Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

ECEN 404 Demo
Team 61: Driver Drowsiness Detection

Dakota Mouton, Ali Imran, Coady Lewis
Sponsor: John Lusher
TA: Max Lesser

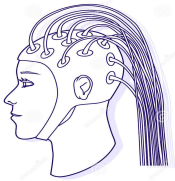
Project Diagram

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

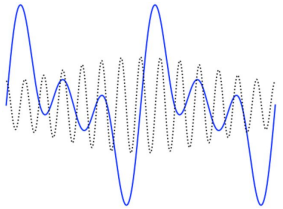
- Collect data
- Muse 2 EEG device

Signal Processor

- Perform live analysis of signals
- Process raw EEG signals

ML Algorithm

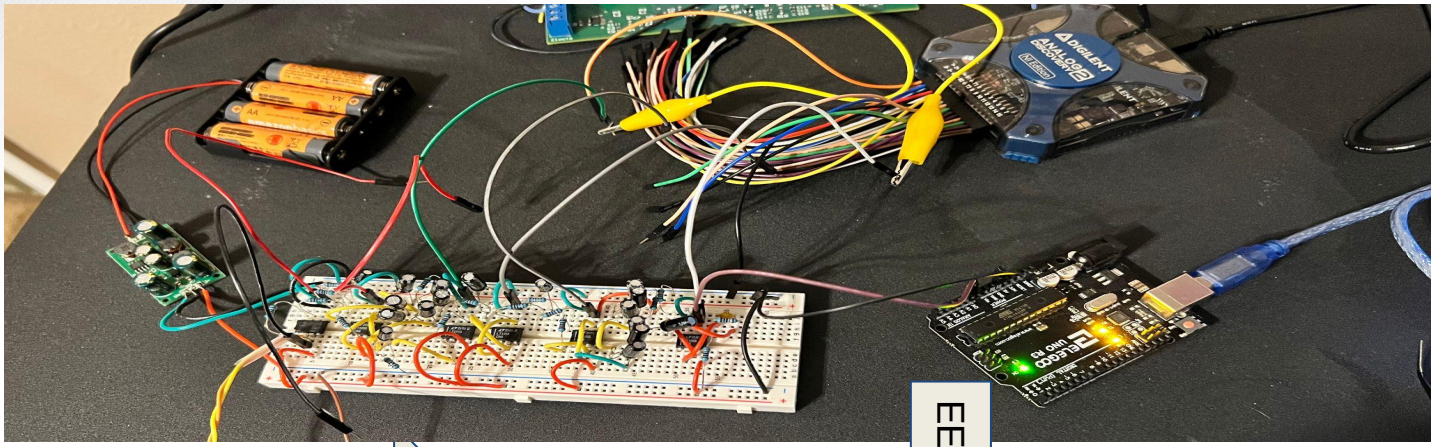
- Input processed EEG signals
- Output fatigue state of user

