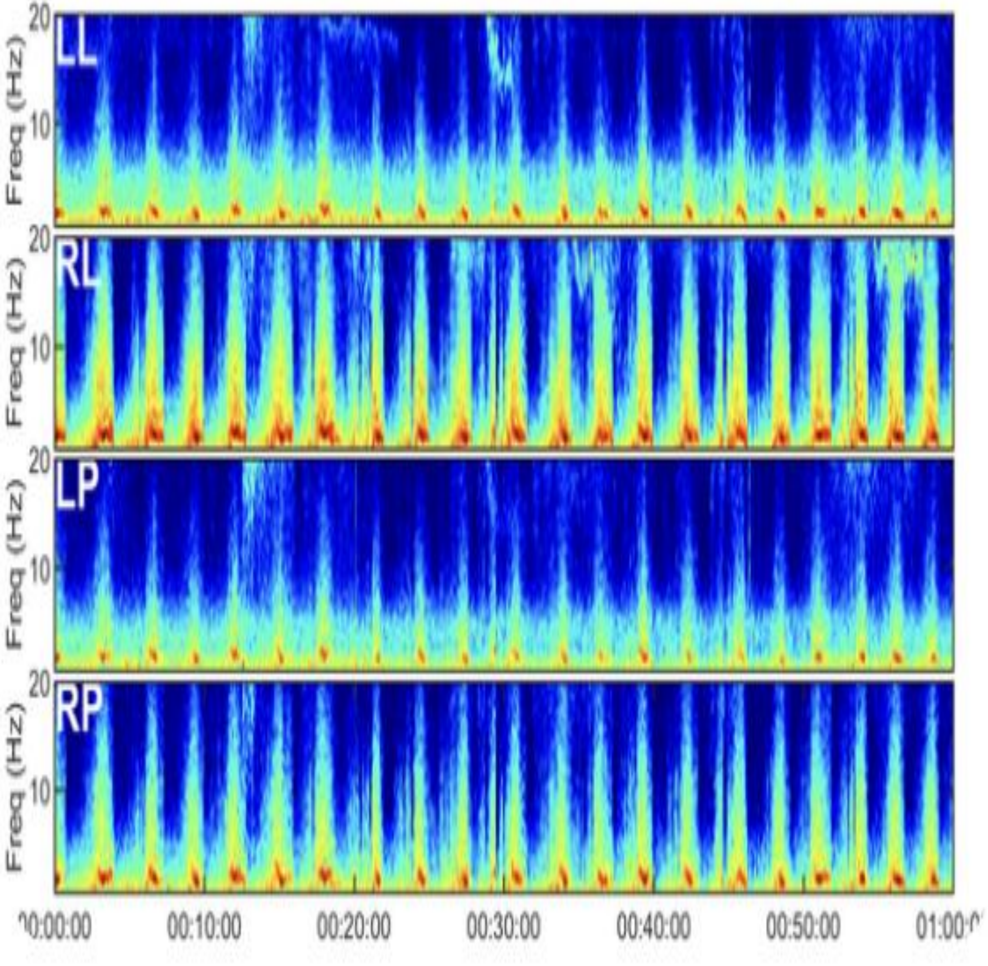
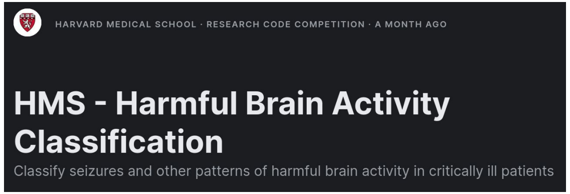
Harmful Brain Activity Classification: Utilizing Multi-Modal Data to Enhance Epileptiform Classification by Deep Learning Model via Spatio-Temporal Reasoning

Poopa Kaewbuapan
& KM



Overview of the competition



- Physicians use electroencephalography(EEG) on the critically ill patients to detect seizures and other types of brain activity that can cause brain damage.

