Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

ECEN 404 Final Presentation
Team 61: Driver Drowsiness Detection

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Sponsor: John Lusher
TA: Max Lesser

Problem Overview

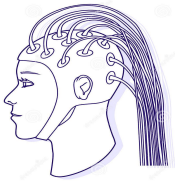
Problem:
Driving fatigue has been a major cause of accidents on the road. Truck drivers are at a greater risk of driver fatigue because of the long hours spent driving.

Solution:
Our Driver Drowsiness Detection System will use a machine learning (ML) algorithm and electroencephalogram (EEG) device to determine a driver's level of fatigue and alert the driver to rest.

Project Diagram

EEG

- Filter out unwanted frequencies.
- Take in brain waves in microvolts and amplify them to volts.
- Send data to MCU



MCU

- Receive incoming signals from EEG
- Send data to computer running ML algorithm

Dakota

Simulator

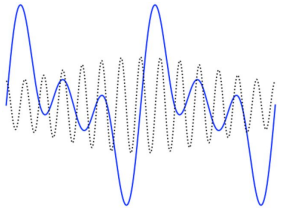
- Collect data
- Muse 2 EEG device

Signal Processor

- Perform live analysis of signals
- Process raw EEG signals

ML Algorithm

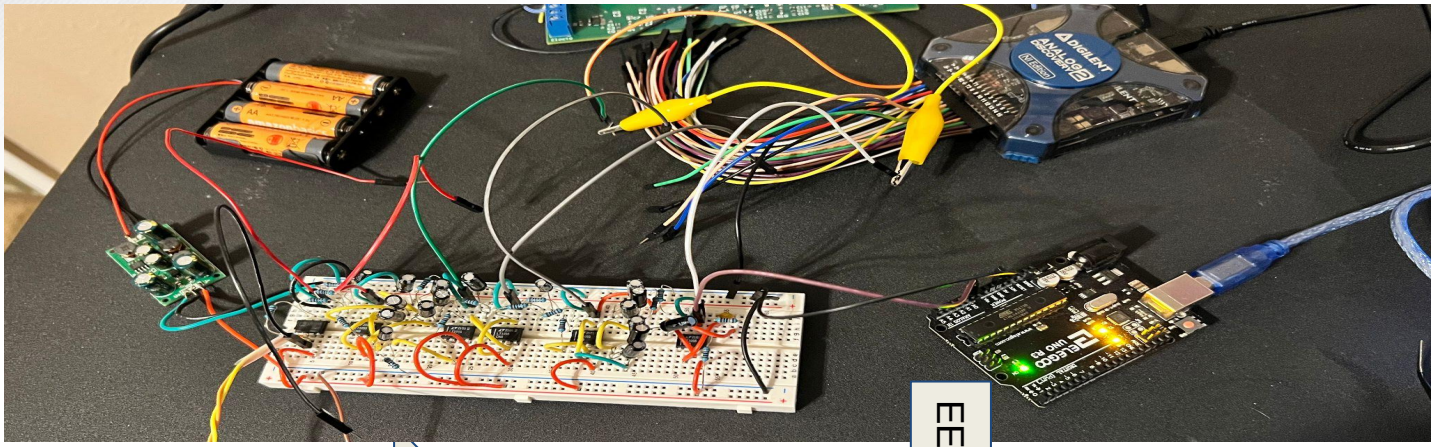
- Input processed EEG signals
- Output fatigue state of user

