EMG Computer Interface

CDR - SDP Team 12

University of Massachusetts Amherst
BE REVOLUTIONARY™

Revised Problem Statement

We want to emphasize touchless options for computer interfaces

While there are many products that allow for **touchless interactions** with computers, there are no comprehensive and easily customizable gestures interfaces that allow the user to **navigate and interact with a computer** without touching any common screens or buttons.

WHERE? → **WHAT?**

Academic, Company, Organization Campuses → Presenting, Transactions, Lecturing

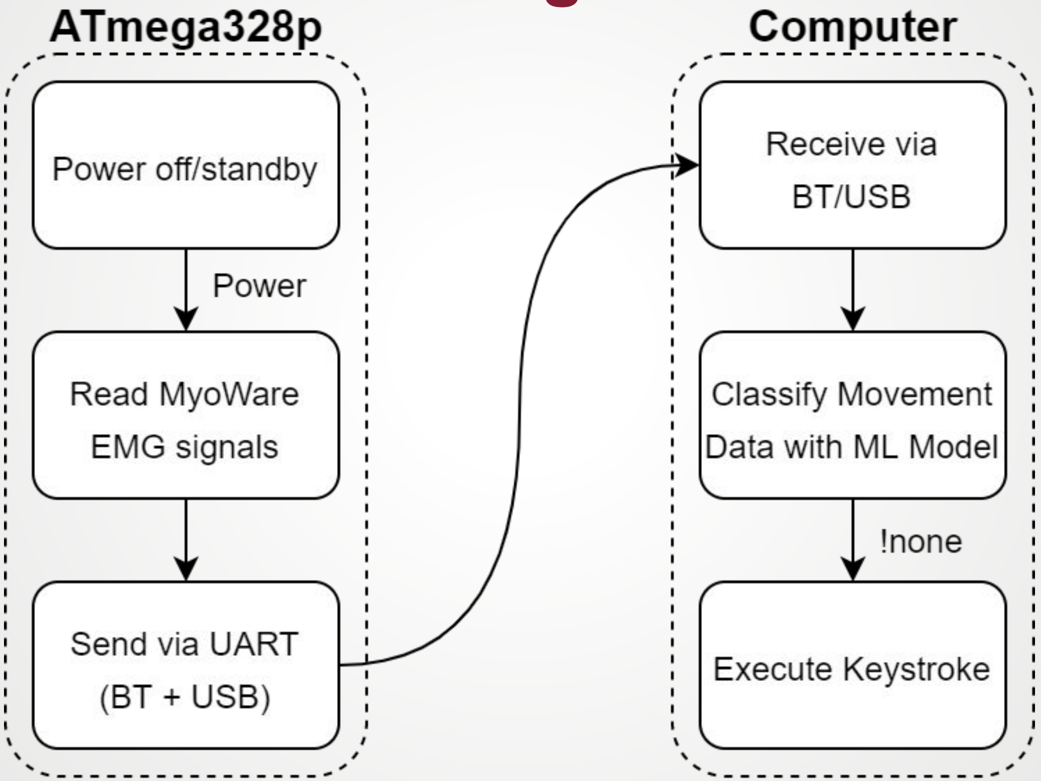
Updated Interface Specification & Verification Plan

Requirement	Description	Verification
Sensing Accuracy/Gesture Recognition	Sensing system will translate and transmit inputs with better than **90% true positive/negative** and less than **10% false positive/negative** rate for **5 distinct gestures**. I.e. Fist, thumbs up, pointing	Test that the sensing system can meet true positive/negative and false positive/negative percent specifications over 100 trials for each gesture
Reliability	Performance of the device must be consistent regardless of changes in between use	Demonstrate that **Sensing Accuracy** verification holds when pads are intentionally misplaced and across three different users
Pre-Input Time	The time between stepping in front of an interface and inputting commands **will be less than 1 minute**	Test that pre-input connection time is on average less than a minute over 100 trials
Power Consumption	The device should have sufficient battery life to last throughout a work day and be in **active use for three hours**	Demonstrate that device can be actively used for at least three hours by measuring current draw