- Manual review of EEG recordings is time-consuming and, prone to fatigue-related errors, even when those reviewers are experts.

- The goal of the project is to automate EEG analysis to help doctors and brain researchers detect seizures and other types of brain activity that can cause brain damage

Competition metric

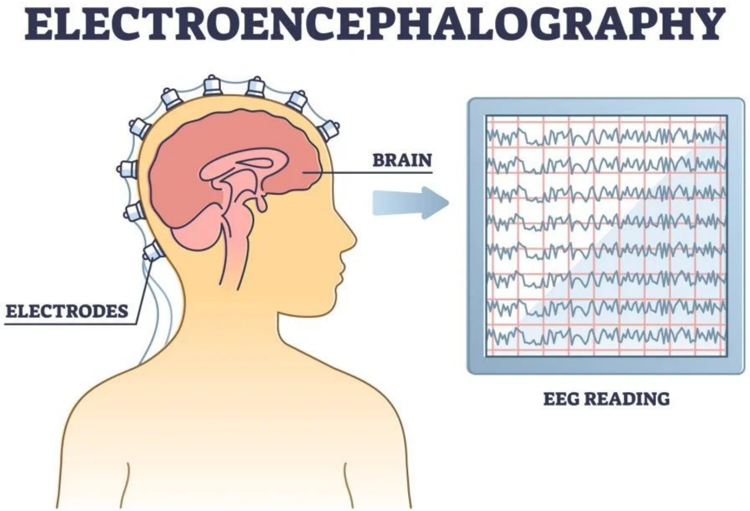
There are six patterns of interest for this competition:

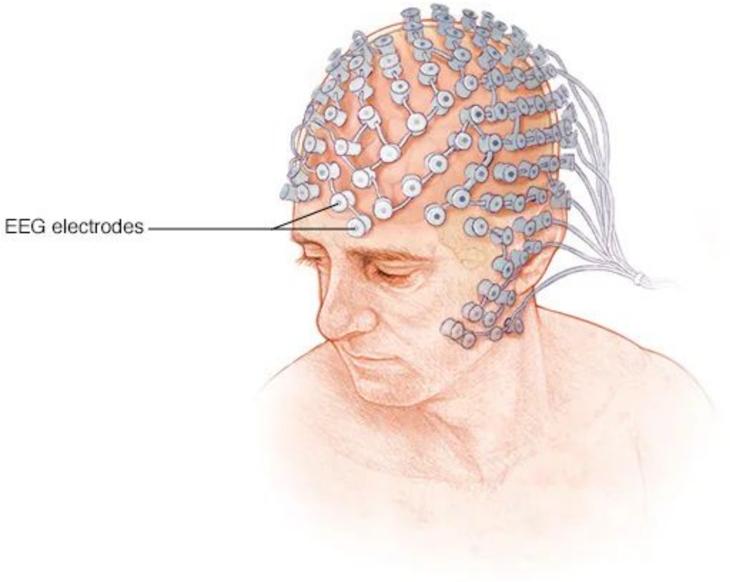
- Seizure (SZ)
- Generalized periodic discharges (GPD)
- Lateralized periodic discharges (LPD)
- Lateralized rhythmic delta activity (LRDA)
- Generalized rhythmic delta activity (GRDA)
- Other

Minimize the KL divergence of the predicted classification probabilities to the ground truth

Electroencephalography (EEG)

“A technique for the recording of electrical activity arising from the human brain”