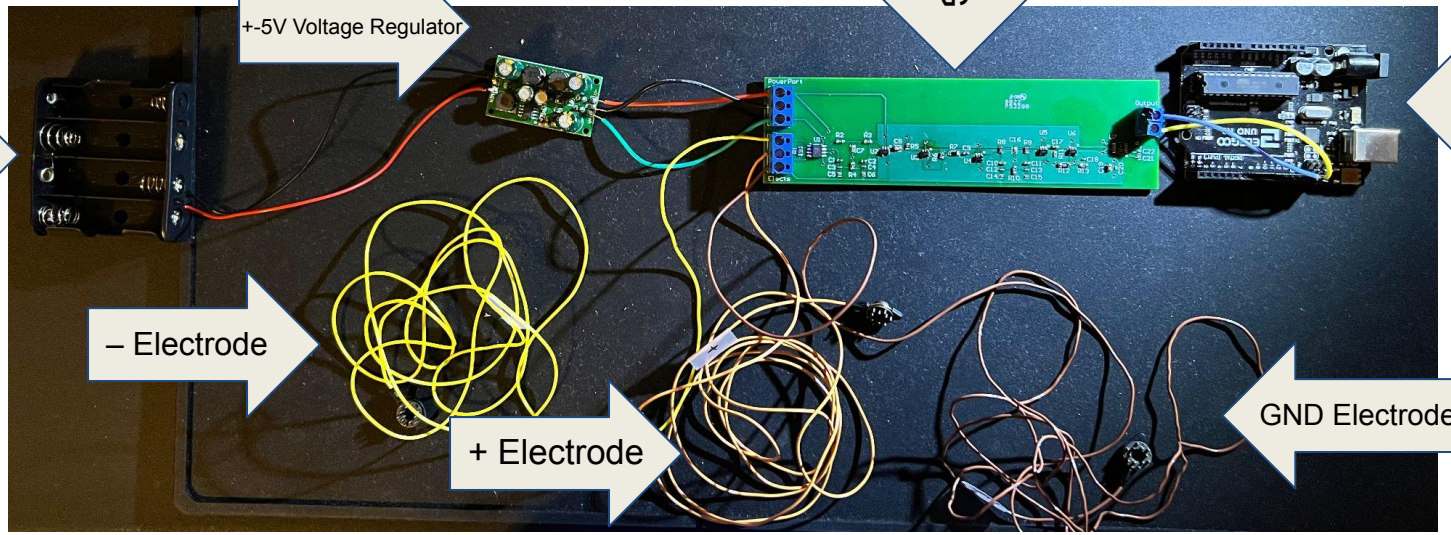


Team 2: Coady and Ali

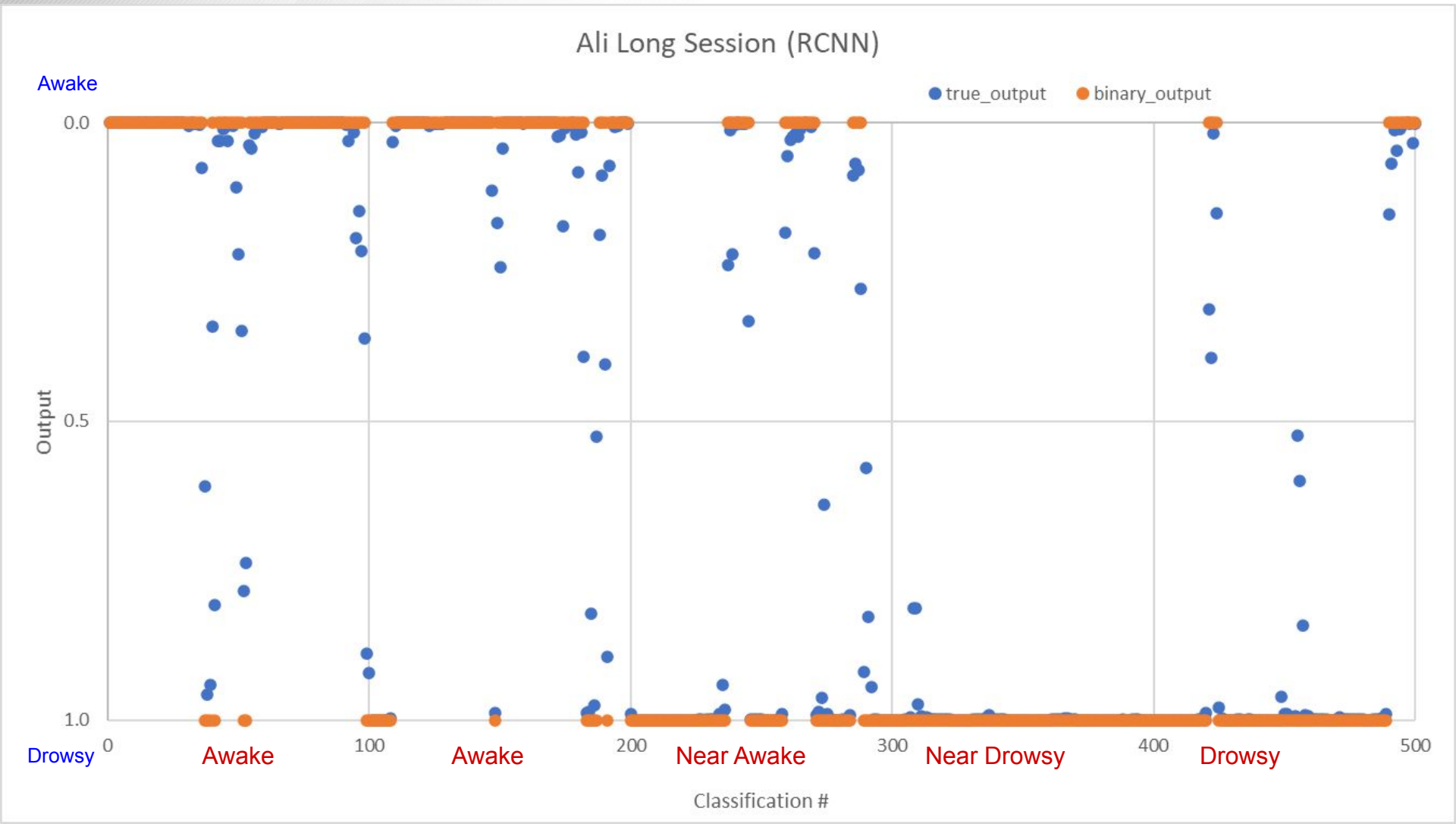
Project Photos: Model Classification