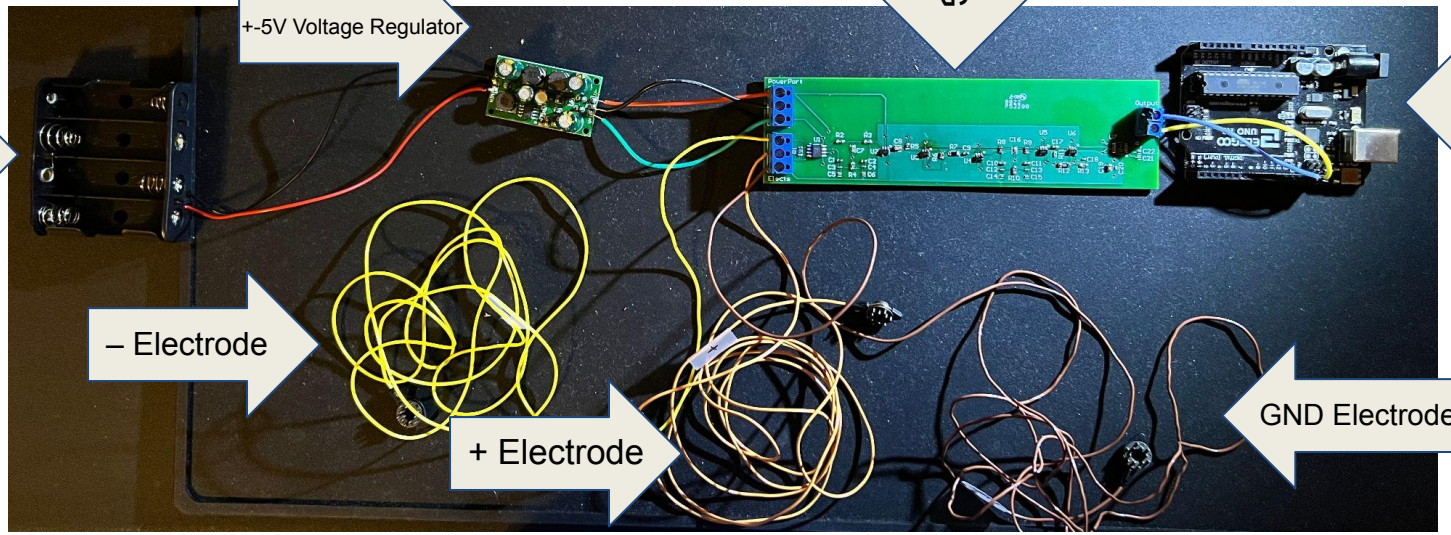


Team 2: Coady and Ali

Project Photos

Project Photos: EEG





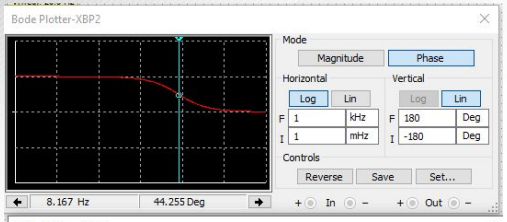
EEG System Accomplishments

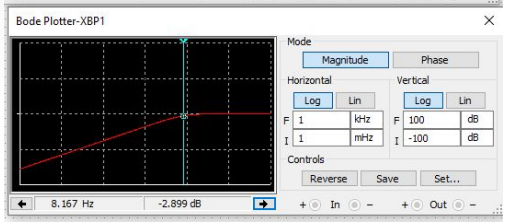
Specification	Details	Result
Designed Simulated Circuit for Initial Testing	Developing a series of Highpass, Lowpass and Notch filters to clean noise from signal	Pass
Breadboarding Prototype	Amplify milivolt signal to volts for more accurate visualization	Pass
PCB Design	Create EEG as a PCB for final product	Pass*
Establish Serial Communication with MCU	Using I2C bus to send analog voltages to the MCU for processing, then sends to excel sheet	Pass

Pass*: Not fully functional, will explain ahead.