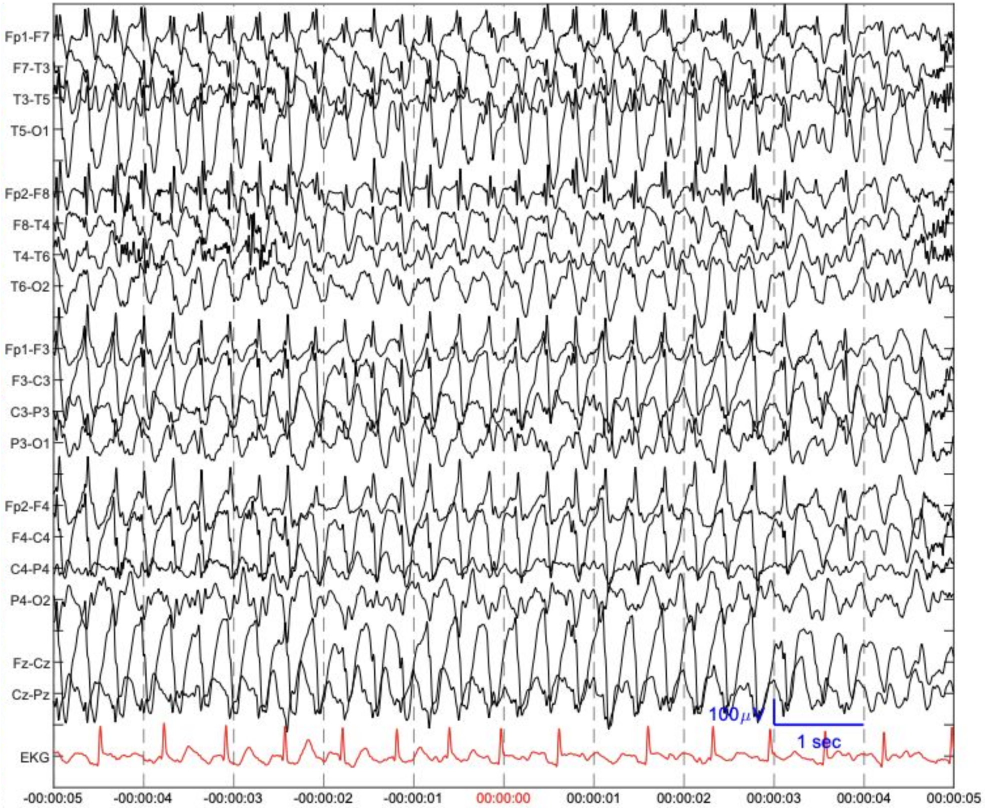




What does EEG data look like?

- The height of the waves (amplitude) shows how strong the signal is.

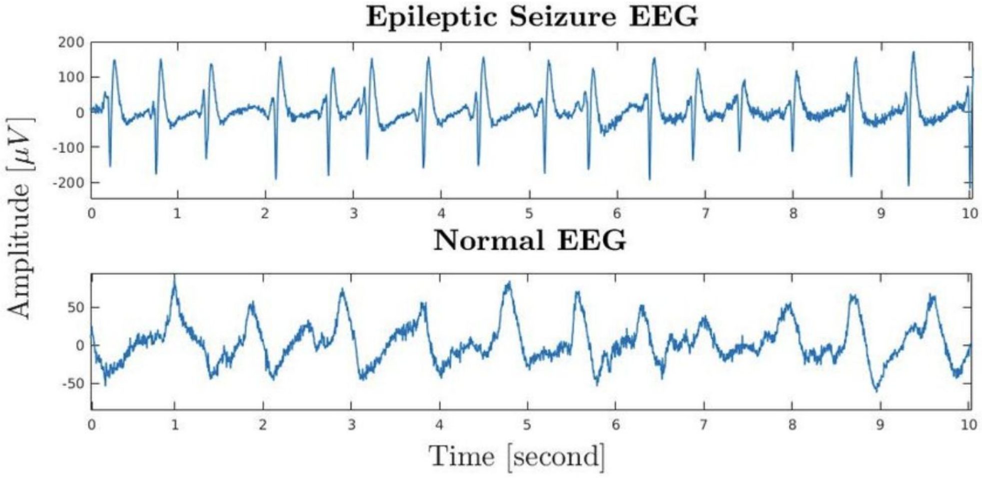
- The speed of the waves (frequency) tells you how fast the brain cells are firing



What can we learn from EEG data?

