Embedded Systems Project Document

Jack Reamy

1. Initial Project Idea

PROJECT TITLE: Mind Controlled Prosthetic Fingers
PROJECT DESCRIPTION: This project will aim to construct hardware for 4 prosthetic fingers that mirror the activity of a user's natural fingers. The system will consist of 3 major components: a hand training device, a user data collection sleeve, and the 4 prosthetic fingers. The system will first be externally dependent for training and processing power, but once a sufficient machine learning model is trained, the system will be able to operate as a standalone running the trained model in the embedded system itself.

The hand training device will be a glove-like device that takes in positional data from the user's fingers. This will be used in training the machine learning model, as it will be used to associate user intent with actual finger motions. The data collection sleeve will have an array of electrodes contacting various points along the upper arm of the user collecting live data from the user. This will be akin to an EEG signal, except that it is more localized to the portion of the body that is actually intended to be used (the fingers). This will pre-filter the possible 'intent' data collected by the system instead of connecting to the user's head. This will also be a less cumbersome device than a scalp mounted EEG. The 4 prosthetic fingers will only allow axis of motion, simplifying the prosthetic's function from the actual function of a user's fingers.

Once fully developed, the device will be standalone, including its own 5 V power source for powering both the prosthetic fingers, data collection sleeve, and microprocessor that controls both devices. It will be arm-mounted, attached to the data collection sleeve.

2. Finding Comparable Products

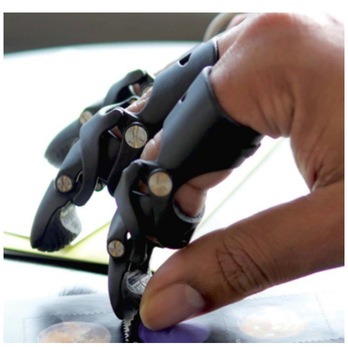
1. DIY 5DOF Robot Five Fingers Metal Mechanical Paw Left and Right Hand - https://www.wish.com/product/58f0ab8c625dcc19b77bf2ec?hide_login_modal=true&from_ad=goog_shopping&_display_country_code=US&_force_currency_code=USD&pid=googleadwords_int&c=%7BcampaignId%7D&ad_cid=58f0ab8c625dcc19b77bf2ec&ad_cc=US&ad_curr=USD&ad_price=107.23&campaign_id=7203534630&gclid=EAIaIQobChMIh4rA8NaD5wIVOB-tBh0CZQ2mEAYYAiABEgLCNvD_BwE

This DIY prosthetic hand is user assembled and allows symmetric construction to be either the left or right hand. Coming in at just $107, this is actually quite a cheap product, but has very limited functionality. The fingers are each driven by a single servo, limiting motion of each finger to a single action. The proposed device will exhibit much greater range of motion, and allow user control, which this device does not.

2. Ottobock Silicone finger and partial hand prosthetics – https://www.ottobockus.com/prosthetics/upper-limb-prosthetics/solution-overview/custom-silicone-prosthetics/

This prosthetic is a lifelike finger or hand replacement made of silicone. It has little to no functionality but is a custom prosthetic. The proposed device will be much less lifelike, but will allow the user to actually control the device instead of merely position it as seen in the image to the left.

3. PIPDriver by Naked Prosthetics – https://www.npdevices.com/product/



Naked Prosthetics designs custom finger prosthetics to match a user's natural finger length, fitting to however much of the user's finger is left. This product also has 1 axis of motion, but is completely mechanical.

4. TASKA Prosthetic Hand – http://www.taskaprosthetics.com/

The TASKA Prosthetic is a waterproof, durable, electrically powered hand prosthetic. It has powered joints akin to the proposed product, along with a rotating thumb, which the proposed product will not attempt. The fingers can also laterally spread, unlike the proposed product. It appears to have limited preset grip positions but does allow individual finger motion at least in the thumb, forefinger and middle finger. The 'grip cycles' are controlled by buttons on the back of the hand, where the proposed device will be completely controlled by user 'intent' data.