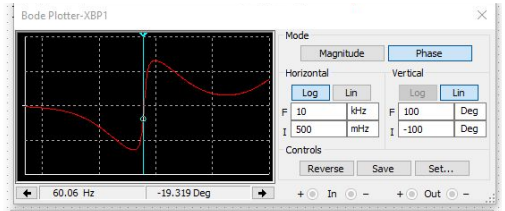
EEG System Simulation

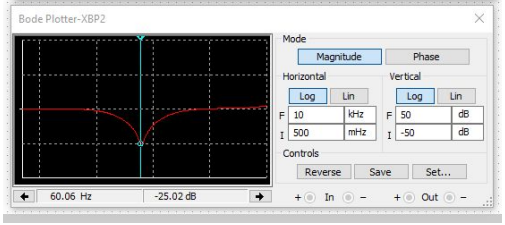
8 Hz HPF



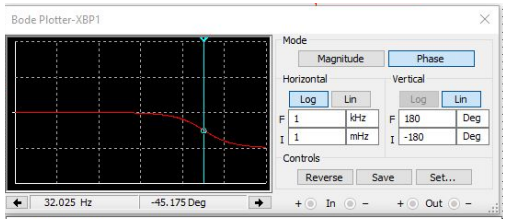


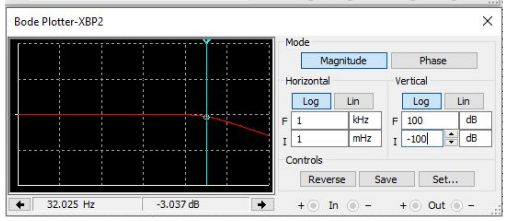
60 Hz Notch Filter

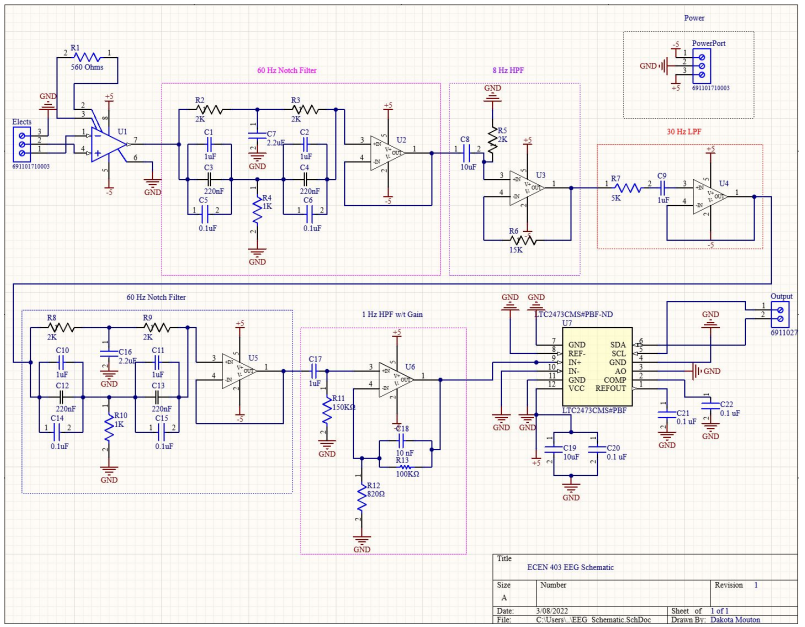




32 Hz LPF

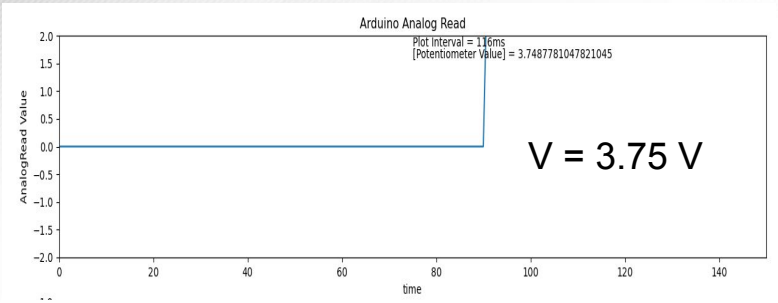






EEG System PCB Results

Analog Voltage Reading



- Might be a shorting issue or bad connection.

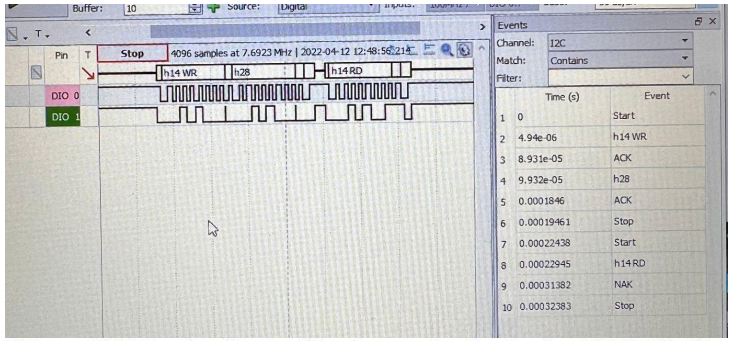
Excel Datasheet

	0
0	3.753666
1	3.753666
2	3.753666
3	3.753666
4	3.753666
5	3.753666
6	3.753666
7	3.753666
8	3.753666
9	3.753666
10	3.753666
11	3.753666
12	3.753666
13	3.753666
14	3.753666
15	3.748778
16	3.753666
17	3.753666
18	3.753666
19	3.753666
20	3.753666
21	3.753666
22	3.753666
23	3.753666
24	3.753666
25	3.753666
26	3.753666
27	3.753666
28	3.748778
29	3.753666
30	3.753666
31	3.753666
32	3.753666
33	3.753666
34	3.753666
35	3.753666

