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CSC532 Machine Learning - Project Proposal

Harmful Brain Activity Classification: Utilizing multi-modal data to enhance epileptiform classification by deep learning model via spatio temporal reasoning

From stethoscopes to tongue depressors, doctors rely on many tools to treat their patients. Physicians use electroencephalography with critically ill patients to detect seizures and other types of brain activity that can cause brain damage. Currently, EEG monitoring relies solely on manual analysis by specialized neurologists. While invaluable, this labor-intensive process is a major bottleneck. Not only can it be time-consuming, but manual review of EEG recordings is also expensive, prone to fatigue-related errors, and suffers from reliability issues between different reviewers, even when those reviewers are experts. The goal of this project is to create a model that can classify the brain activities based on the EEG and spectrograms. The model is able to classify whether the patient has:

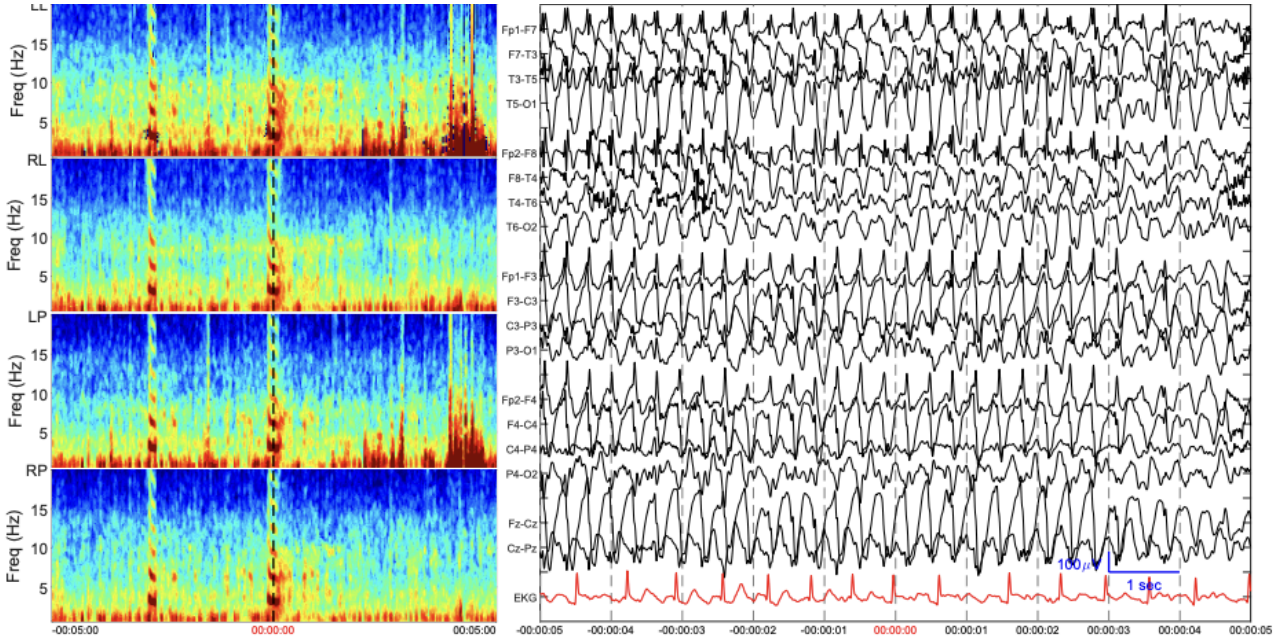
- Seizure (SZ)
- Generalized periodic discharges (GPD)
- Lateralized periodic discharges (LPD)
- Lateralized rhythmic delta activity (LRDA)
- Generalized rhythmic delta activity (GRDA)
- Other conditions apart from the four mentioned above

This is an ongoing Kaggle Competition, which will end on the 9th of April 2024.

Dataset

The dataset is provided by the Harvard Medical School and is available on Kaggle. It comprises the EEGs and the spectrograms of 1950 unique patients, together with the ground truth medical conditions to train the model.

An example of EEG waveform (right side) and its equivalent Spectrograms (left side) of a patient with Seizure:



Objective and Scope

Design a model architecture ensemble that utilized spatiotemporal information in EEG waveform and spectrogram data [DilatedInception WaveNet (Time-domain) + ResNet-34 (Frequency-domain - Spatial)] and comparing with a single model that trained solely on EEG waveform or spectrogram data, if KL divergence score (competition metric) of the model ensemble is improved by more than 1% margin when comparing to both that trained by only EEG waveform and spectrogram. It supports the hypothesis that utilizing both time-domain and power spectra plots of EEG signals are crucial to improving epilepsy activity detection by a deep learning model.