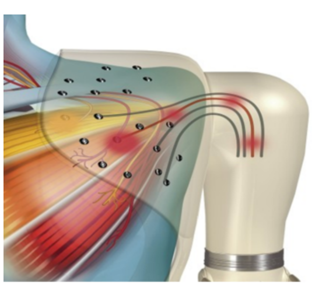
5. Ottobock Bebionic Hand – https://www.ottobockus.com/prosthetics/upper-limb-prosthetics/solution-overview/bebionic-hand/

The Ottobock Bebionic Hand is an electrically powered prosthetic that can shift between 14 preset positions. Again, this product has different thumb positions which the proposed product will not. The device automatically assesses its grip while holding an item, adjusting as necessary to maintain holding the product. Both this product and the proposed device are controlled by a microprocessor. They're proud of it, but all such devices have to be controlled this way…

6. Ossur i-Limb Quantum – https://www.ossur.com/en-us/prosthetics/arms/i-limb-quantum

The i-Limb Quantum is Ossur's prosthetic hand containing individually controlled fingers. Like the above market products, it comes with pre-designed grip positions that it automatically switches between sensing the 'gesture' of the user. It again has a rotating thumb that the proposed device will not attempt and does not seem to have EEG input from the user. Allows designing and sharing custom grip designs.

7. TMR (Targeted Muscle Reinnervation) – https://www.ottobock.co.uk/prosthetics/upper_limbs_prosthetics/product-systems/tmr/



While it is unclear whether Ottobock (the website linked above) produces TMR products on the market, TMR is another innovative method of electrical prosthetics. Specifically, TMR is the process of surgically moving nerves to be more accessible for electrode interaction. TMR is a highly invasive process, unlike the proposed device which will only be on the surface of a user's skin. TMR is a method that can be used in conjunction with various market products but is a medical procedure.

8. Orbit Brain-Controlled Helicopter – https://www.robotshop.com/en/orbit-mobile-brain-controlled-helicopter.html?gclid=EAIaIQobChMI4vbJmfCF5wIVLR6tBh3A_AmeEAkYASABEgL89vD_BwE

This product is less related to the proposed device but is also a non-invasive technology powered by some form of 'intent' data. It uses an EEG to sense the user's brain and follows certain flight paths when certain brain-wave patterns arise and are maintained. The helicopter is a trivial output for this device as it is designed to be a brain-training game where users have positive reinforcement when they focus long enough on a single thought. This device productizes non-invasive mind-controlled technology.

9. AxonHook - https://www.ottobockus.com/prosthetics/upper-limb-prosthetics/solution-overview/axon-hook/

The AxonHook is another Ottobock product that uses myoelectric signals. The hook is designed to be a hand alternative for users that need an elbow-onward prosthetic. Because it was designed by Ottobock, the prosthetic hook can be detached at the wrist and replaced by other prosthetic hands developed by Ottobock.

10. Open Bionics Hero Arm - https://openbionics.com/

The Hero Arm by Open Bionics is another myoelectric prosthetic arm. This prosthetic is 3D printed custom to the remaining portion of the user's limb. It has 6 different preset grips. Something this prosthetic offers that others may not is haptic feedback; it outputs vibrations, lights and beeps to provide user notifications. Themed well, it comes in Iron Man, BB8, or Frozen design.

3. Project Ideation

PARTNER NAME: Jack Reamy

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SUBSTITUTE

1. Hook fingers
2. Clawed gripper
3. Real hands
4. Extendable wolverine claws
5. Spatula hands / cooking utensils
6. Other tools
7. Rotating screwdriver fingers
8. Personal Assistant Robot
9. Fingers on the forehead
10. Exo-suit / extra limbs
11. Brass knuckles / weighted metal hands
12. Cheese fingers
13. Chicken fingers
14. Sowing machine fingers
15. Finger is a telescope

COMBINE

16. Laser pointer fingers
17. Knows what you're writing based on motion / impulses
18. Thick fingers / more fingers
19. Interchangeable fingers
20. Hand and foot interchangeable
21. Teeth are fingers
22. Impulses your actual fingers
23. Arm generator
24. Controls other parts of you
25. Thumb is finger
26. Fingers are thumbs
27. Finger is a generator
28. Combine finger and speaker
29. Detachable individual fingers
30. Finger missiles / projectiles

ADAPT

31. Weaponize the hand
32. Flamethrower
33. Foot that is a hand prosthetic
34. Tail with a hand (third arm?) aipom
35. LCD display on the hand / arm – built in smart watch
36. Sponge fingers for doing dishes
37. Chopstick fingers
38. Winch-controlled fingers
39. Skip the game controller, it is your hands
40. Keyboard fingers – knows where you're typing
41. Cigarette lighter
42. Extendable finger
43. Finger whip
44. Detachable flying fingers
45. Flashlight fingers