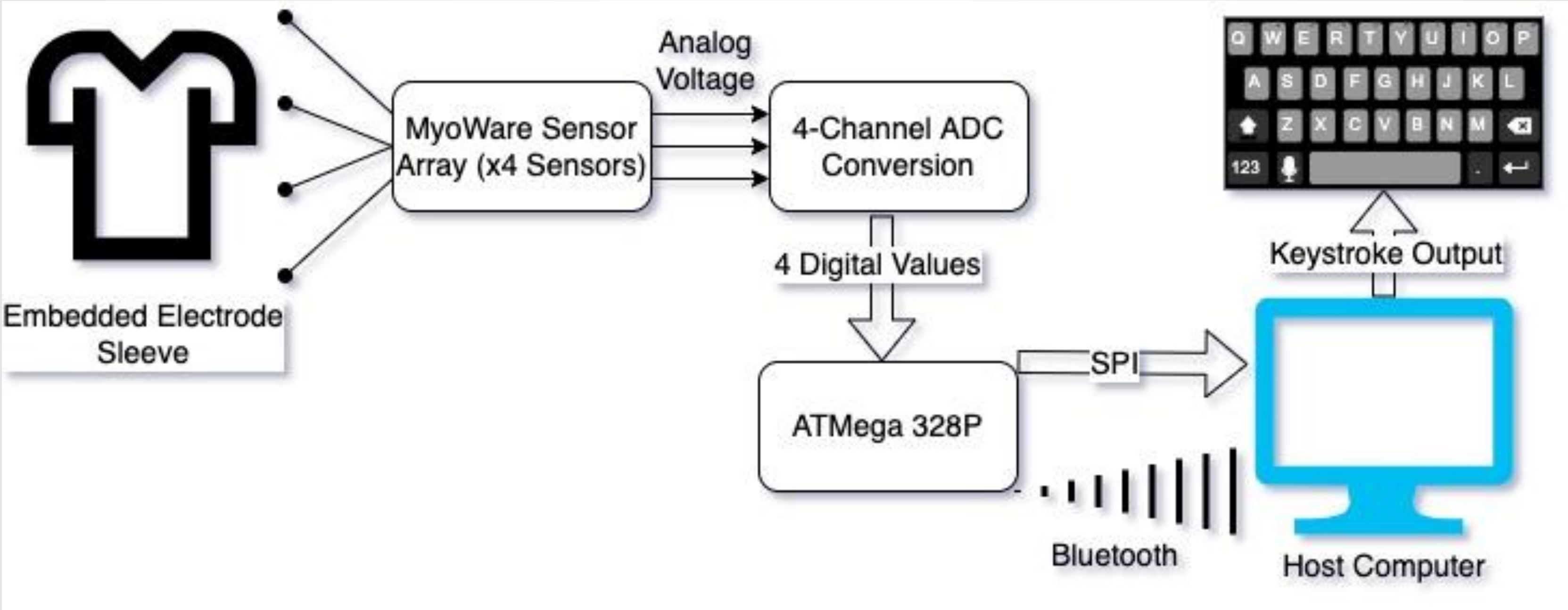
Updated Physical Specification & Verification Plan

Requirement	Description	Verification
Ergonomics	User must be capable of writing on paper and utilizing phone while wearing device	Demonstrate the ability to write a paragraph and utilize a cellphone to make a call
Interface Distance	User must be capable of utilizing device to interface with a computer **up to 3 meters away**	Demonstrate the ability to connect device and use from multiple distances (3 increments) up to 3 meters away from the computer
Customizability	Allow **custom mapping of up to 5 human movements to distinct inputs**	Verify that all keyboard inputs can be custom bound to distinct movements (each finger and any finger combination)

