analyze in MATLAB



First Attempt at Data Collection

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Initial Data Collection

- Control Variables
  - Test duration: 10 seconds
  - Armband worn the exact same way for each test
  - Movements, repeated multiple times:
    - Palm facing in, wrist action in
    - Palm facing in, wrist action out

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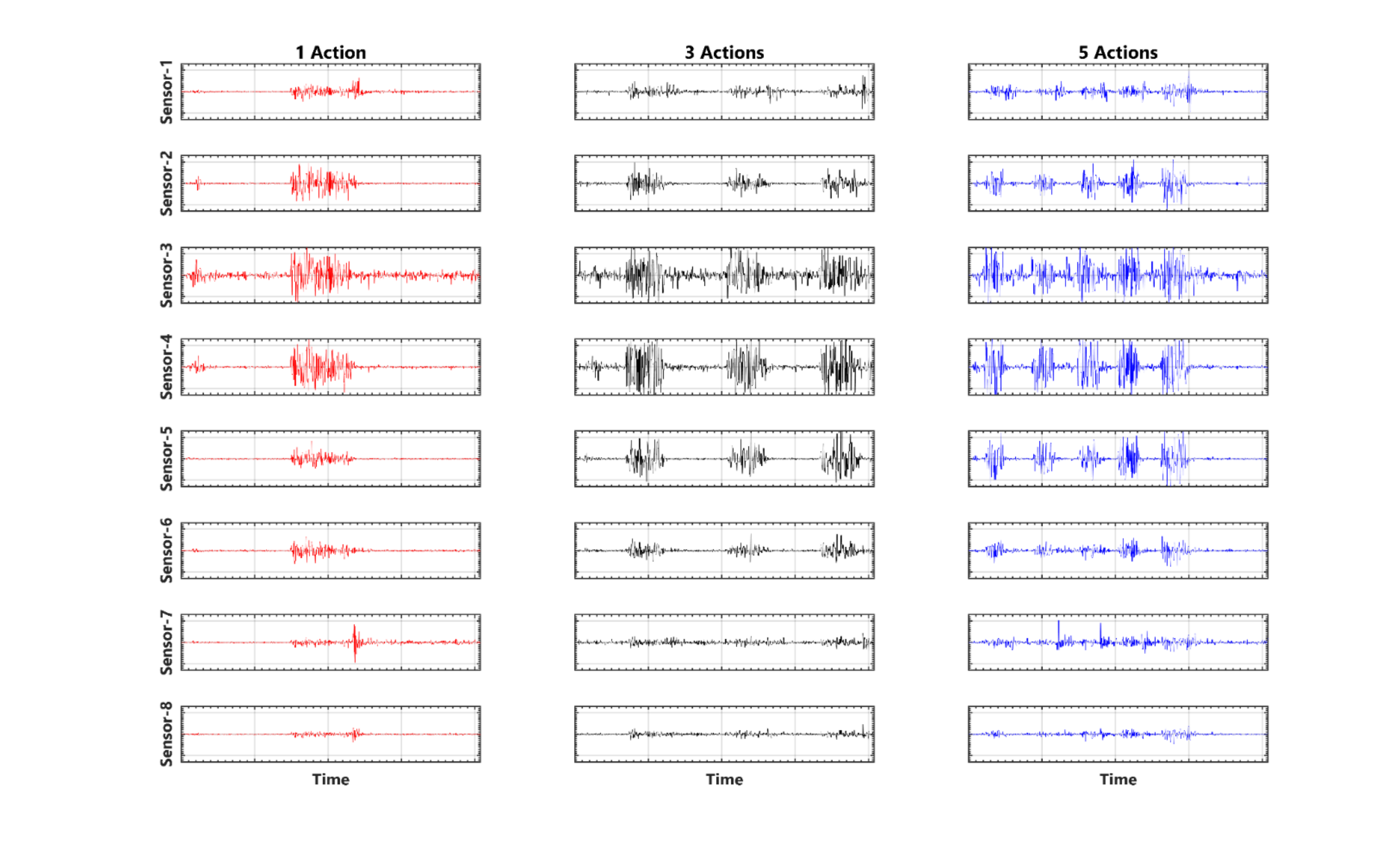
Revised Data Collection