MODIFY, MINIFY, or MAGNIFY

46. Smaller fingers
47. Larger fingers
48. Fewer fingers
49. More fingers
50. Crab-claw hands
51. Low-power mode by shaking hand on/off
52. High-power mode
53. Rocket arm that flies you
54. Gripper on the finger
55. Electromagnetic fingers
56. Fingers that somehow help you swim… webbed fingers?
57. Magnifying glass attachment
58. Passive mode for power generation
59. The Underminer – mole man – and other digging names
60. Easier to replace natural hand

PUT TO ANOTHER USE

61. Rapid Pez dispensers
62. Taser fingers
63. Automatic texter
64. Exo-suit for your hands (power gloves)
65. Smartphone in your hand
66. Animatronics
67. Muscle control to other things
68. Electrodes to USB (read muscle activity)
69. Muscle to mouse

70. Muscle monitoring for PT / training
71. Can turn into a fan
72. Control other people
73. Yoyo
74. Smart keys in your hand for your car
75. TV controls

ELIMINATE OR ELABORATE

76. Solar powered arm
77. Wind powered arm
78. Gas powered arm
79. Nuclear powered arm
80. Arm powered by another arm
81. Emotion-based arm motion
82. Fingers that can move both directions
83. Single actuator per finger
84. More joints in each finger
85. Less joints in each finger
86. Simple fingers: hook-like
87. Lab-grown real fingers
88. Sticky fingers that don't move
89. No actual sensors on the body, just guesses what to do
90. Other hand positions the fingers / has a

REVERSE

91. Fingers that are backward
92. Pockets in the prosthetic
93. Haptic feedback
94. Brain control nerve damaged hands
95. Control someone else's arm
96. Arm control controls you
97. Gloves that get warmer as you move them – generate power etc
98. Interchangeable fingers
99. AI hand that sends you information about what it's doing
100. AI hand that teaches you how to use it
101. Dead hand-holder
102. Brain controlled standalone robot
103. Battery for other devices (pacemaker etc) connected
104. Arm-wrestling arm for training
105. PT finger trainer

4. Project Valuation

At this point you will want to restate your project adding in whatever changes came from the SCAMPER exercise. If nothing has changed, copy it here again – but hopefully, something has changed.

PROJECT TITLE: Brain Fingers

PROJECT DESCRIPTION: This project will aim to construct hardware for 4 prosthetic fingers that mirror the activity of a user's natural fingers. The system will consist of 3 major components: a hand training device, a user data collection sleeve, and the 4 prosthetic fingers. The system will first be externally dependent for training and processing power, but once a sufficient machine learning model is trained, the system will be able to operate as a standalone running the trained model in the embedded system itself.

The hand training device will be a glove-like device that takes in positional data from the user's fingers. This will be used in training the machine learning model, as it will be used to associate user intent with actual finger motions. The data collection sleeve will have an array of electrodes contacting various points along the upper arm of the user collecting live data from the user. This will be akin to an EEG signal, except that it is more localized to the portion of the body that is actually intended to be used (the fingers). This will pre-filter the possible 'intent' data collected by the system instead of connecting to the user's head. This will also be a less cumbersome device than a scalp mounted EEG. The 4 prosthetic fingers will only allow axis of motion, simplifying the prosthetic's function from the actual function of a user's fingers. Future development of the product would allow interchangeable fingers allowing modularity such as different textures for different gripping environments.

Once fully developed, the device will be standalone, including its own 5 V power source for powering both the prosthetic fingers, data collection sleeve, and microprocessor that controls both devices. It will be arm-mounted, attached to the data collection sleeve.

Ideally the prosthetic will be further developed to either send feedback to the user either via an array of small vibrating motors on the data collection sleeve or through activating the electrodes in the sleeve to send information to the user.

CUSTOMER JOBS

1. They *can't live* if they can't feed themselves… Could orient the prosthetic toward being useful with food stuffs
2. Literally everywhere they go they would benefit from having an arm. In theory the state of the person prevents them from engaging in some activities that would be fun or useful to them
3. Handshakes, hugs, games, writing, typing, we use our arms in just about every context.
4. Driving, typing, food preparation, cleaning themselves. Have you ever tried going to the bathroom without being able to use your hands?
5. I wouldn't say there are 'problems' I think there are features that could be very useful to users if the fingers / hand were modular allowing various different functionality.
6. Autonomy. Users will feel better about themselves / less like a burden the more they're able to do on their own
7. Confident, independent, capable, not just 'the guy missing his arm'. The Hero arm is a cool example of using prosthetics to build confidence. They're for kids and have themed colors /

design like Iron Man or Elsa from Frozen. Simple things like that could be enough, it's probably enough to just have functionality though

8. Autonomous, confident, capable…
9. Ideally, the arm would be usable for many years with the option to replace / upgrade various components. It would probably not be worn at night, but other than that it would almost constantly be used.