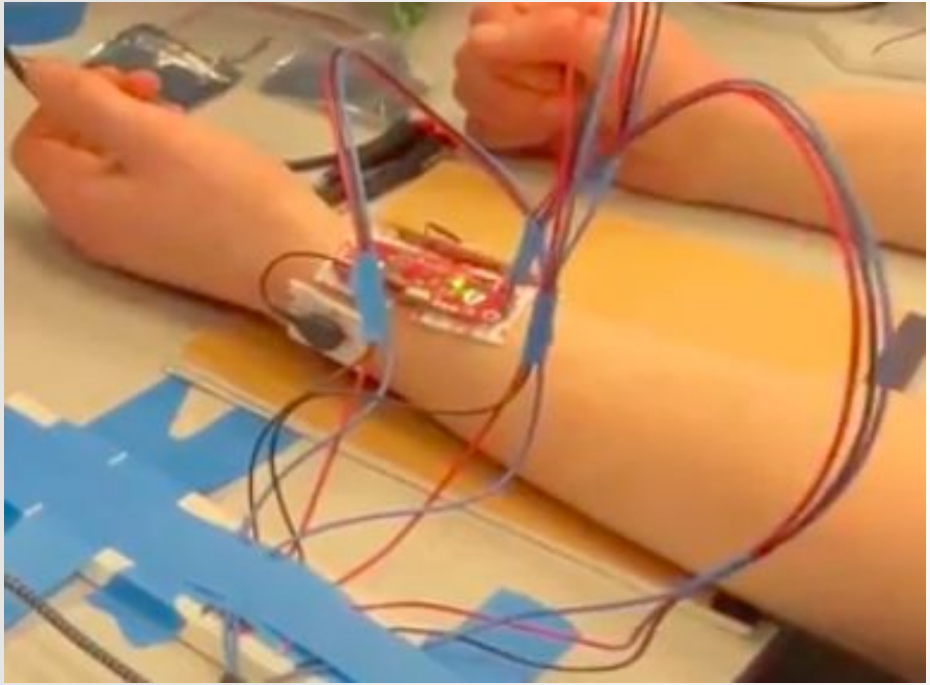
Updated Software Block Diagram



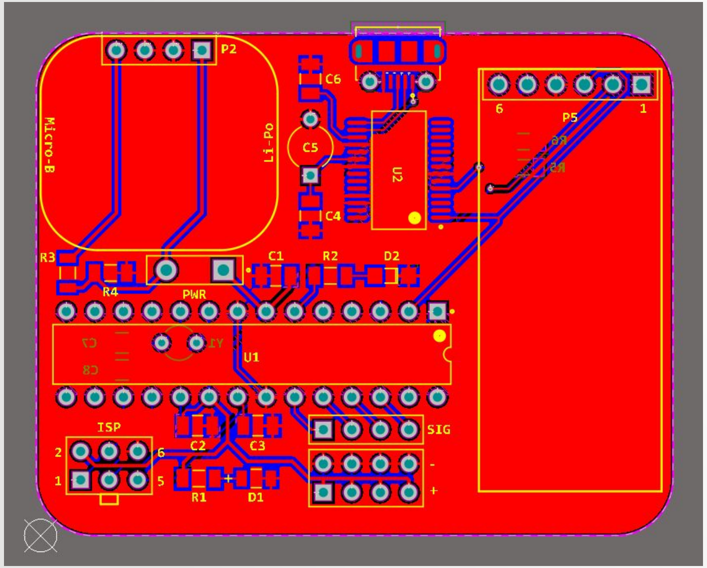
Updated Hardware Block Diagram

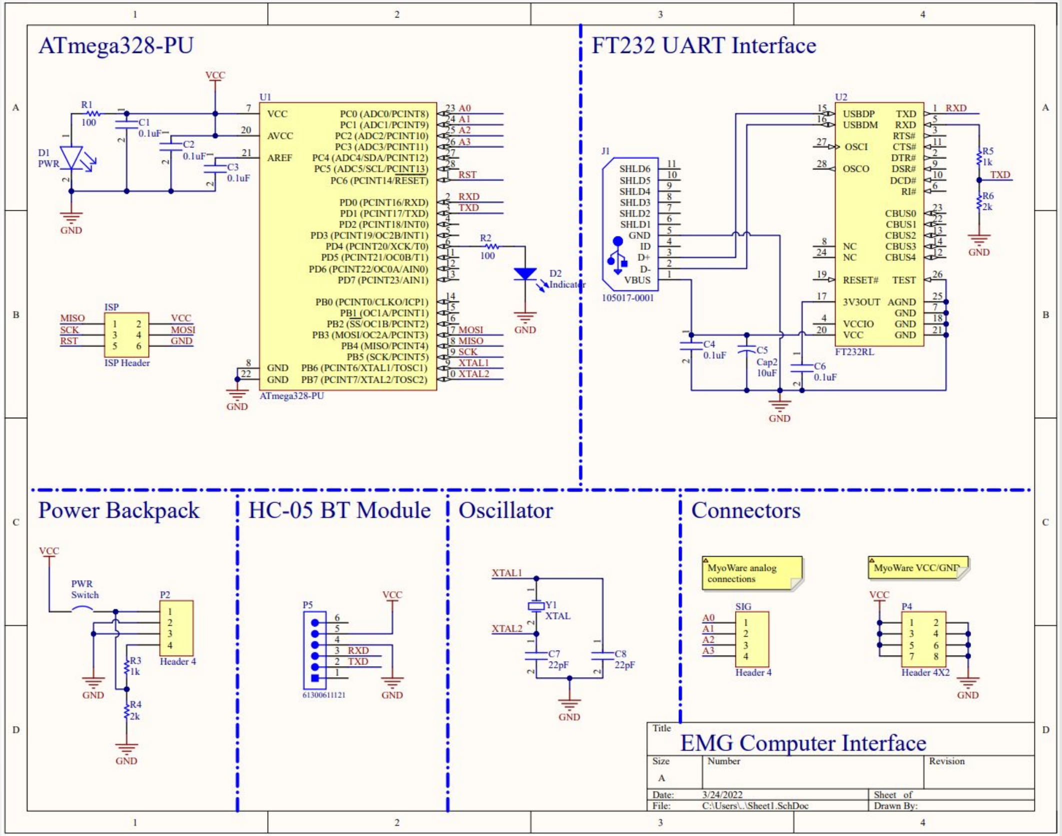


Sleeve Design Process

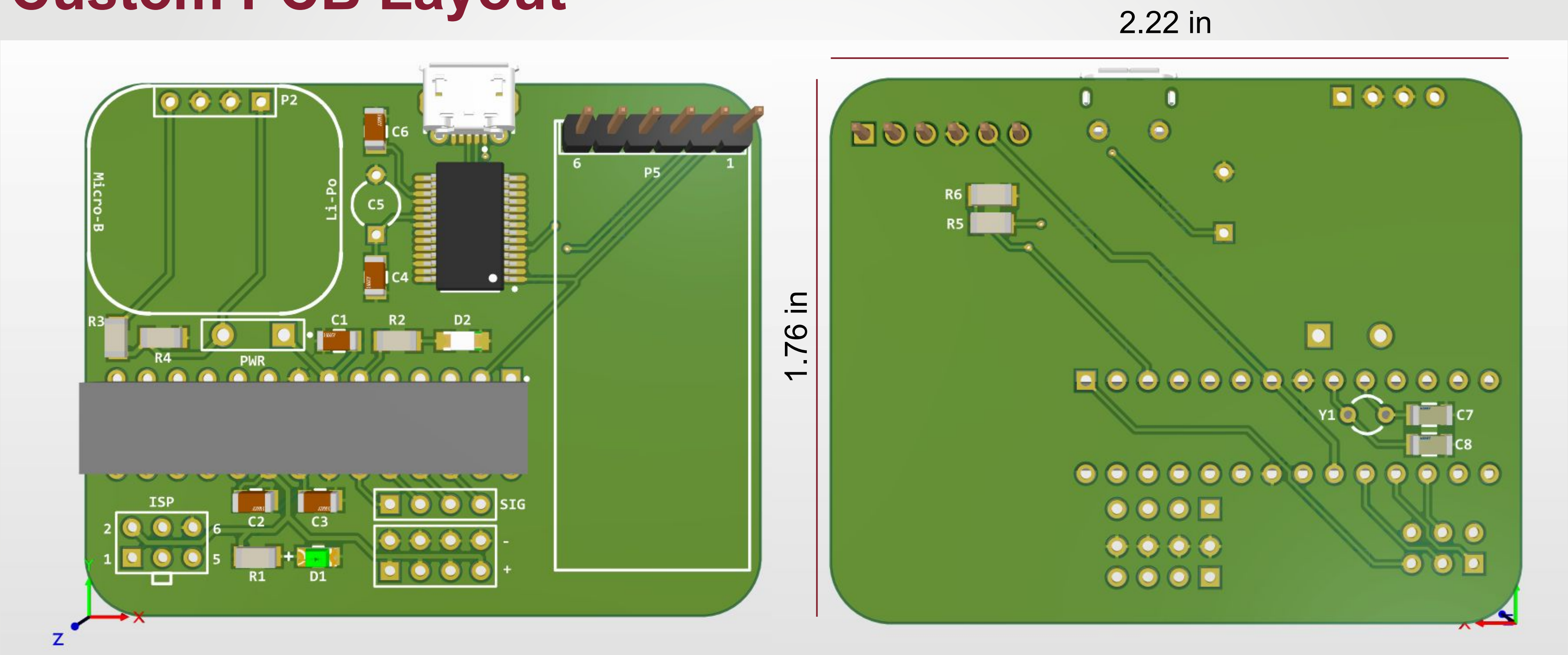


Custom PCB Design





Custom PCB Layout



Our CDR Deliverables

- ✓ **Implement machine learning to classify 3 motions with ~85% accuracy**
  - Python machine learning can classify 4 distinct motions (includes “none”) when fed live data with >85% accuracy
- ✓ **Reusable and ergonomic electrode sleeve**
  - Reusable EMG electrode pads incorporated into a sleeve
- ✓ **Switched from Arduino-based processing to C code on 328P**
  - No longer using default Arduino libraries to send sensor data over Bluetooth
- ✓ **Switched hardware to full proto-board**
  - The hardware was moved from Arduino, to a full protoboard (mock of our PCB)

Our Still-To-Achieve Deliverables for FPR

Implement machine learning to classify 5 motions with >90% accuracy