Hand Measured Voltage Across Circuit

Positive Electrode Voltage:	0.736 V	
Negative Electrode Voltage:	0.756 V	
U1 Postivie Input:	0.8 V	
U1 Negative Input:	0.758 V	
U1 Output:	0.590 V	
U2 Input:	0.580 V	
U2 Output:	0.576 V	
U3 Input:	0.009 V	neg
U3 Output:	0.008 V	neg
U4 Input:	0.005 V	neg
U4 Output:	0.065 V	
U5 Input:	0.069 V	
U5 Output:	0.171 V	
U6 Input:	0.005 V	neg
U6 Output:	4.3 V	
ADC Input:	4.41 V	
SDA Line:	3.75 V	
SCL Line:	3.75 V	

Logic for ADC



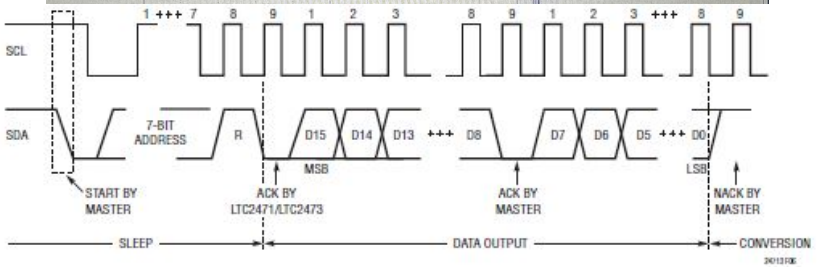


Figure 6. Read Sequence Timing Diagram

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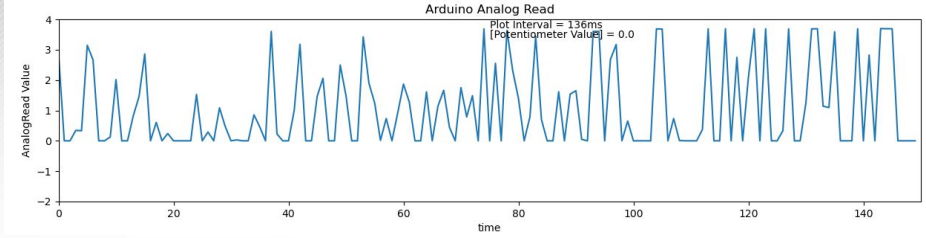
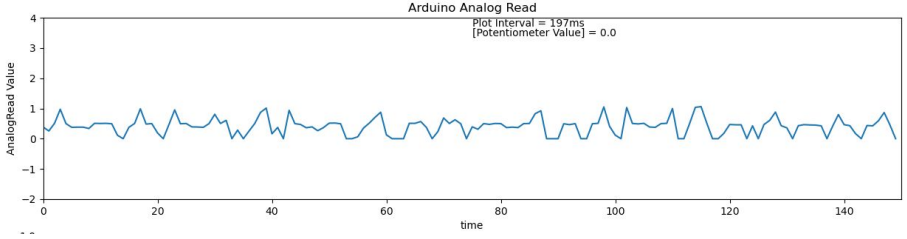
EEG System Breadboard Results

Analog Voltage Reading



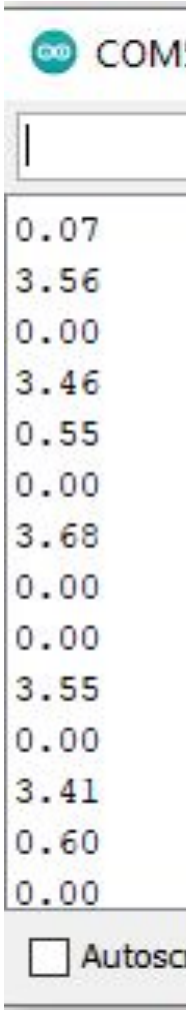
Analog Voltage Reading (after 10 mins)



Hand Measured Voltage Across Circuit

Location:	DC		True RMS	AC RMS
Positive Electrode Voltage:	0.011 V		0.300 V	0.300 V
Negative Electrode Voltage:	0.004 V	neg	0.110 V	0.110 V
U1 Output:	0.390 V		3.9 V	3.9 V
U2 Output:	0.180 V	neg	0.622 V	0.612 V
U3 Output:	0.020 V	neg	0.600 V	0.600 V
U4 Output:	0.021 V	neg	0.240 V	0.240 V
U5 Output:	0.029 V	neg	0.065 V	0.058 V
U6 Output:	1.24 V		0.513 V	0.447 V