CUSTOMER PAINS

1. For the frequency of use and nature of the project, users would be willing to pay in the 10s of thousands to 100s of thousands. 'Takes too much time' if the prosthetic is slow / doesn't respond naturally. 'Requires substantial effort' again if the prosthetic is not natural to use.
2. When they can't do something / feel incompetent because of their physical hinderance.
3. The current prosthetics that are in use have limited natural movement. It would be better to have a bidirectional communication system wherein the prosthetic moves as one would intend to move their own fingers and reports some amount of the same senses that one's own fingers would sense.
4. Customers currently meet with either no prosthetic and limited to no capabilities with that limb, a partial or mechanical prosthetic and some capability, or a myoelectric prosthetic and more capability. Life is just hard when you don't have hands…
5. Being a burden to those around them.
6. Being seen as incapable. Being incapable. There are probably disability rights in the US preventing them being fired for their lack of limb, but they can still be relegated to minor tasks.
7. … pretty sure they'd've learned to live with it by now. If they're kid, they might be bullied about their arms. Parent's probably worry about their children.
8. Seems callous to tell someone without an arm that they're doing it wrong…
9. This product would have both an upfront cost, and a few months of training the prosthetic to contend with.

CUSTOMER GAINS

1. They wouldn't have to ask for as much help. Big saving in ego and sense of personhood.
2. Most people would probably be happy with some bare functionality that responds to their intended use of their hand. Actual haptic response would be a blessing and natural motion would be much appreciated.
3. They would most like the proposed natural response of the prosthetic and the range of motion / positions it offers.
4. Adding modularity would increase customer ease. Pretrained models on datasets of multiple people would shorten training time.
5. Their independence and lack of need of others help.
6. They're looking for the ability to use both hands instead of just one or one with a basic prosthetic.
7. Having hands…
8. Failure comes when the physical disability prevents them from doing something that they would naturally like to do. Failure in the prosthetic would be that it leaves them back at this baseline state, if it didn't respond to their intent.

9. They would want better quality. If the prosthetic could be shown to be more natural than others in the market, or if it gave them better bidirectional communication it would outperform other options.

PAIN RELIEVERS

1. This would save on time – we do things in parallel making use of both of our hands. It would save on effort also being able to use two hands.
2. Would remove constant frustrations of not being able to do tasks
3. Would be much better than no prosthetic or than purely mechanical ones increasing functionality
4. yes
5. They would be and feel less dependent / less of a burden to others
6. They would gain confidence in their abilities
7. Maybe… depends on how worried they are / how much negative social context is alleviated
8. Again, seems callous to tell someone without an arm that they're doing it wrong…
9. This doesn't really lower costs or learning curve, it mostly increases functions

GAIN CREATORS

1. This is the same question… This would save on time – we do things in parallel making use of both of our hands. It would save on effort also being able to use two hands.
2. The sort of feedback that I'd like to integrate into this system would be a great feature for users and the natural response would be appreciated…
3. Ditto
4. They'd have a hand, increasing accessibility, function, etc.
5. It could be a cool hand!
6. It specifically acts like a hand
7. Their dream of having a hand comes true
8. The intent is that the prosthetic would behave naturally, being able to mirror what their natural hand would do. This setup would ideally be able to be trained to do just that.
9. The ML aspect of this, along with the feedback and natural movement will overcome barriers. It's designed to interact / communicate like a real hand.

5. Final Project Statement

PROJECT TITLE: Mind Controlled Prosthetic Fingers
PROJECT DESCRIPTION:

This project will be a research vehicle, recording data on the position of human fingers and myoelectric signals generated on the upper arm and forearm. It provides an invaluable source of data for prosthetics research as it gathers high granularity data on finger location using 16 accelerometers, and multiple sources of myoelectric data using surface-level electrodes. A simplified prosthetic of 4 fingers will also be developed as a sample output for the device.