Project Photos: EEG

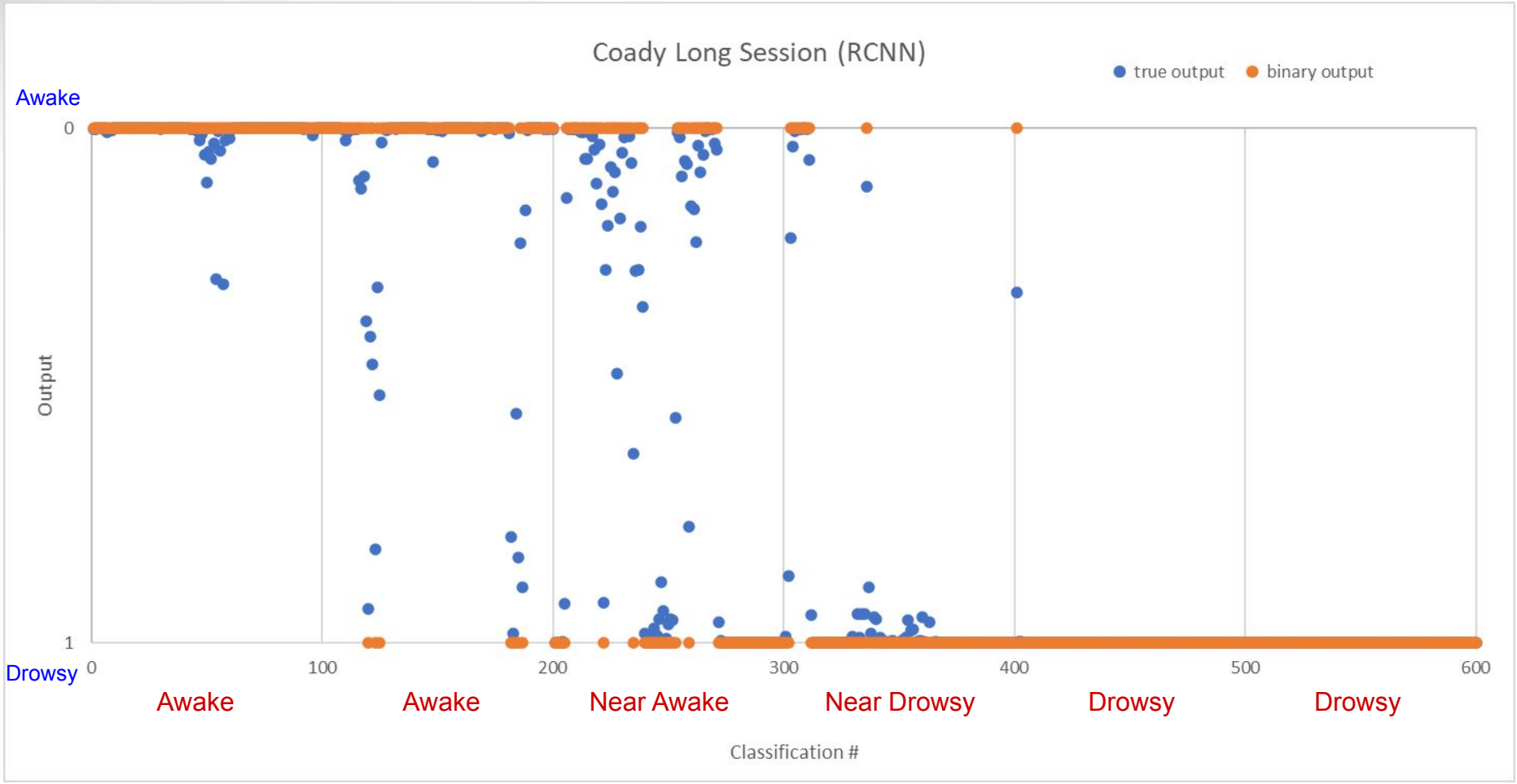




Long Session Output (Ali)



Long Session Output (Coady)



Accuracies (Long Sessions)