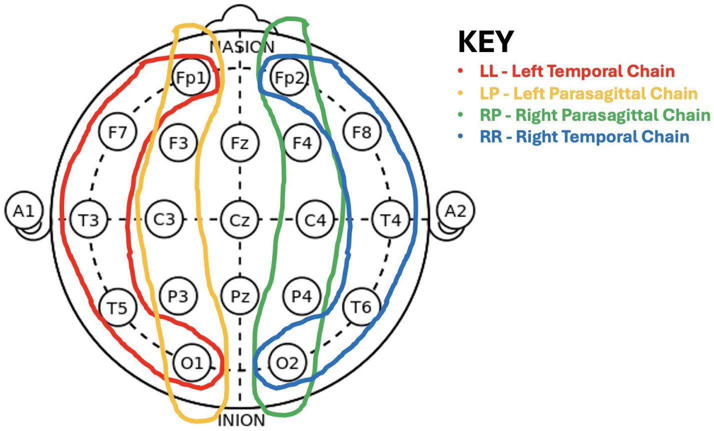
- Different types of brain activity have different wave patterns.

- Doctors use EEG to study conditions like epilepsy, where the brain's electrical activity is abnormal.

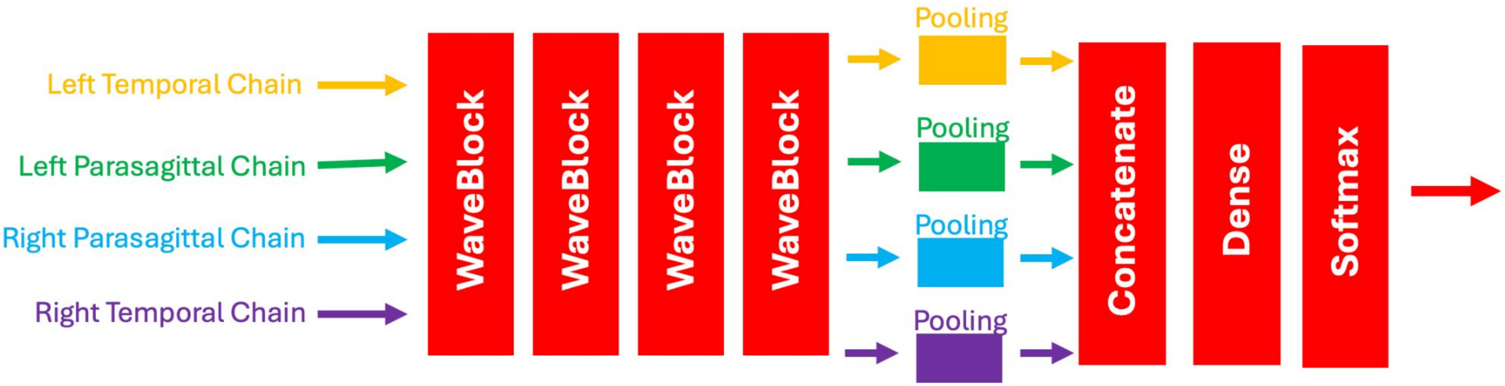


Espinosa, Natalia, Arthur Amorim, and Rudolf Huebner. "Feedforward Neural Network with Backpropagation for Epilepsy Seizure Detection."

WaveNet (Chris Deotte)