The hand-monitoring system will consist of 16 accelerometers, each mounted its own small chip fastened to a glove that the test subject wears. Each segment of each finger will have a different accelerometer, along with one placed on the back of the palm and the base of the thumb. Most accelerometers can only be configured in one of two addresses. The MMA8453QT accelerometer will most likely be used and will be connected to the PCA9548A 8-channel I2C multiplexer allowing connection to the 16 accelerometers.

The myoelectric sensor from MyoWare will be used to monitor the electrical signals in the test subject's arm. The device will be built for interfacing with up to three different inputs at once, but for the purposes of this class, one MyoWare sensor will be used. In future development, the MyoWare sensor would be replaced with custom sensors providing multiple data inputs.

The output device will be up to 4 independent fingers with individual joints. They will have one axis of motion, providing a primitive approximation of the motion of a hand. For the purpose of this class, the prosthetic will be programmed to approximate the motion of the user's hand based on the accelerometer data rather than on the EMG data collected. The number of fingers developed will depend on price and availability of materials. Each prosthetic finger will consist of 3 servos, which will be a significant portion of the budget.

Within prosthetics research, many independent research projects have been conducted, primarily collecting their own set of data. This project will provide a research vehicle fit for collecting useful data for prosthetics research. This research will be used to develop accurate machine learning models capable of controlling prosthetics with intuitive control. Current prosthetics are on the cusp of becoming capable of responding fully to a user's intended motion, and data collected in this realm will promote the development of such prosthetics.

The benefits of having naturally responding prosthetics are obvious and life changing. When one loses a limb, they experience an irreversible change in their mobility and autonomy; simple tasks become difficult or impossible, often leading to mental health issues. These limitations can be mitigated by sufficiently functional prosthetics, restoring the ability to perform complex and delicate tasks. The full or partial loss of an arm severs the constant communication between one's brain and their intricate and invaluable hand. Many amputees experience this as a 'phantom limb' which can cause constant minor annoyance to excruciating pain. The patient's brain is still attempting to communicate with their missing limb, experiencing the lack of response as perception of movement, touch, pressure, temperature, or other possibly painful senses. It has been shown that visually tricking the patient into seeing their limb move naturally can mitigate these experiences. The brain is still processing stimuli that it believes to be coming from the limb, whether or not it actually is, and would positively react to a lifelike and naturally responding prosthetic.

There are a number of myoelectric prosthetics currently on the market, with varying degrees of functionality and responsiveness to human intention. The prosthetics currently available transition between a set of predefined grips and finger positionings. Some such prosthetics are the TASKA, the Hero Arm, the Bebionic Hand, and the i-Limb Quantum.

The TASKA is a robust hand prosthetic designed to be usable in many normal-life applications. It is waterproof and has built in measures to prevent damage to the fingers. The wrist has 3 positions that the user can set it in, and a motorized thumb. The fingers flex between different positions but have a number of grips that the user can cycle between with different buttons on the back of the hand. While this is a much more developed prosthetic than the one in the proposed project, the project aims to provide higher and more natural functionality.

The Hero Arm is designed as a cheaper and reliable lower arm prosthetic. It is 3D printed and prioritizes supporting the user's self-esteem. It has designs for kids such as Iron Man, BB8, and Elsa from Frozen. The arm has a total of 6 grips and shifts between them based on EMG data. It also provides haptic feedback giving the user some amount of sensory information from the arm. The proposed project will not provide feedback, but could be modularized to provide either haptic feedback or myoelectric response.

The Bebionic Hand by Ottobock connects to their various arm prosthetics providing some amount of natural motion. They have 3 different hand sizes and 14 different grip positions that the hand cycles between. Again, this prosthetic provides much more functionality in the mechanics of the hand prosthetic, but much less detailed control than the proposed project could provide.

The i-Limb Quantum by Ossur is similar to the above prosthetics. It is distinct in that it shifts between different grips based on how one moves the limb, using gesture data as well to control the grips. Similar to the proposed project, in only provides one axis of motion for the primary fingers but includes a multi-axis thumb.

As stated, this project will primarily be a data collection vehicle for developing the field of prosthetics. The device will monitor the independent position of each finger allowing machine learning models to be developed for the independent motion of each finger. This will help the development of future prosthetics that have a more natural response to user's intended motion.

6. Housing/Test Environment

For this project two test housings will be developed. First, the hand position monitoring glove will be constructed. The device will consist of a conventional glove, with the 16 accelerometer ICs attached to it in a static-discharging manner. Pairs of ICs will be connected in parallel, bussing back to the microcontroller. This will allow the device to select different IC pairs to communicate with via I2C, and select the proper device using the I2C multiplexer.