Total: 93.6%

Fully Awake: 92.3%
Fully Drowsy: 95%

False Positive: 7.7%
False Negative: 5%

Software System Results

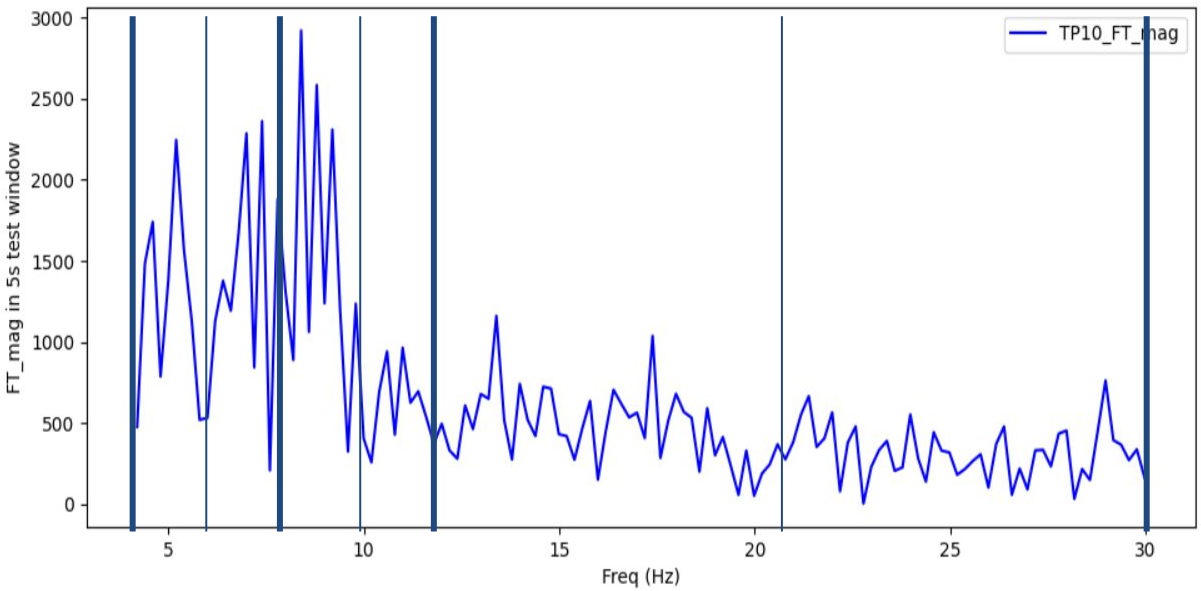
- Full Awake/Full Drowsy Test (2 Subjects)
  - https://youtu.be/pWFG5qb1vY0
- Response to Stimulus Example
  - https://youtu.be/Y3JlhLka4Ks

Signal Analysis Design

- EEG signals can be erratic.
- To get usable features, the final implementation pulls bandlimited power from 6 bands and calculates 15 comparative ratios for each electrode. The operation was performed with an FFT on window sizes of 5 seconds.
- Windows must be adjacent to keep sequential structure.
- Live analysis script feeds processed values to ML in real time.