1DConv

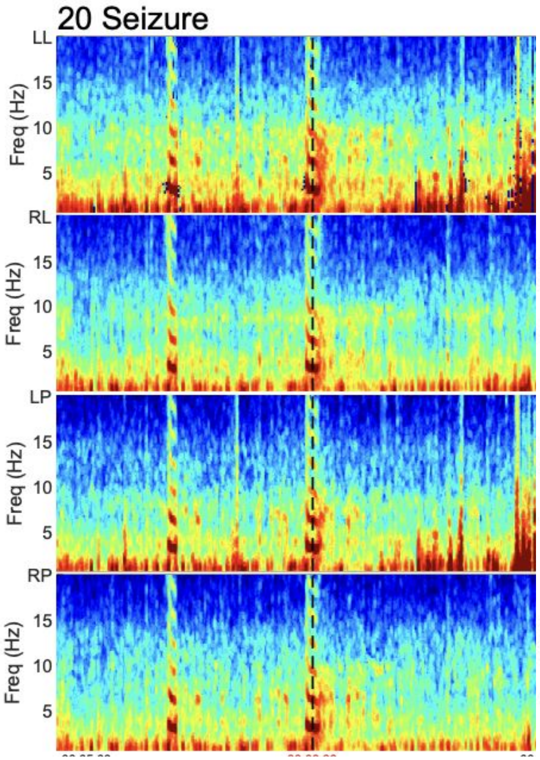


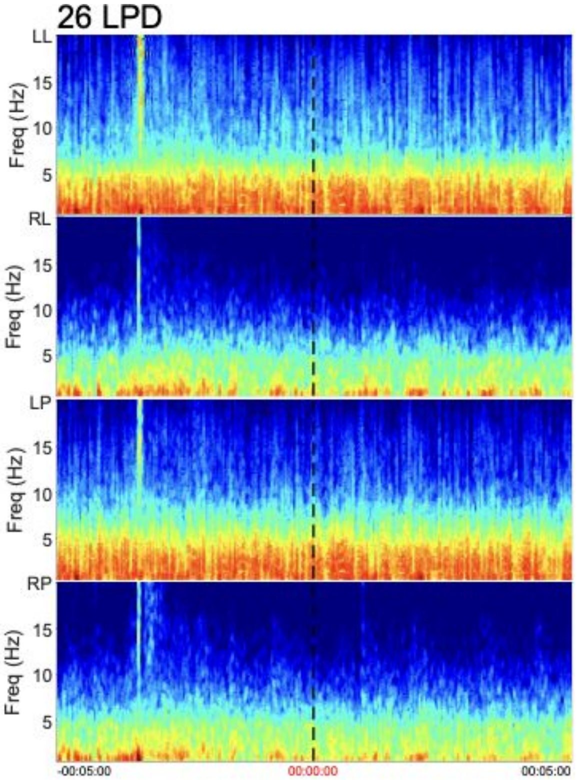
https://www.kaggle.com/code/cdeotte/wavenet-starter-lb-0-52

Spectrograms: Brain waves in color!

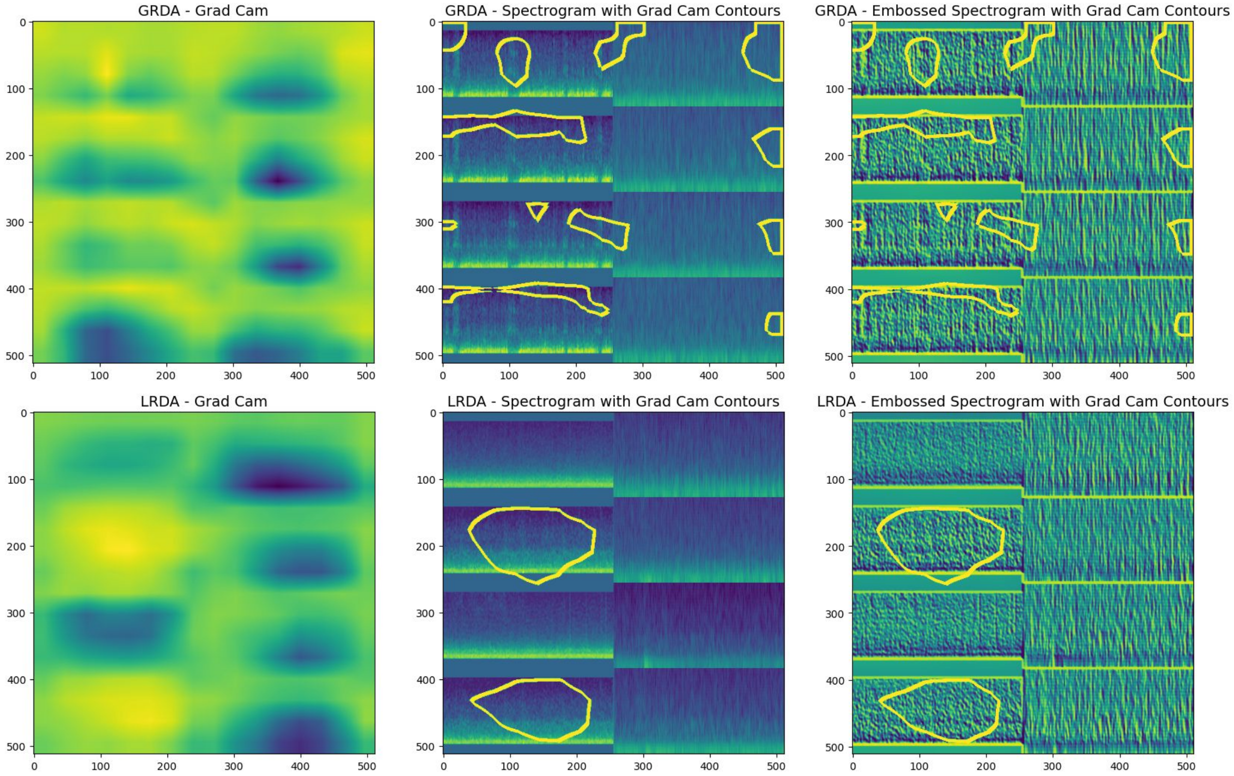
- Showing the different frequencies of brain waves like colors on a spectrum.