The second test device is the set of actual prosthetic fingers. Each finger will be constructed identically and will be controlled by three servo motors. The fingers will have the ability to flex individual joints whether by controlling (a) a pulley-based system with the servos in the base of the hand, or (b) by directly controlling servos in the fingers. Either system may be developed and will provide sufficient motion for the project.

The arm monitor for this project will consist of an IC that reads data from 3 electrodes on the user's arm and connects to the microcontroller. For this class the MyoWare sensor will be used, but in future a larger suite of electrodes would be integrated allowing multiple devices at once to read data from the user's arm.

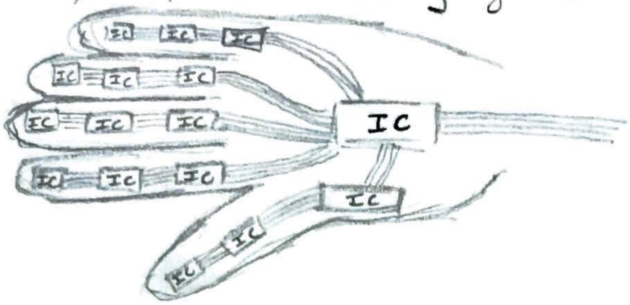
A simple test proving the functionality of the prosthetic would be to have the fingers mirror the position of the hand, based on the accelerometer data. This will provide a simple test for the ability to accurately position the fingers based on the internal representation of hand position data. Once some accuracy of the prosthetic fingers has been achieved, the project can implement the machine learning aspects. A crucial test to perform is to set up a data monitoring system which controls the communication between the micro and the computer. This will need to be functional both with the myoelectric sensors and either the glove or prosthetic hand. Data collection is the primary purpose of the device, meaning that an accurate ability to record appropriate data is crucial.

Once the individual components of the system have been tested and a preliminary amount of data has been collected, the final proof-of-concept test can be run whereby the accelerometer glove is removed and the prosthetic fingers are controlled solely by the myoelectric data coming from the users arm.

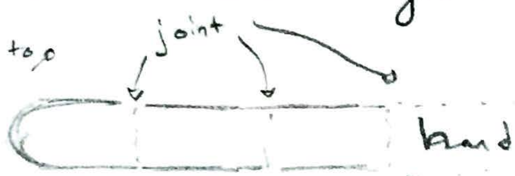
Jack Reany	ENGE 420	2020-02-08

Housing/Test Environment

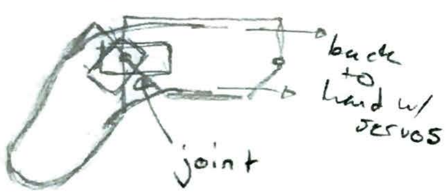
1. Hand position monitoring glove



2. Prosthetic Fingers

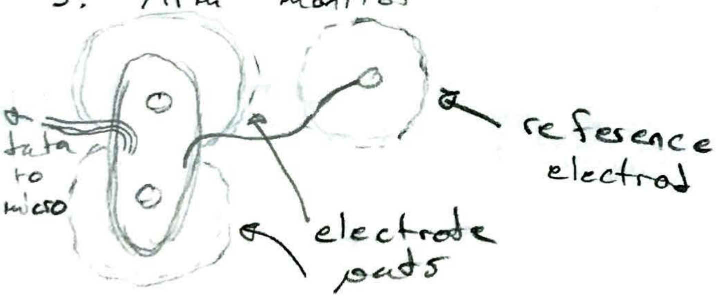


a) pulleys (side)



b) motors (side)