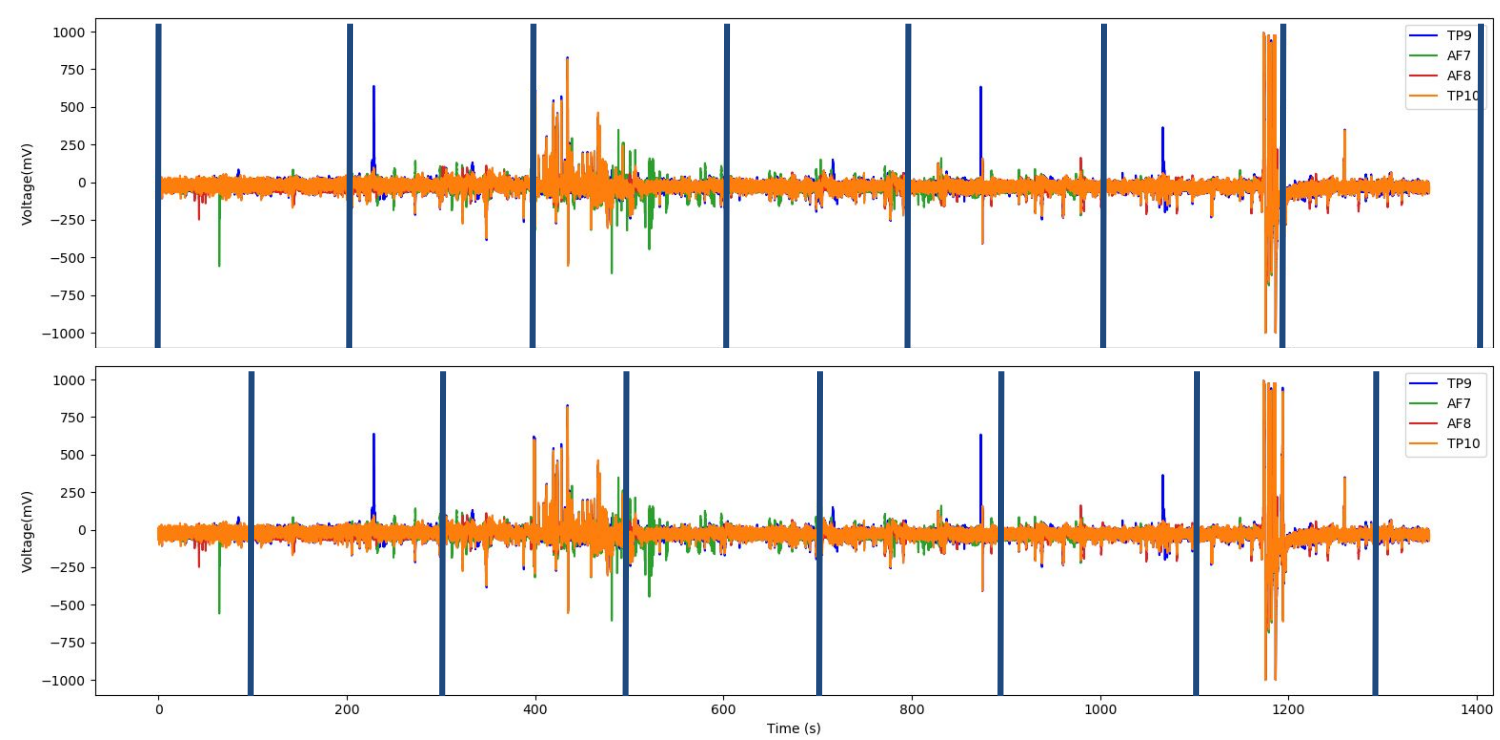
Signal Analysis Design

- Doubling the number of bands from 403 gave repeatable testing accuracy improvements of 9-10%.
- Increasing the number of bands increases the amount of information, but we are limited by the feasible amount of training data.



- Randomized data augmentation was tried, but it didn't give good results, as time dependency was lost.
- The offset method was settled on, but overuse yields overfitting.

Signal Analysis Design



- This is how offsetting the windows generates many times more data points without losing the sequential structure. Overlap is used for the non-sequential case.

ML Model Design

Naive Bayes | Kernel SVM | Neural Network

↓

Kernel SVM

↓

Recurrent Neural Network (RNN)

