EEG Signal Analysis for Emotional Stimulus Decoding

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Abstract

Importance of Emotional Stimulus Decoding:

- Emotions control our daily lives, having a positive or negative affect
- Being able to determine a person's emotional state will help improve their life

Goals:

- Classify between the different stimuli based off EEG data
- Identify channels most associated with classifying emotions within the stimuli

During this REU program, the goal is to classify accurately between different emotional stimuli using a variety of machine learning techniques.

Introduction

Electroencephalogram (EEG):

- A test that records the electrical signals of the brain.
- Recorded using electrodes that are put on the scalp which measure brain activity and send data in the form of signals.
- Can be classified based off band frequencies
- Can be fed to machine learning algorithms for classification

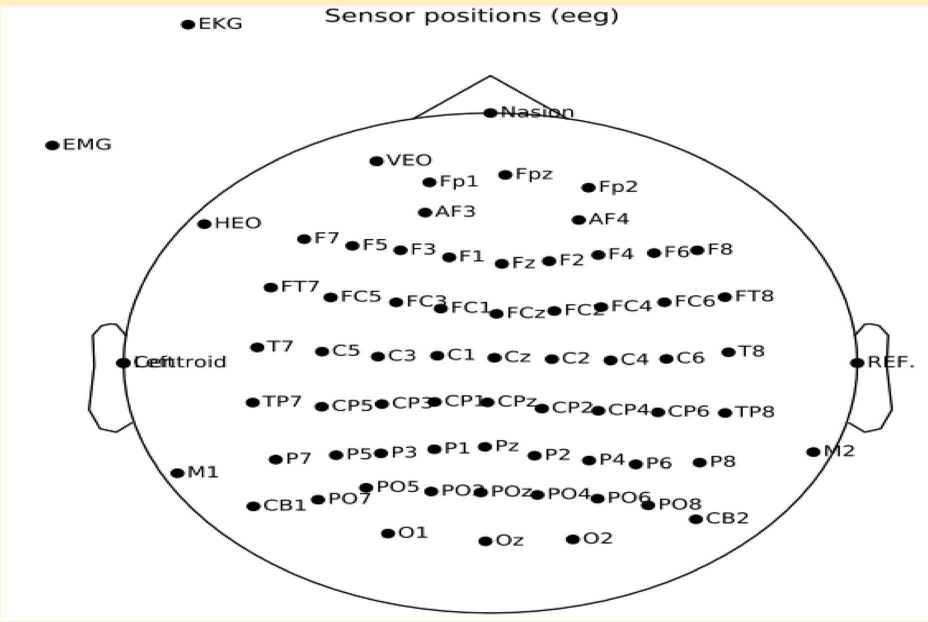


Figure A: Positions of the EEG channels on the scalp

Our Dataset:

- LaBar Facemorph files, conducted by Kevin LaBar, Michael Crupain, James Voyvodic and Gregory McCarthy at Duke University.
- 64 EEG channels recorded with Neuroscan SynAmps
- 24 participants were shown 4 different stimuli: static fear, static anger, dynamic fear, dynamic anger

Figure B: Example of images depicting either fear or anger stimuli

Methodology

Tools:

- Google Collab
- Python
- TensorFlow
- SciPy
- MNE

MEG + EEG ANALYSIS & VISUALIZATION

Models:

- 1D-Convolutional Neural Network (CNN)
- Long Short-Term Memory (LSTM)

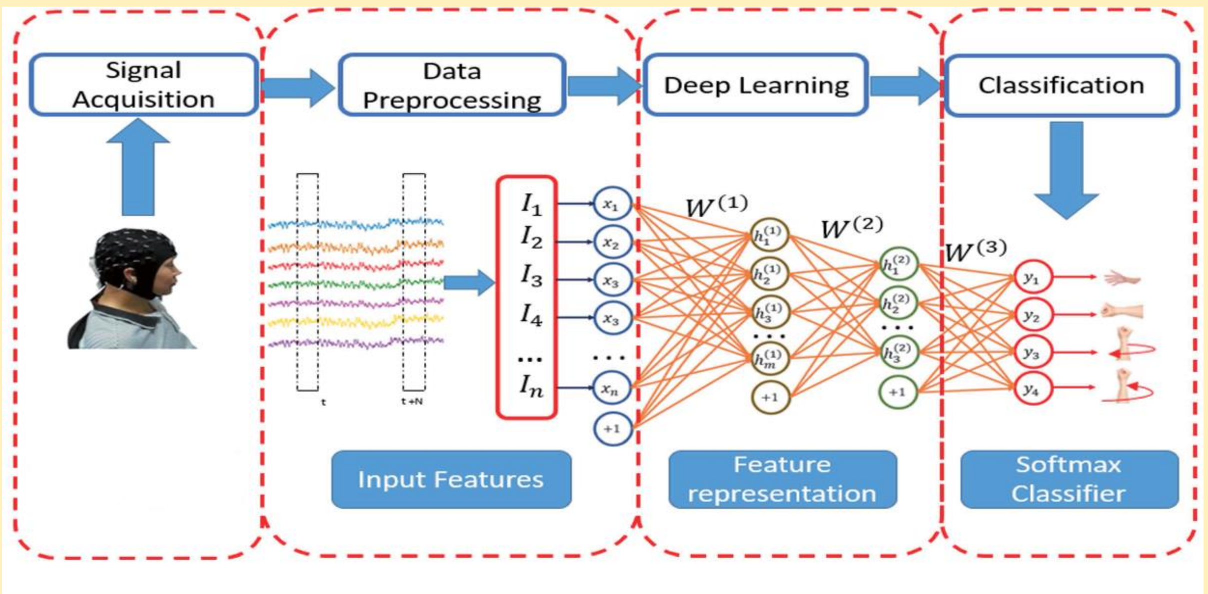
Techniques:

- Fine-Tuning
- Transfer Learning
- Scaling
- Cross Validation

Classifications:

- Fear vs Anger
- Static vs Dynamic

Figure C: A general overview of the process from collecting EEG data to classifying it [1].