3. Arm monitor



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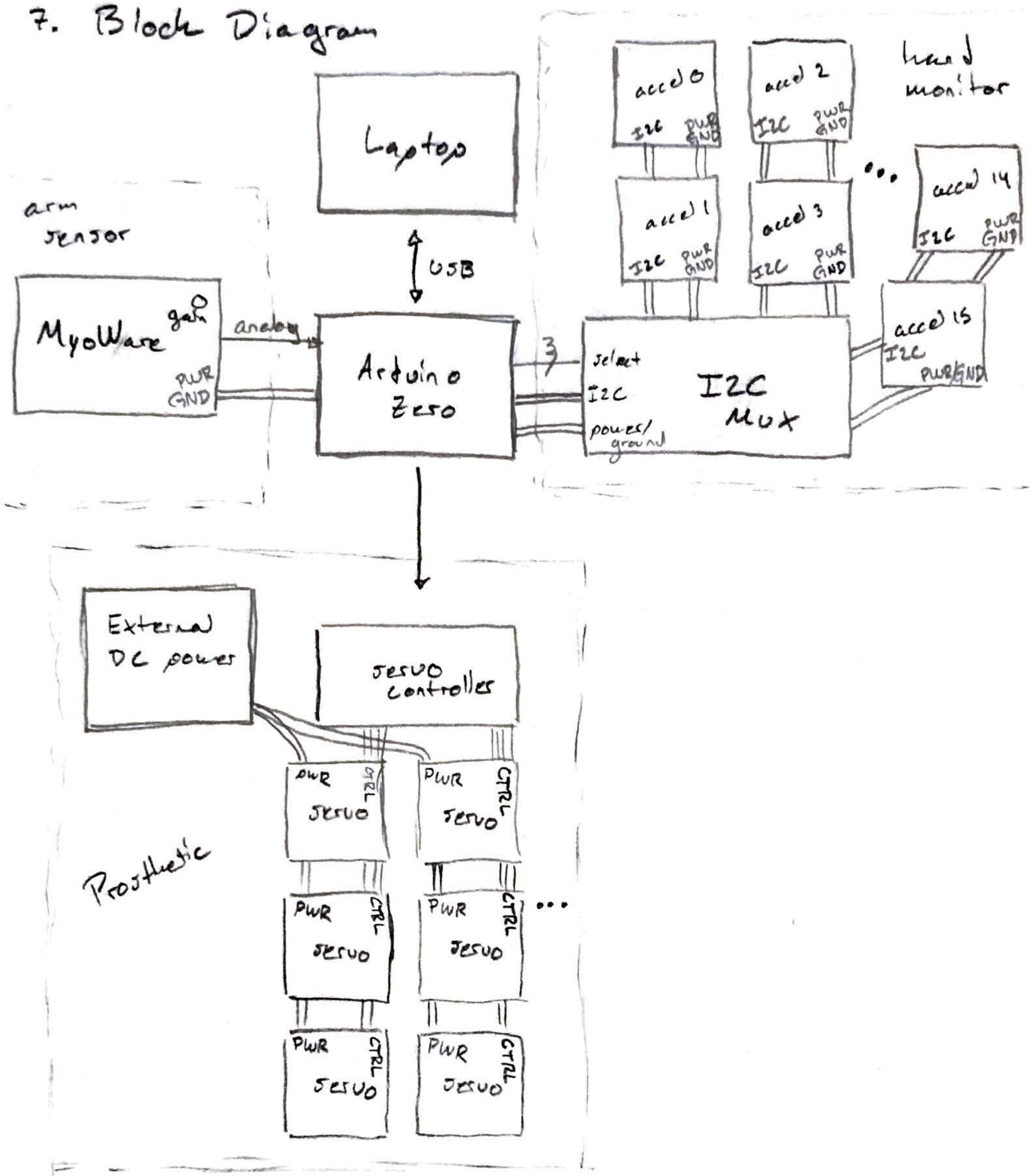
7. Block Diagram



8. Application Programming Interface (API)

1. `void set_i2c_mux(uint8 addr);`

    `Configures the i2c mux channels.`

2. `uint8 read_accelerometer(uint8 id, uint16* accel_data);`

    `Sets the correct MUX address and begins the accelerometer read, returns i2c status`

3. `uint16 read_emg(uint8 id);`

    `Reads the attached emg source.`

4. `uint8 set_servo(uint8 id, uint16 angle);`

    `Sets the specified servo angle, returns i2c status.`

5. `uint8 send_data(uint16* data);`

    `Begins a serial output of the current recorded data, returns serial status.`

9. Bill of Materials (BOM) / Budget

Part #	Description	Quantity	Price per Unit	Total Cost
SEN-13723	MyoWear EMG analog sensor	1	37.99	37.99
B01AME7YC0	RedDot EMG Electrode pads (100 per unit)	1	15.74	15.74
PCA9548AD,118	NXP 8-channel I2C multiplexer	1	1.84	1.84
KX003-1077	Rohm Semiconductors 3-axis I2C accelerometer	16	1.07	17.17
M20-9980346	2x3 pin header male	25	0.229	5.73
M20-9990345	1x3 pin header male	16	0.165	2.64
2094506	1x2 screw terminal	1	0.49	0.49
B00D57XC9Q	2x3 pin header female (25 pack)	1	8.65	8.65
B007R9SQQM	10-wire ribbon cable (15 feet)	1	6.87	6.87
AOD417	Reverse Voltage Protection Transistor	1	0.47	0.47
LM340SX-5.0	5V Linear Regulator	1	1.48	1.48
PCA9685PW,118	16-channel LED/Servo driver	1	2.26	2.26
B07L2SF3R4	Servo Motors (10 pack)	2	18.88	37.76
Total				139.09