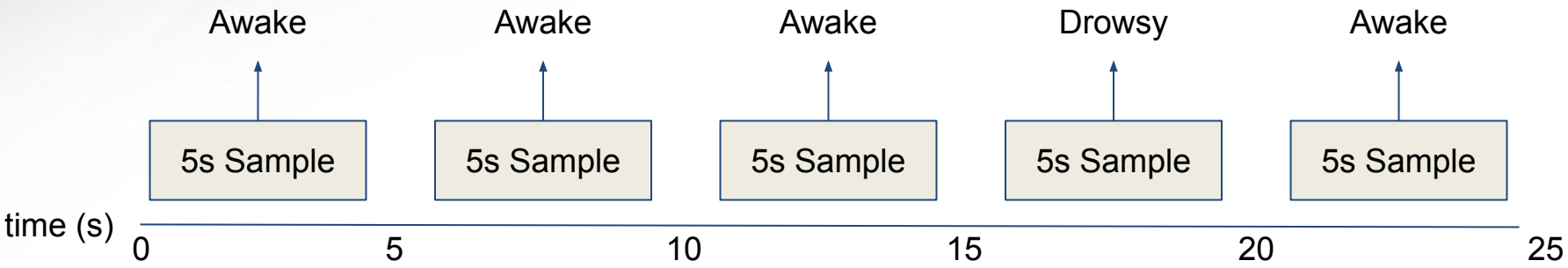
- time dependencies

↓

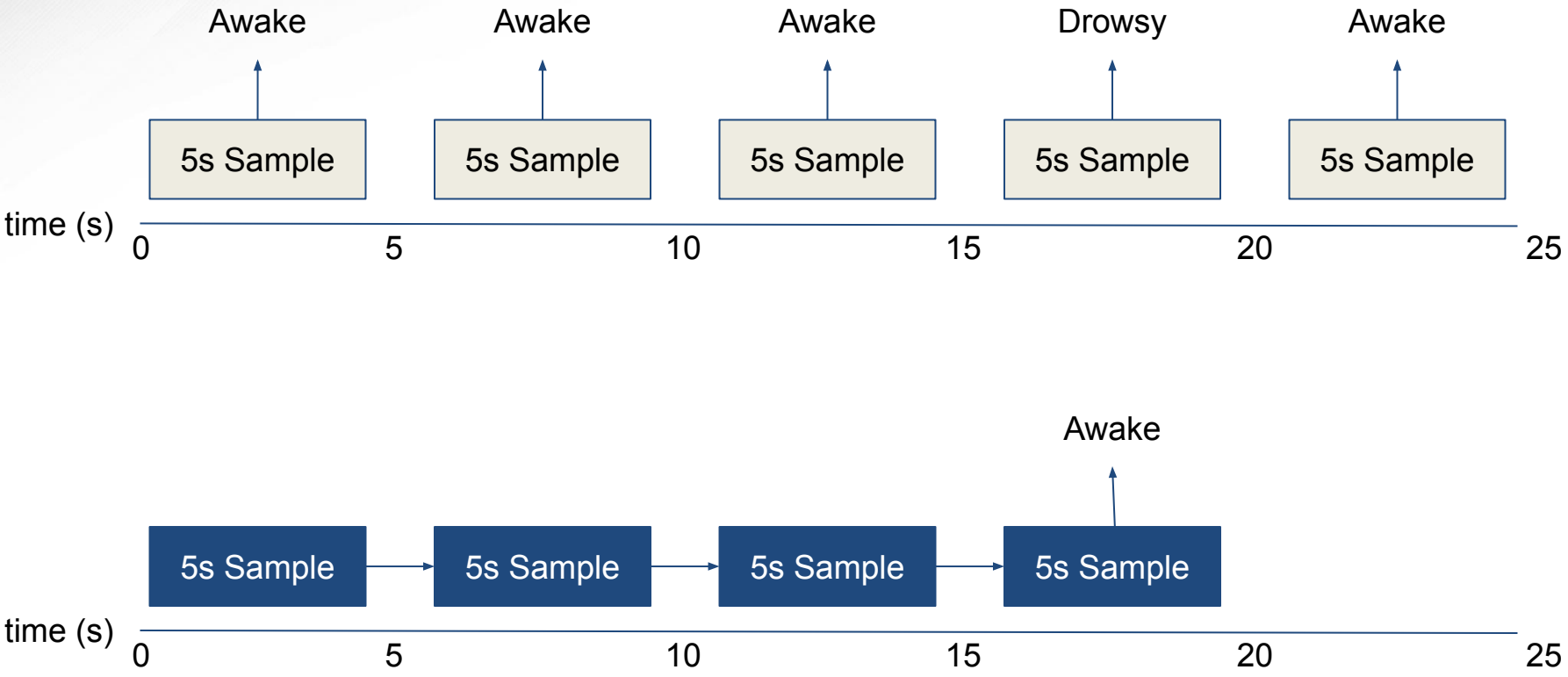
Recurrent Convolutional Neural Network (RCNN)