- This helps doctors see patterns and changes in brain activity more easily.





Spectrogram Grad-CAM on ViT (Chris Deotte - Kaggle)



https://www.kaggle.com/code/cdeotte/grad-cam-what-is-important-in-spectrograms

Experiment Controls

Temporal Model: Training on 50 seconds time window EEG signal – Bandpass filter of 0.1-20 Hz, WaveNet 1DCNN backbone

Spatial Model: Training on Mel spectrograms reconstructed from 50 seconds time window EEG signal – Bandpass filter of 0.1-20 Hz, EfficientNet-2B 2DCNN backbone

(Keras Tensorflow implemention - Trained on Kaggle’s GPU T100 environment)

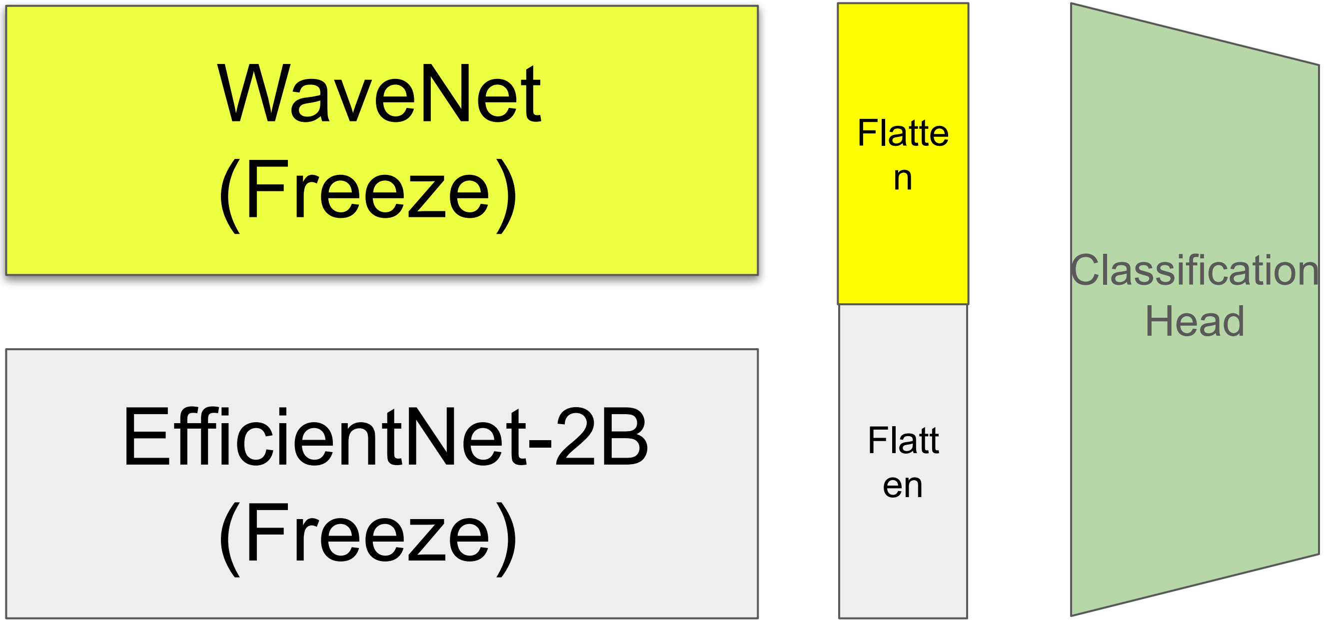
Both Information Model: Ensemble of trained Temporal model and trained Spatial model