Arduino IDE Data



0.1 V - 3.7 V

Excel Data

	0
0	0.488759
1	0
2	0
3	1.632454
4	0
5	2.947214
6	1.617791
7	0
8	1.089932
9	1.744868
10	0
11	0.654936
12	2.179863
13	0
14	0.982405
15	0
16	2.062561
17	3.113392
18	0
19	0.752688
20	3.347996
21	1.901271
22	0.562072
23	3.690127
24	0.171065
25	3.010753
26	1.676442
27	0.347019
28	0.40567
29	0
30	0
31	0.782014
32	1.246334
33	0.034213
34	0
35	0

0.02 V - 0.54 V

Excel Data (after 10 mins)

	0
0	0
1	0
2	0.542522
3	0.527859
4	0.503421
5	0.312805
6	0
7	0.01955
8	0.56696
9	0.537634
10	1.109482
11	0.513196
12	0.342131
13	0
14	0
15	0.542522
16	0.503421
17	0.527859
18	0.200391
19	0.351906
20	0.332356
21	0.537634
22	0.537634
23	0.821114
24	0.835777
25	0
26	0.239492
27	0.322581
28	0.513196
29	0.542522
30	0.537634
31	0.078201
32	0
33	0

EEG System Challenges/Solutions

Challenges:

- Losing MCU subsystem team member.
- Getting the I2C protocol to connect and communicate with the arduino board for send the ADC data.
- Possible shortage or disconnect between the PCB IC'S causing the misreading result.

Solutions:

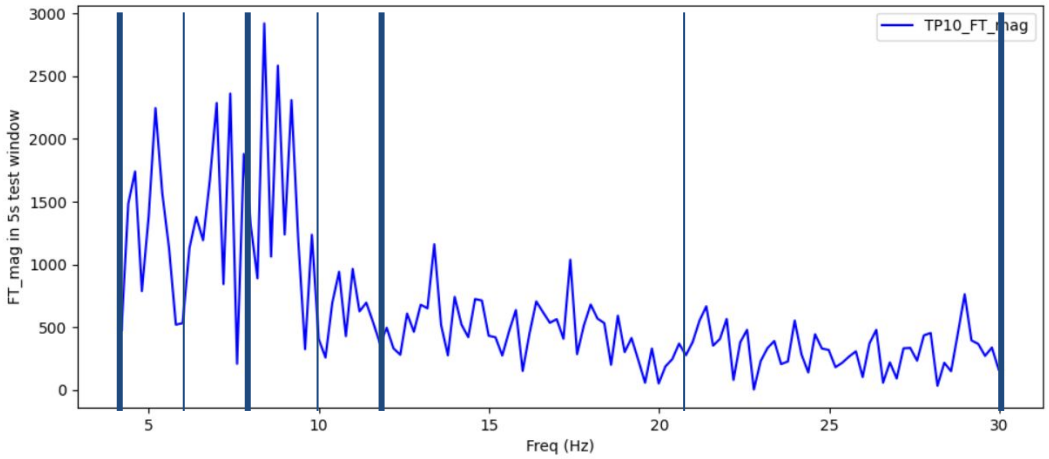
- Switched from custom MCU to Arduino Uno R3 for integration and computer communication.
- Reseating the wired connections between devices fixed the communication issue, however the ADC from the PCB would only send one result.
- Working with Max to find the cause of the issue and resolve before demo.

Signal Analysis Design

- EEG signals are erratic and highly variable.
- To get usable features, the final implementation pulls bandlimited power from 6 bands and calculates 15 comparative ratios. The operation was performed on window sizes of 5 seconds.
- To match the sequential constraint of the RNN input, window overlap was dropped for the final implementation, but extra data is still generated by offsetting all of the windows in a sample.