- both time and spatial dependencies

Recurrency

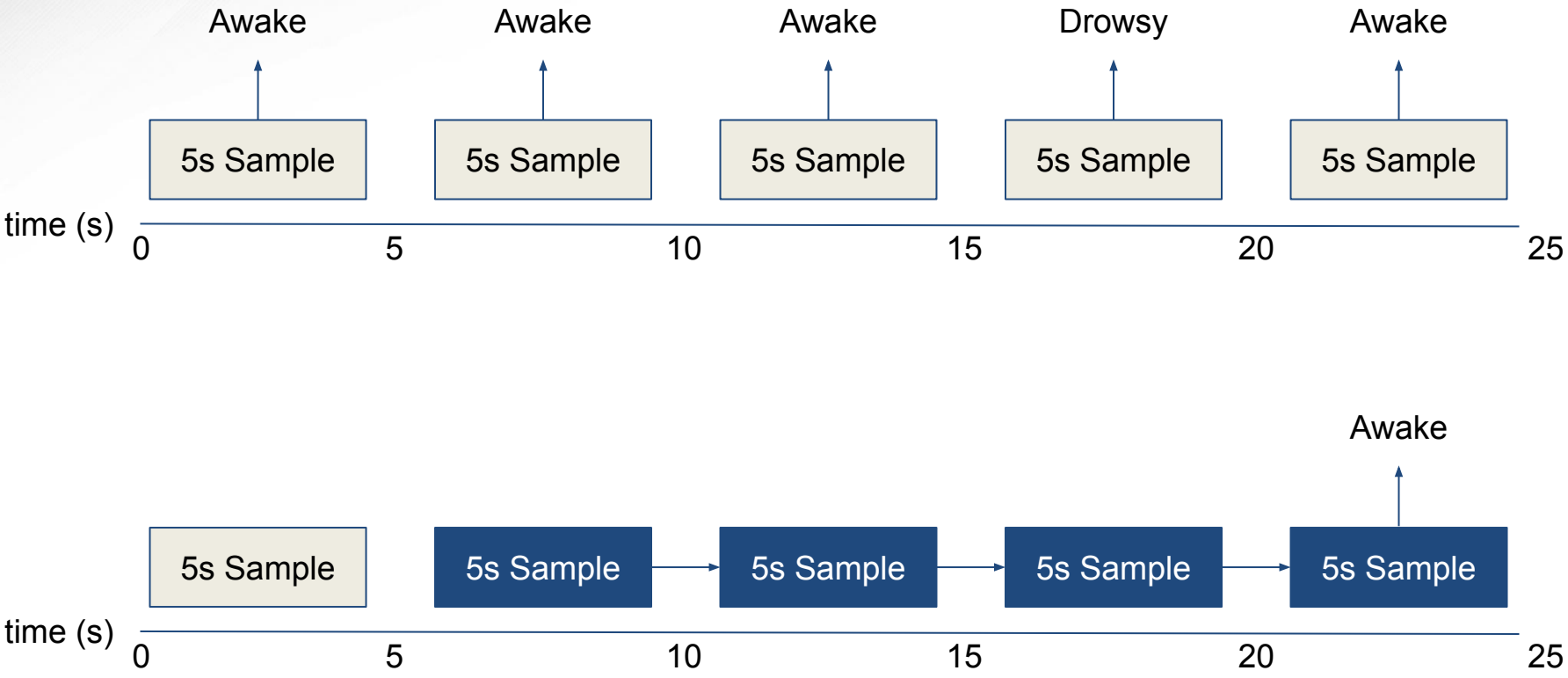

Awake
Awake
Awake
Drowsy
Awake
5s Sample
5s Sample
5s Sample
5s Sample
5s Sample
time (s)
0
5
10
15
20
25

Recurrency



Sequence Length = 4

Recurrency



Sequence Length = 4

Convolution

Features per Electrode (15)

Electrodes (4)						
TP9	f0	f1	f2	…	f13	f14
AF7	f0	f1	f2	…	f13	f14
AF8	f0	f1	f2	…	f13	f14
TP10	f0	f1	f2	…	f13	f14

Convolution

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Electrodes (4)				…		
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AF7	f0	f1	f2	…	f13	f14
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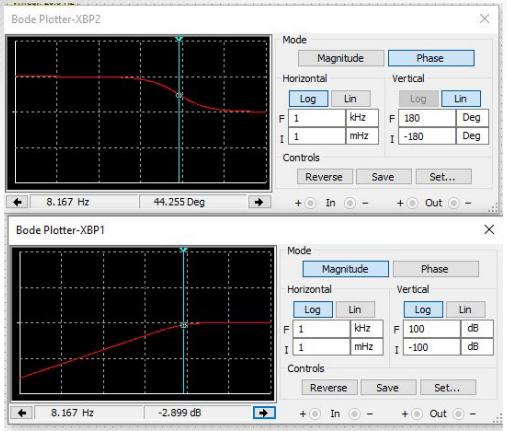
Hardware System Results

Specification:	Details:	Results:
Input Voltage = 148 mV - 812 mV amplified up to 1.25 V	Max voltage rating desired is 1.25 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	Pass
EEG Filtering Above 32 Hz	Reducing noise for signal processing by removing spikes in frequency band	Pass
EEG Filtering at 60 Hz	Reducing powerline interference and large spike at 60 Hz	Pass

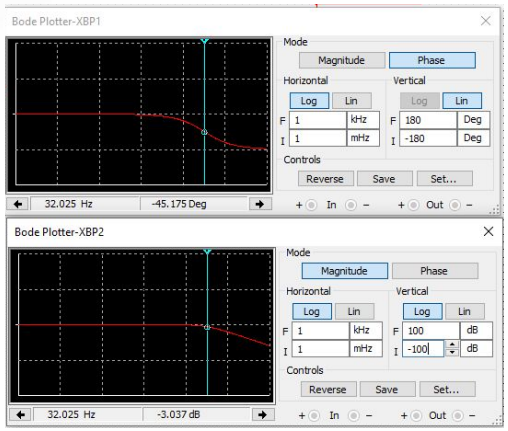
*The ADC output goes close to zero whenever a frequency outside our range is put through the system.