Need to expand training dataset to incorporate more gestures/motions and increase training dataset size

Reliable Sleeve

Improve the reliability of the sleeve implementation

Incorporate battery system and Bluetooth in final PCB

The battery recharge system and Bluetooth modules have been incorporated into the proto-board

Develop Host GUI

Allows seamless training data collection and model prediction, and allows user to customize gesture to keybinding

The “Theoretical Precision” of ML

RMS Model

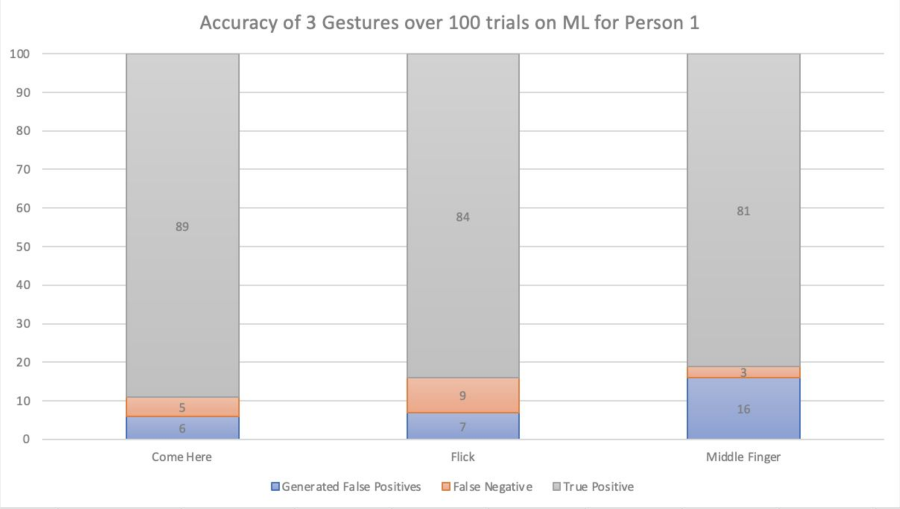
```
[[20  0  0  0]
 [ 0 27  0  0]
 [ 1  0 22  0]
 [ 0  2  0 80]]
              precision    recall  f1-score   support

   come_here       0.95      1.00      0.98        20
       flick       0.93      1.00      0.96        27
      middle       1.00      0.96      0.98        23
        none       1.00      0.98      0.99        82

    accuracy                           0.98       152
   macro avg       0.97      0.98      0.98       152
weighted avg       0.98      0.98      0.98       152
```