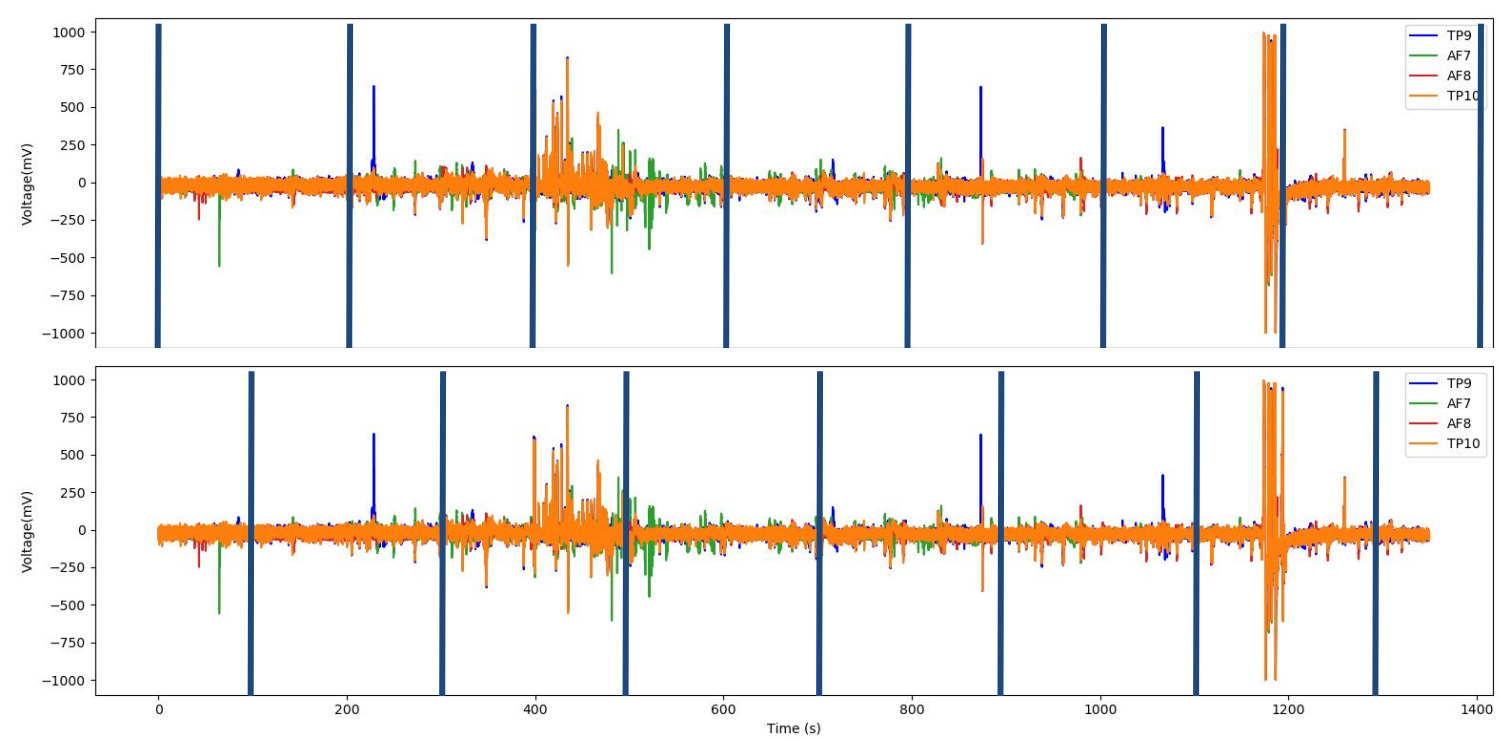
Signal Analysis Design

- Doubling the number of bands gave repeatable accuracy increases of 9-10%.
- Losing the overlap was one of the downfalls of going to an RNN, but the RNN's accuracy increase outweighed that loss.



- Randomized data augmentation was tried, but it didn't yield good results.
- A different data augmentation method was settled on.

Signal Analysis Design



- This is how offsetting the windows generates many times more data points without losing the sequential structure.

ML Model Design

Naive Bayes | Kernel SVM | Neural Network

↓

Kernel SVM

↓

Recurrent Neural Network (RNN)