EEG System Simulation

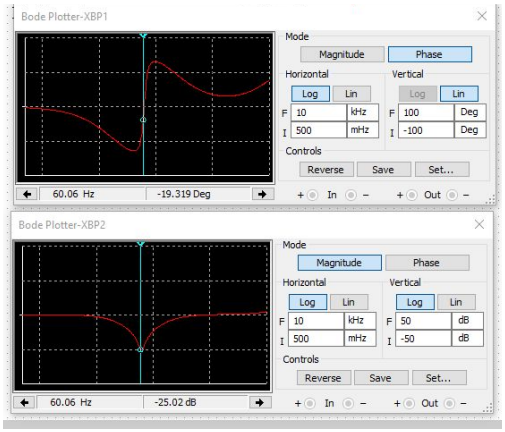
8 Hz HPF



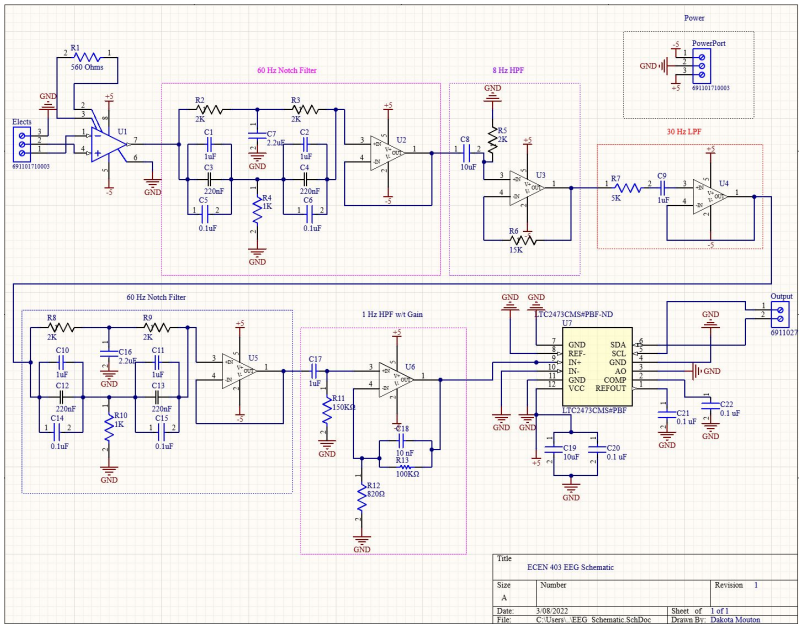
32 Hz LPF



60 Hz Notch Filter



Instrumentation Amp
Gain: 5.94 V/V



EEG System Cost

2 Electrode EEG

Category	Part Number	Item Name	Location to	Cost per Part	Quantity	Total Cost
Instrumention Amp	AD8221BRZ-R7CT-ND	AD8221BRZ-R7 Instrumentation Amp	https://ww	$10.90	1	$10.90
Single Op Amp	ADA4610-1ARJZ-R7	ADA4610-1ARJZ-R7 single op amp	https://ww	$2.81	5	$14.05
ADC	LTC2473CMS#PBF-ND	LTC2473CMS#PBF-ND ADC	https://ww	$4.55	1	$4.55
			Totals:	$18.26	7	$29.50
Capacitors	399-7848-1-ND-Cut Tape	C0603C105K9PAC7867 (1uf)	https://ww	$0.10	6	$0.60
	1276-2897-1-ND - Cut Ta	CL21A106KPFNNWE (10uf)	https://ww	$0.22	2	$0.44
	1276-1176-1-ND - Cut Ta	CL05B224KO5NNNC (220nf)	https://ww	$0.10	4	$0.40
	478-1114-1-ND - Cut Tap	0402YC103KAT2A (10nf)	https://ww	$0.10	1	$0.10
	1276-1043-1-ND	CL05A104KA5NNNC (0.1uF)	https://ww	$0.10	7	$0.70
	1276-1134-1-ND	CL10B225KP8NNNC (2.2uF)	https://ww	$0.12	2	$0.24
Resistors	RNCP0805FTD1K00CT-NI	RNCP0805FTD1K00 (1k)	https://ww	$0.10	2	$0.20
	RNCP0805FTD2K00CT-NI	RNCP0805FTD2K00 (2k)	https://ww	$0.10	5	$0.50
	RNCP0805FTD15K0CT-NI	RNCP0805FTD15K0 (15k)	https://ww	$0.10	1	$0.10
	YAG5090CT-ND	RT1206BRD075KL (5k)	https://ww	$0.65	2	$1.30
	A130442CT-ND	CRGP0603F150K (150k)	https://ww	$0.17	1	$0.17
	RMCF0805FT13K0CT-N	RMCF0805FT13K0 (13k)	https://w	$0.10	1	$0.10
	CRT1206-FZ-1002ELF	652-CRT1206FZ1002ELF (10k)	https://w	$0.30	1	$0.30
			totals:	$2.26	35	$5.15
Buck boost converter	5V Step-Up/Step-Down V	Buck boost converter	https://ww	$14.95	1	$14.95
Dry Electrodes	FRI-2140-1E	Package of 15 Disposable/Reusable Dry E	https://ww	$34.95	1	$34.95
Alkaline Batteries		Amazon Basics AA 1.5 Volt Performance A	https://ww	$5.49	1	$5.49
Battery Holder for 4 Batteries		LAMPVPATH (Pack of 2) 4 AA Battery Hold	https://ww	$5.99	1	$5.99
2 Output Pin Termina	732-2028-ND	6.91103E+11	https://ww	$0.71	1	$0.71
Power 3 Input termin	732-2027-ND	6.91102E+11	https://ww	$0.71	2	$1.42
			totals:	$62.80	7	$63.51
Grand Total:	$98.16					

Challenges for Future (Hardware)

- Reducing footprint of pcb to fit on a hat or wearable accessory for the driver.
- Shielding input electrodes from electrical interference in the surrounding environment.
- Upscaling the circuitry the use more electrodes for more accurate measurements.

Challenges for Future (Software)

Sample Labeling Methods

- Individual rather than batch sample labeling

Data Volume and Subject Count

- Build a more robust and generalized model
- Will allow for more bands from signal processing

Simulation Realism

- Vehicle NVH