Raw Model

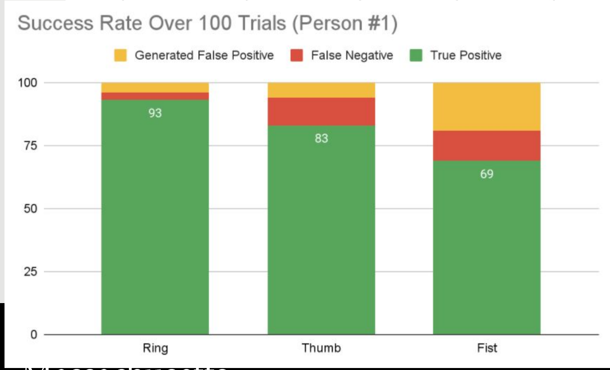
```
[  27    0    3    1]
[   0   29    0    0]
[   2    0   52   14]
[   0    1    6 2893]]
              precision    recall  f1-score   support

   come_here       0.93      0.87      0.90        31
       flick       0.97      1.00      0.98        29
      middle       0.85      0.76      0.81        68
        none       0.99      1.00      1.00      2900

    accuracy                           0.99      3028
   macro avg       0.94      0.91      0.92      3028
eighted avg        0.99      0.99      0.99      3028
```

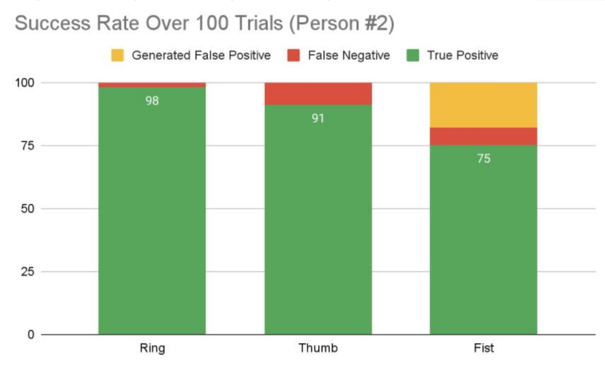
~30,000 Raw EMG Signal points ~1350 RMS Training points ~150 RMS Testing Points

The “Actual Precision” of ML



← Precision for 3 gestures using RMS/ML





← Precision for 3 gestures using Threshold from MDR

Budget Breakdown

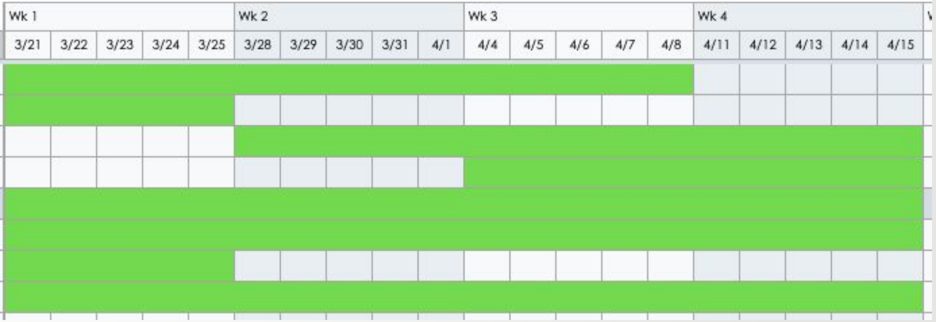
Generic Name	Specific Name	Cost	MDR or FPR
Reusable EMG Electrodes (80 count)	n/a	$15	Both
Sleeve Components	Tape, Snap-pins, Reuseable Pads	$15	Both
	Cables, Cable Shields	$10	FPR
Bluetooth Module (2 count of each)	HC-05	$10	Both
USB-to-Serial Breakout	FT232RL	$25	FPR
Rechargeable Battery Setup	2124 Battery Backpack	$20	Both
MDR Components (Op Amps, Resistors, Capacitors, etc.)	Misc.	$10	MDR
Myoware Sensor (4 count)	Sparkfun Myoware Sensor	$160	Both
	Additional Myoware 2.0 Sensors	$80	Both
Electrodes (120 count)	Versa-Trode Electrodes	$36	Both
Onboard Components (Op Amps, Resistors, Capacitors, etc.)	Misc.	$30	FDR
PCB	TBD	$60	FDR
TOTAL COST		**$471.00**	