10. Daily Journal

2020-01-13 – First day of class. The professor inspired me to do my absolute best to make this project the greatest thing the world has ever seen. Man, I love this professor! I am so excited about this class! I look forward to journaling each day the exciting things that I am learning.

2020-01-14 – First lab. Altium sucked so bad we didn't even use it (licensing errors for some reason). I did research on the first 6 or so comparable products.

2020-01-15 – Class period spend working on the first lab. I got the ATMEL 28P3 entered and am partially done with the Grayhill part. Ended on step 16 of "Create the Grayhill 76SB04T footprint."

2020-01-17 – Worked on Lab 1. I completed the Grayhill 3D extrusion and created the symbol for it. Next I will work on the ATmega168V symbol.

2020-01-20 – Worked on Lab 1 from 6:30 am to 1 pm. Completed the entire lab.

2020-01-21 – Worked on Lab 2 in class. Completed 2 of the 3 SCAMPER exercises and pulled my weight for the last person's SCAMPER via Google Docs.

2020-01-22 – Went over the BOM for the Traffic Light board talking through all the components, electrical design logic and powering / protecting board components.

2020-01-24 – Went over level shifting circuits using a diode and a transistor. Looked into different part libraries.

2020-01-25 – Finished section 4 of this document.

2020-01-27 – Researched the ESP8266EX shield, had to leave early for mandatory club fair presence.

2020-01-28 – Worked on ESP8266 Shield in Lab, only partially completed the board.

2020-01-29 – Went over the ESP8266 Shield demo project, continued Shield development.

2020-01-31 – No class, worked on routing shield components

2020-02-03 – Talked about Level Shifting for the LED shield, finished routing ESP8266 shield, but forgot to turn it in.

2020-02-04 – Began work on the LED shield. Mostly was successful finding parts needed for shield, working on getting LED footprint.

2020-02-05 – Went over the design review checklist in class.

2020-02-07 – Remembered to turn in lab 3! Went over different electronics components and the pros / cons of different capacitors. Almost completed section 5 of this document.

2020-02-08 – Completed sections 5, 6, and 7 of this document.

2020-02-10 – Went over power regulators. Finished routing Lab 4 board. Fabbing ESP board failed, routing issue

2020-02-11 – Completed design review checklist. Finished redesign.

2020-02-12 – Submitted Lab 4 board for printing. Started over ESP fab, out of ink.

2020-02-17 – Fabbing Lab 3 board 9 or 10 hours, untested but all pins seem to connect. Realized some last minute redesign was stupid and the ESP shield now sits over the digital pin headers.

2020-02-18 – Bless the Lord the board works. Completed Lab 6 – connecting the ESP shield to the wifi and getting it to control the status LED on the Zero. Realized I soldered the ISP header on upside down, but it works fine :)

2020-02-19 – Going over Google Sites, the Rainbow Spreadsheet, and the Gitlab. Approx. budget of $100 - $150. Digikey, Mouser, Amazon, McMaster-Carr. VERSON CONTROL!!! Setting up Git Repo.

2020-02-21 – Parts research, ordered analog components, looking into I2C components (MUX & Accelerometer)

2020-02-24 – Serial Communication Setup. Writing Python script to interface with Arduino, setting up communication protocol.

2020-02-25 – Accelerometer board design. First draft completed. Need to shrink width.

2020-02-26 – Resized Accelerometer board successfully and continued documenting chip design. Still need to add mounting holes.

2020-03-13 – Got Altium set up on my laptop so I can work remotely during the Corona shindig.

2020-03-13 onward: Altium Libraries did not work once moving off campus. I eventually pulled directly from the SVN repository source and downloaded the files I needed. I developed the I2C to Serial forwarding protocol and simulated hardware. Progress on the project was made steadily throughout the time away from campus, with many full days spend developing the I2C based drivers of the various components once the I2C to Serial driver was functional.