Timeline & Deliverables

Phase	Date & Duration	Task List	Deliverable	Status
#1 Project Ideation	22/02/2024 - 05/03/2024 (13 days)	- Learning about the competition by EDA and Training starter notebooks	Design of deep learning model architecture with decision in model's backbones and how to preprocess input (waveform -> spectrogram, signal processing)	Completed
#2 Competition Sprint	06/03/2024 - 09/04/2024 (35 days)	- Explore the competition discussions to gain insights on information gain of the DL classification model on spectrogram or original wavelet - Implement and train the team model	Public leaderboard position of best submission with the deep learning model of Team KM and Poopa for the competition	Ongoing
#3 Post-Competition: Individual Experiment	10/04/2024 - 30/04/2024 (21 days)	- Implementing and training 3 models based on CNN-backbone on 50 secs EEG bipolar montage wavelet and generated spectrogram from the wavelet 1. Spatiotemporal	Experiment Results: Margin of difference of evaluation metric (KL divergence) between 3 models (Spatiotemporal, Spatial, Temporal)	Tentative

		DilatedInception WaveNet (handles wavelet) + ResNet34 (handles spectrogram) This model comprises of 2 CNN backbone that will have their flatten feature weights concatenated and apply a classification head at the end 2. Spatial - ResNet34 (spectrogram only) 3. Temporal - DilatedInception WaveNet (wavelet only)		
#4 Documentation	01/05/2024 - 14/05/2024 (13 days)	- Format experiment results and literature review with Kaggle findings into the final presentation slides	Final Presentation Slides	Tentative

References

Competition Page
https://www.kaggle.com/competitions/hms-harmful-brain-activity-classification

Dataset
https://www.kaggle.com/competitions/hms-harmful-brain-activity-classification/data
https://www.kaggle.com/datasets/cdeotte/brain-eegs: Preprocessed EEG wavelet data from Kaggle Grandmaster Chris Deotte

Starting Notebooks (EDA, Training and Inference, Insights)
https://www.kaggle.com/competitions/hms-harmful-brain-activity-classification/discussion/473406 **:** About the characteristics of EEG - Octopus210 (Expert)
https://www.kaggle.com/competitions/hms-harmful-brain-activity-classification/discussion/472976 : Grad Cam : What is important in Spectrograms? - Chris Deotte (Grandmaster)

https://www.kaggle.com/code/abaojiang/lb-0-46-dilatedinception-wavenet-training : [LB 0.46] DilatedInception WaveNet - Training - AbaoJiang (Master) => One of the backbone model notebooks used. Based on Chris Deotte's works
https://www.kaggle.com/competitions/hms-harmful-brain-activity-classification/discussion/479207 : Preprocessing in the Labeling Done by Experts - rafaelzimmermann1 (Expert) => Very important discussion regarding possibility of the competition organizer to disclose the experts methodology of preprocessing the dataset for reproducibility of the competition
https://www.kaggle.com/code/seanbearden/effnetb0-2-pop-model-train-twice-lb-0-39 : EffNetB0 2 Pop Model Train Twice - [LB 0.39] - Sean Bearden (Expert) => Significant insight regarding distribution split within the dataset, suggesting a two pass training. Based on Chris Deotte's works.
https://www.kaggle.com/code/yunsuxiaozi/hms-baseline-resnet34d-512-512-inference-6-models : HMS baseline_resnet34d(512*512 inference 6 models) - yunsexiaozi (Master) => One of the backbone model notebooks used.

External Resources

D. Ma, J. Zheng, and L. Peng, "Performance evaluation of epileptic seizure prediction using time, frequency, and time–frequency domain measures," Processes, vol. 9, no. 4, p. 682, 2021.

Kim, Kion (2018), WaveNet: Increasing reception field using dilated convolution, Medium https://medium.com/@kion.kim/wavenet-a-network-good-to-know-7caaae735435

Balaban, Jonathan (2022), How WaveNet Works?, Medium https://freedium.cfd/https://towardsdatascience.com/how-wavenet-works-12e2420ef386

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