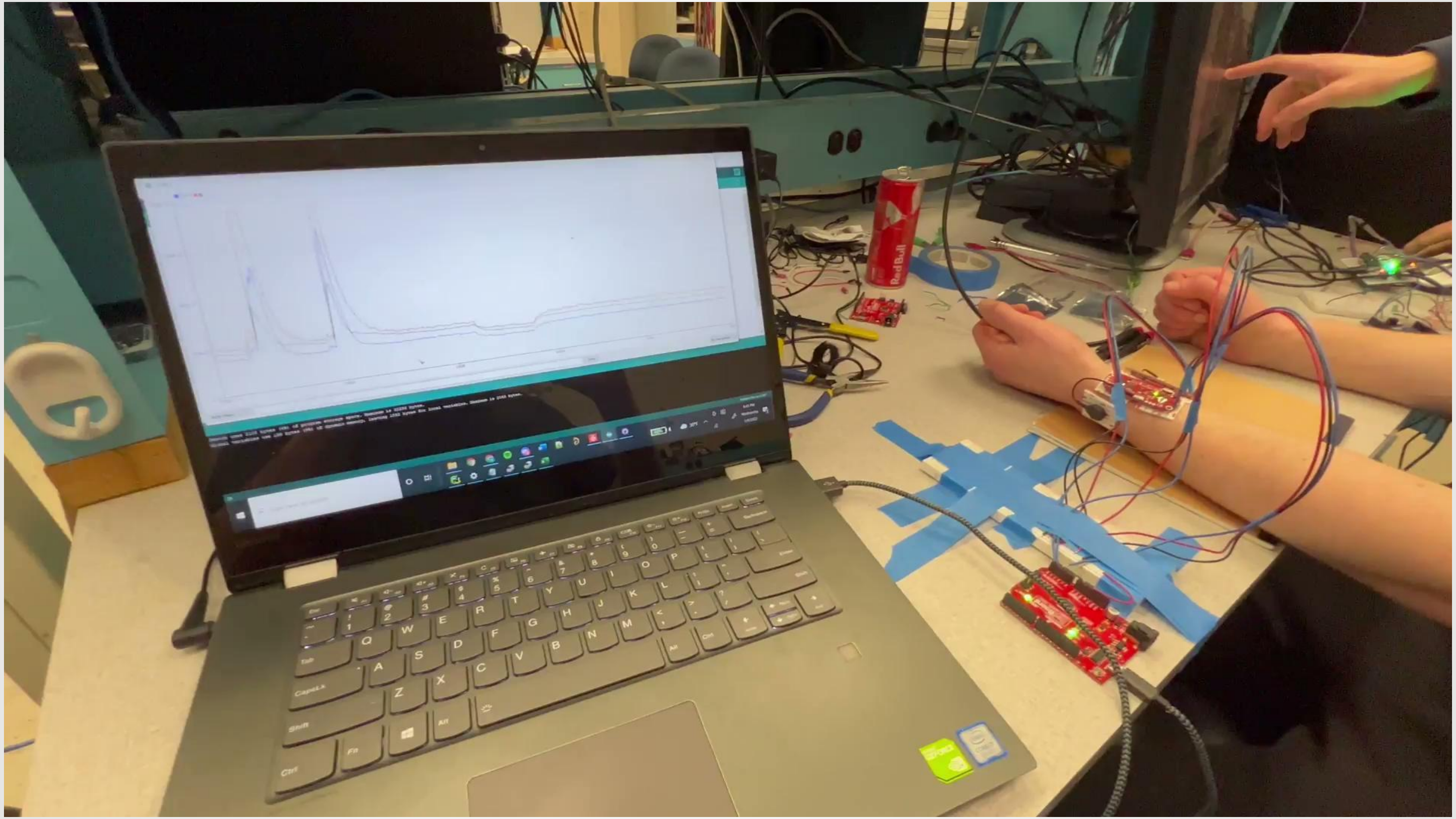
Gantt Chart

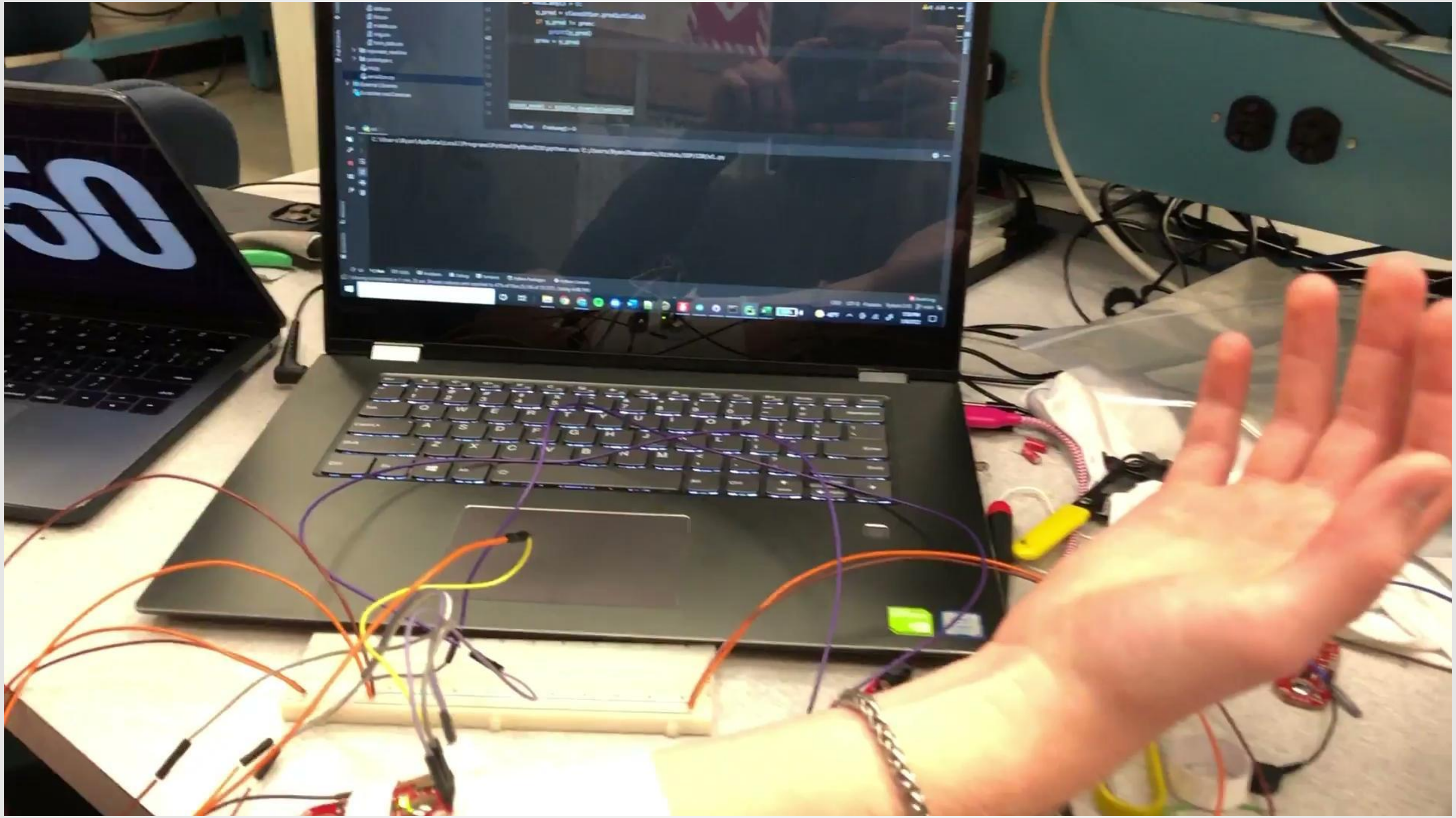
PROJECT			START DATE		
FPR Presentation			Monday, March 21, 2022		<--