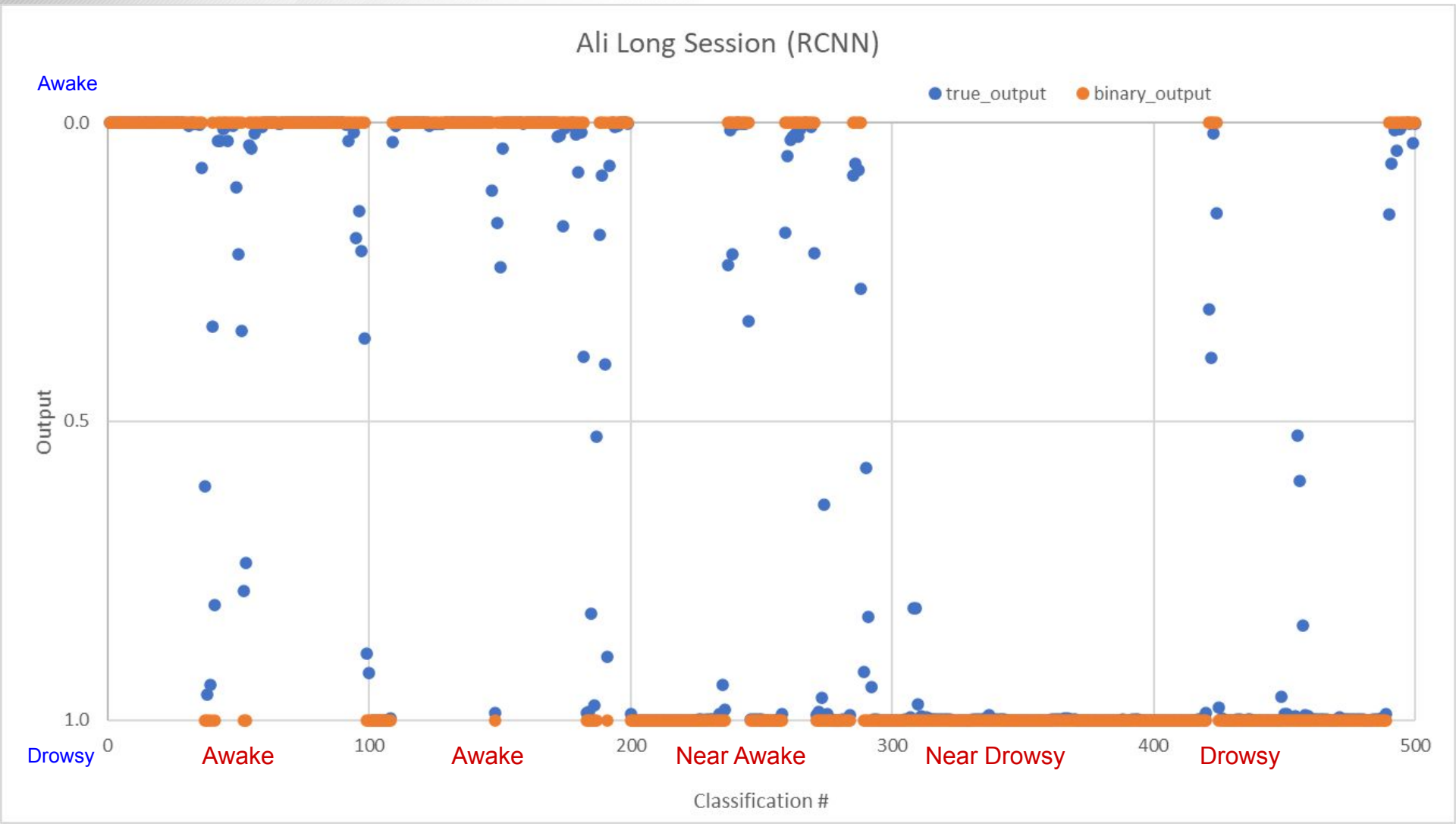
- time dependencies

↓

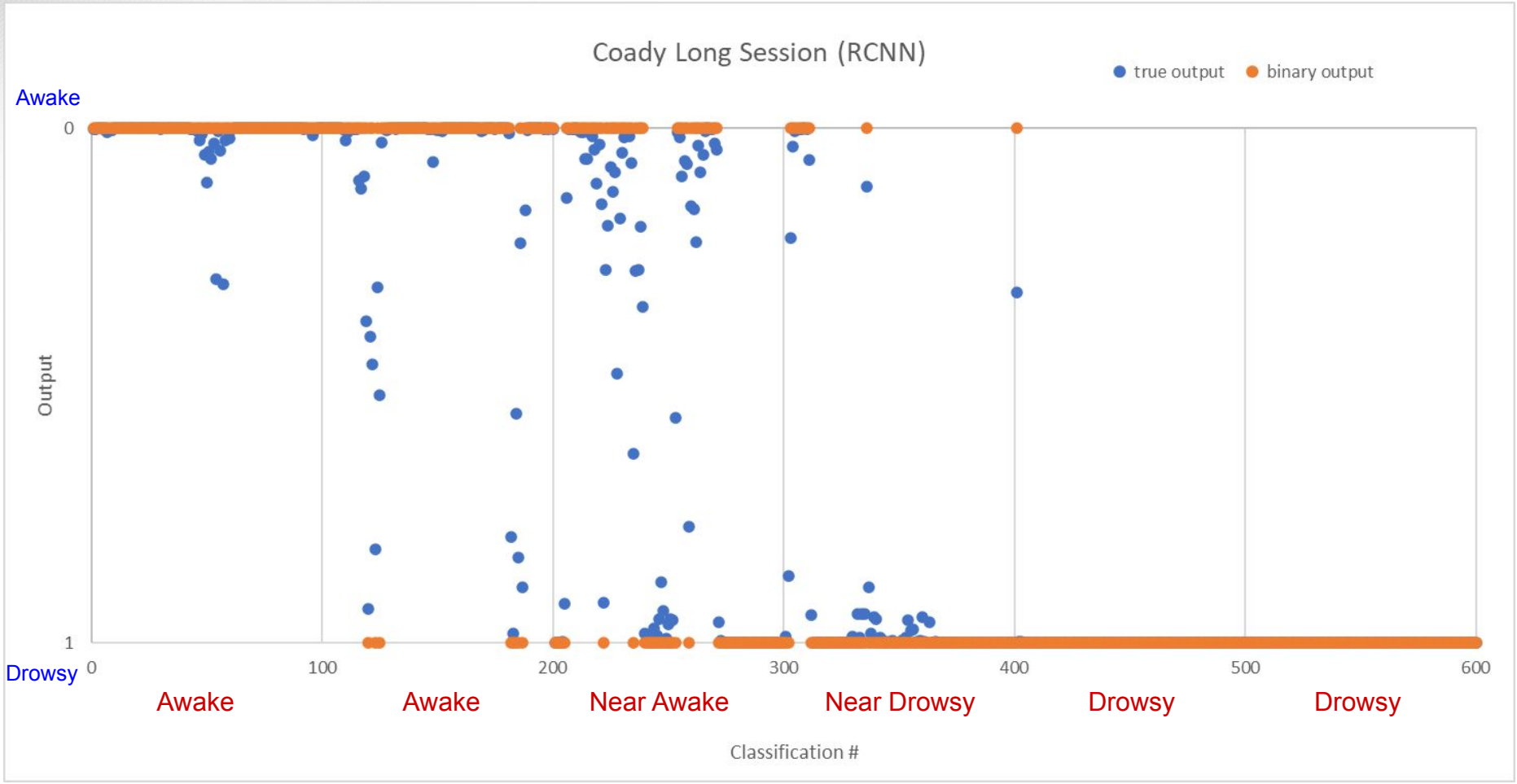
Recurrent Convolutional Neural Network (RCNN)

- both time and spatial dependencies

Long Session Output (Ali)



Long Session Output (Coady)



Software System Results

- Full Awake/Full Drowsy Test
  - https://youtu.be/WBdDPMvdBsY
- Response to Stimulus Example
  - https://youtu.be/Y3JlhLka4Ks

Hardware System Results

Specification:	Details:	Results:
Input Voltage = 148 mV - 812 mV amplified up to 1.3 V	Max voltage rating desired is 1.3 V from the amplifier IC.	Pass*; Input = 200 mV (differential), Output = 1.24 V
Circuit Vcc Regulated to +- 5V	Take 6V input and hold at +- 5V for powering circuit	Pass; Vcc+ = 5V, Vcc- = -5V
EEG Filtering Below 8 Hz	Reducing noise for signal processing by removing spikes in frequency band	Untested
EEG Filtering Above 32 Hz	Reducing noise for signal processing by removing spikes in frequency band	Untested
EEG Filtering at 60 Hz	Reducing powerline interference and large spike at 60 Hz	Untested

*Results for breadboard circuit, PCB results of Input = 736 mV, Output = 4.3 V from circuit and 3.75 V on SDA line do not pass this validation.

Conclusions

- The largest issues for the model came from a combination of the device (muse) and the nature of EEG data.
- Current status
  - ML/SP: integration/test/validation complete. Working on final settings for demo.
  - EEG: Integration complete but PCB circuit is not functioning, will either be fixed by end of week or switching to breadboard circuit for demo. Frequency validations to be completed by end of week.