Result (KL divergence - lower is better)

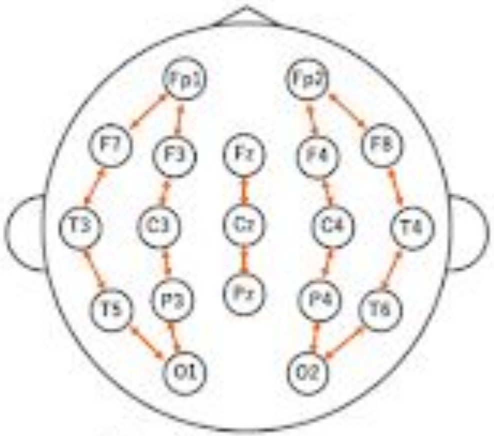
	Public Leaderboard (LB)	Cross Validation (CV)	Differences of LB and CV
Temporal Model	0.4	0.6951	0.2951
Spatial Model	0.39 (+ 2.5% from Temp)	0.6288	0.2388 (- 0.0563 from Temp
Spatiotemporal Ensemble	**0.38** (+ 2.56% from Spa)	0.6085	**0.2285** (- 0.0103 from Spa)

https://www.kaggle.com/datasets/nartaa/features-head-starter-models

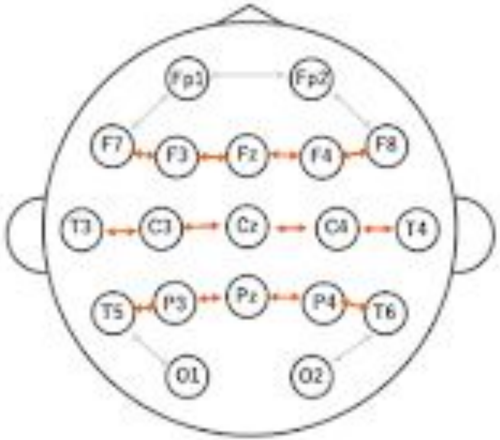
(Near) Future Works



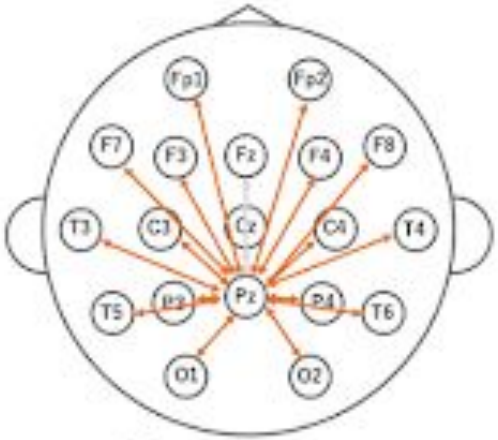
Future Works



Double banana



Horizontal



Pz reference

Thank you