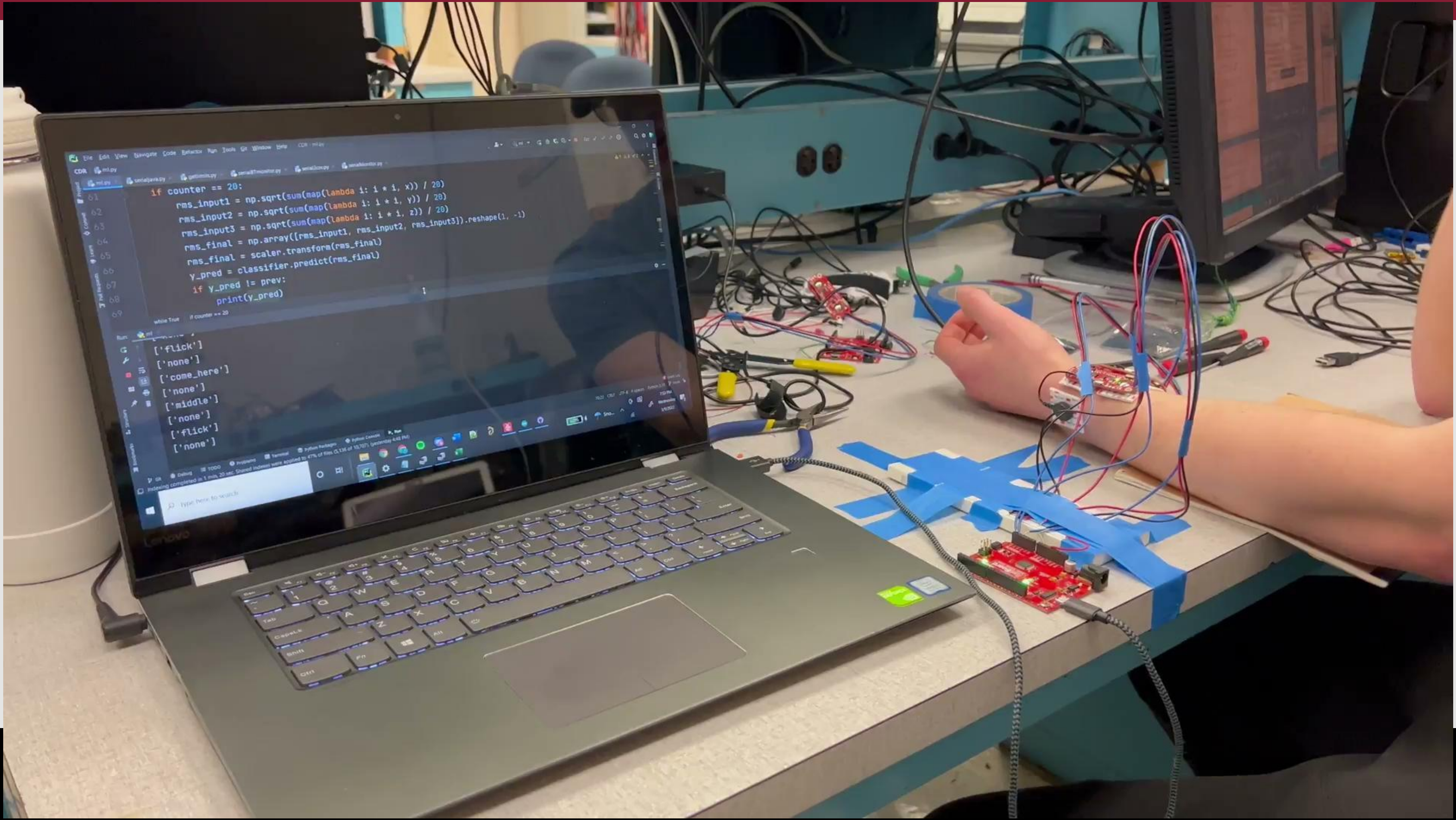
User to complete non-shaded fields only.