Multiple datasets of wrist moving outward for 10 seconds

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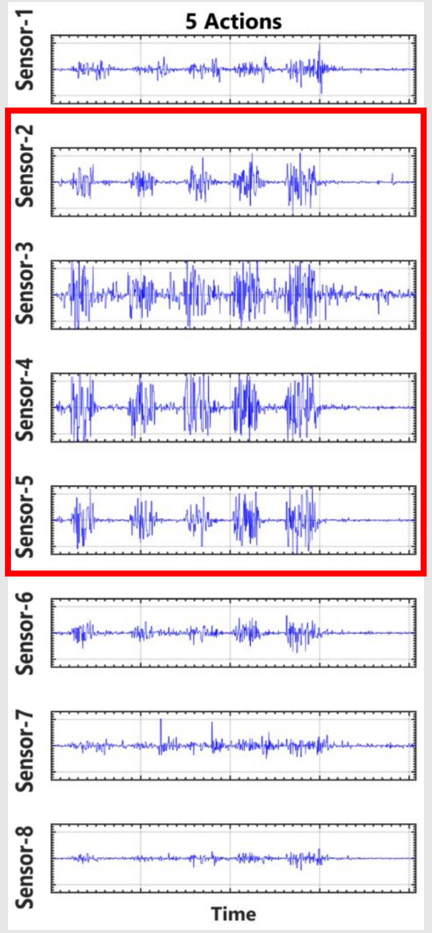
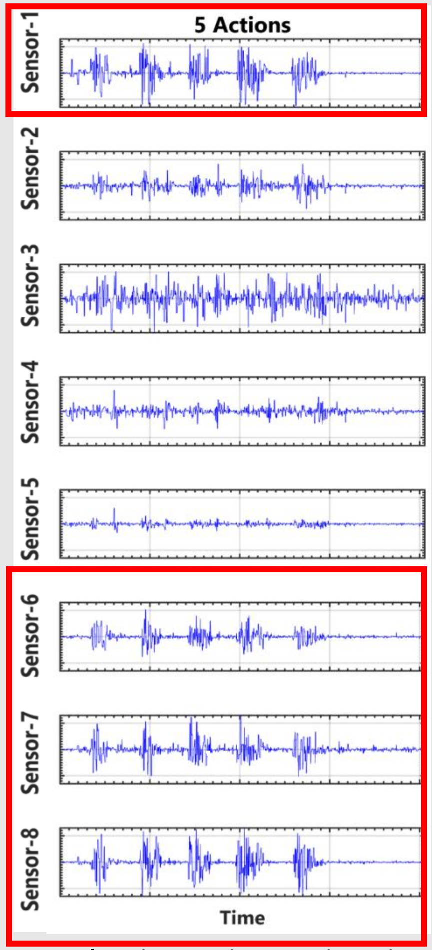
Data Analysis



Palm in, wrist action out



Palm in, wrist action in

Myo Gesture Control Armband with labeled sensors

	Palm in, wrist action outward	Palm in, wrist action inward
High Sensor Activity	2, 3, 4, 5	1, 6, 7, 8
Moderate Sensor Activity	1, 6	2
Low Sensor Activity	7, 8	3, 4, 5

Data Analysis

- Data Analysis
  - Envelope detection
  - Fourier Analysis
  - Thresholds
  - Dominance table
- Gesture Recognition
  - Supervised / unsupervised learning
  - Look-up table
  - Neural network

Future Data Collection

- Continue to collect data
  - Different users
  - Test all gestures
- Pattern recognition
  - Choose method for pattern recognition
  - Associate patterns with gestures

Parts List

Parts List

- Thalmic Labs Myo Armband (1)
- Raspberry Pi 3B and Power Supply (3)
- Raspberry Pi 3b Camera (2)
- 8GB Micro SD Card (3)
- HDMI / VGA / DVI Cable (only need one of these options)
- Computer Monitor (1)
- Servo Motor (2, one motor to pan each camera)

Parts List

- Case for the Raspberry Pi boards
- Material to make a mount for the servo motors and Pi board cases
- Second Myo armband

Looking Forward

Division of Labor

Aditya Patel	Jim Ramsay
Communication • Video feed communications • System component communication network • Monitor connections • Website design	**Data Collection** • Pattern recognition • Armband configuration • Data analysis
Computing • Raspberry Pi 3B setup / code • PWM generator • Pi GPIO configuration	**Camera Hardware Design** • Case • Mounts • Servo motor wiring

Schedule

	Weeks 1 & 2	Weeks 3 & 4
November	1. Write proposal 2. Submit parts list to Chris Mattus 3. Get raw data from armband 4. Discuss/consider filtering options	1. Make website 2. Draft project proposal presentation 3. Practice presentation 4. Revise proposal for final submission
December	1. Finalize the website design 2. Post project deliverables 12/7/2017	1. Collect data 2. Start thinking about data analysis options
January	1. Start pattern recognition 2. Develop preliminary tests for gesture detection	1. Compare gesture detection options and choose which to continue with 2. Begin Raspberry Pi development

Schedule

	Weeks 1 & 2	Weeks 3 & 4
February	1. Configure Raspberry Pi and peripherals 2. Hardware design and building	1. Finalize and compile code 2. Gather any data needed for final submission
March	1. Begin work on final draft	1. Make poster 2. Finish final draft
April	1. Practice poster presentation 2. Begin drafting project presentation	1. Finalize project presentation 2. Practice project presentation 3. Finalize project report

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Questions?

Sources

- https://www.ripublication.com/ijaer16/ijaerv11n2_05.pdf