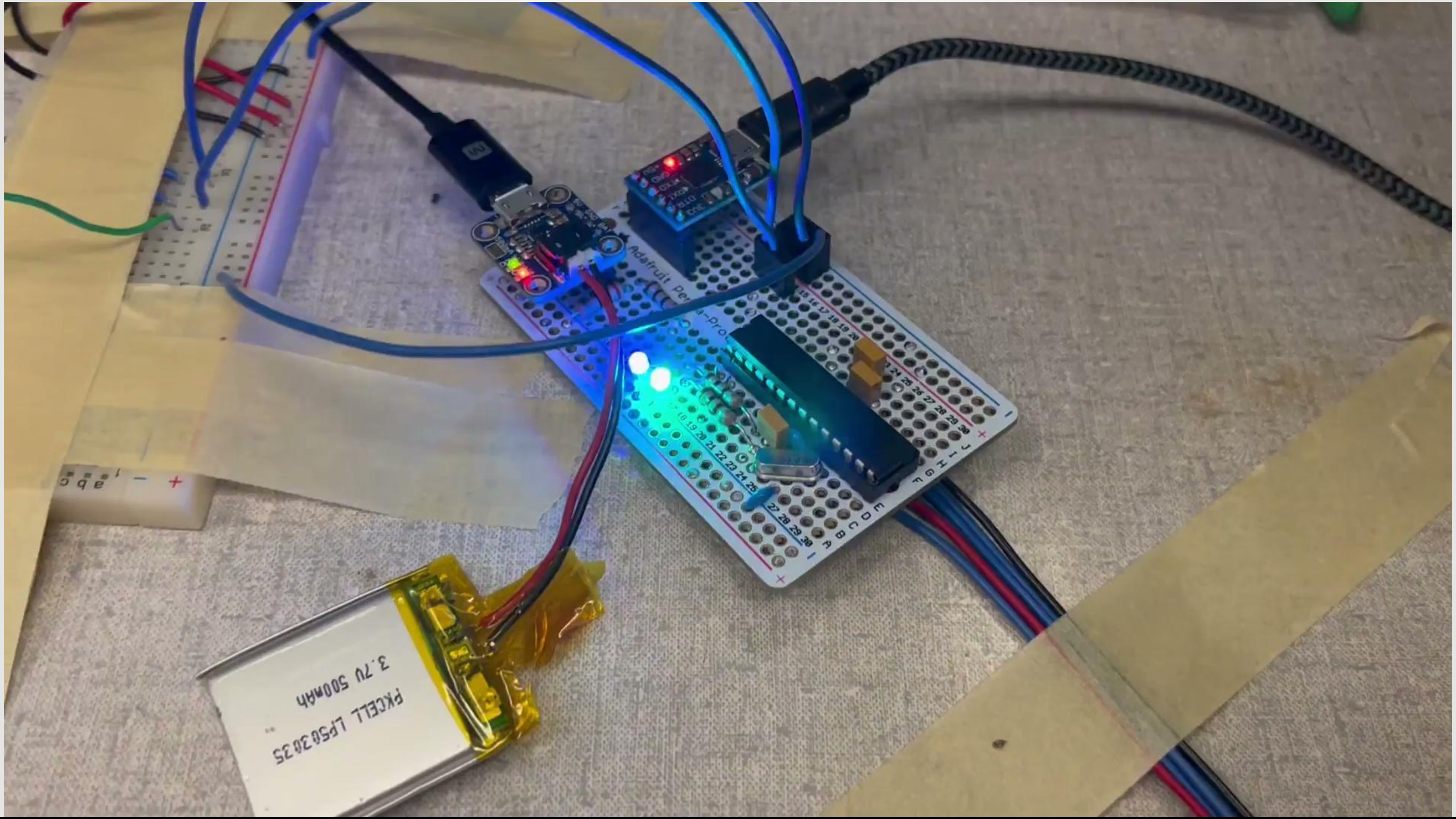
TASKS	TASK OWNER	STATUS	START DATE	END DATE	DAYS
PCB Verification	Sam	In Progress	03/21/22	04/08/22	15
Implement Bluetooth Module into Protoboard	Ryan	In Progress	03/21/22	03/25/22	5
Expand Training Dataset	Berke	In Progress	03/28/22	04/15/22	15
Create Sensor Array Holder	Aidas	In Progress	04/04/22	04/15/22	10
Software			**11/01/21**	**04/15/22**	**120**
Host GUI (Data collection, customized gestures)	Berke	In Progress	11/01/21	04/15/22	120
1-Way Bluetooth Communication	Ryan	In Progress	03/21/22	03/25/22	5
Expand ML Model	Sam	In Progress	03/21/22	04/15/22	20








if counter == 20:
rms_input1 = np.sqrt(sum(map(lambda i: i * i, x)) / 20)
rms_input2 = np.sqrt(sum(map(lambda i: i * i, y)) / 20)
rms_input3 = np.sqrt(sum(map(lambda i: i * i, z)) / 20)
rms_final = np.array([rms_input1, rms_input2, rms_input3]).reshape(1, -1)
rms_final = scaler.transform(rms_final)
y_pred = classifier.predict(rms_final)
if y_pred != prev:
print(y_pred)
['flick']
['none']
['come_here']
['none']
['middle']
['none']
['flick']
['none']


FKCELL LP503035
3.7V 500mAh

Thank you

Questions?