Results

Fear vs Anger Classification:

1D-CNN	LSTM
ACCURACY: 59.00% (+/- 9.17%)	ACCURACY: 54.00% (+/- 4.90%)

Confusion Matrix:

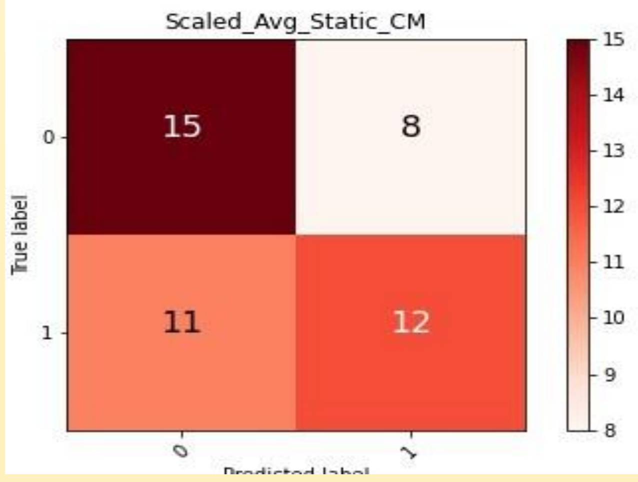


Figure D: Confusion Matrix for a fear vs anger classification of the static files using a 1D-CNN Model.

Static vs Dynamic Classification:

1D-CNN	LSTM
ACCURACY: 57.68% (+/- 1.31%)	ACCURACY: 52.36% (+/- 1.90%)

Confusion Matrix:

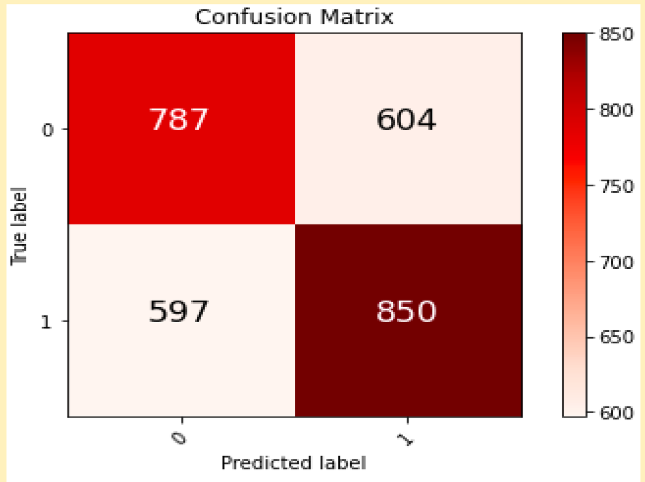


Figure E: Confusion Matrix for a static vs dynamic classification of the fear files using a 1D-CNN Model.

Figure F: Scalp topography combined with a butterfly of EEG signals for a user, showing what parts of the brain are activated at different time frames throughout the stimuli

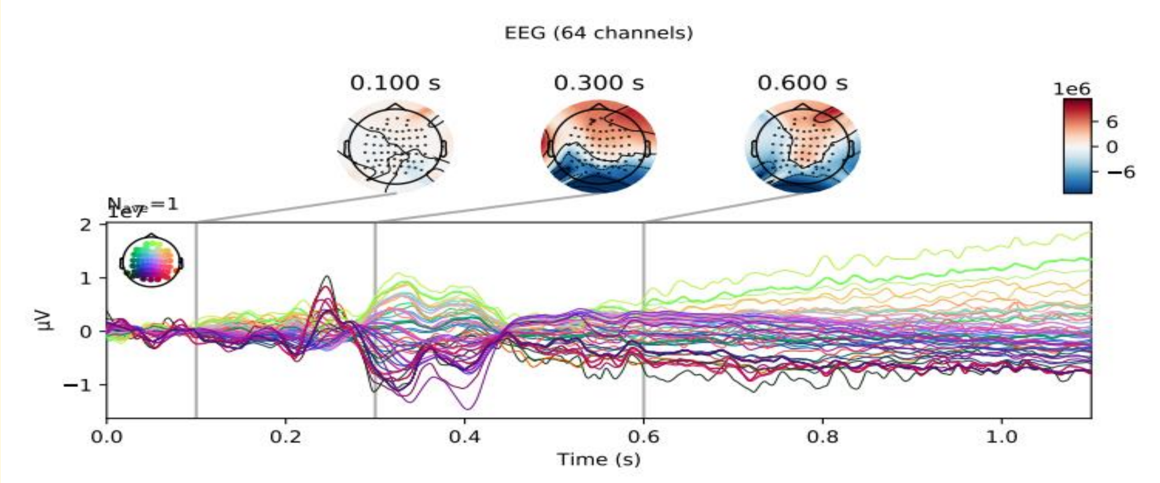
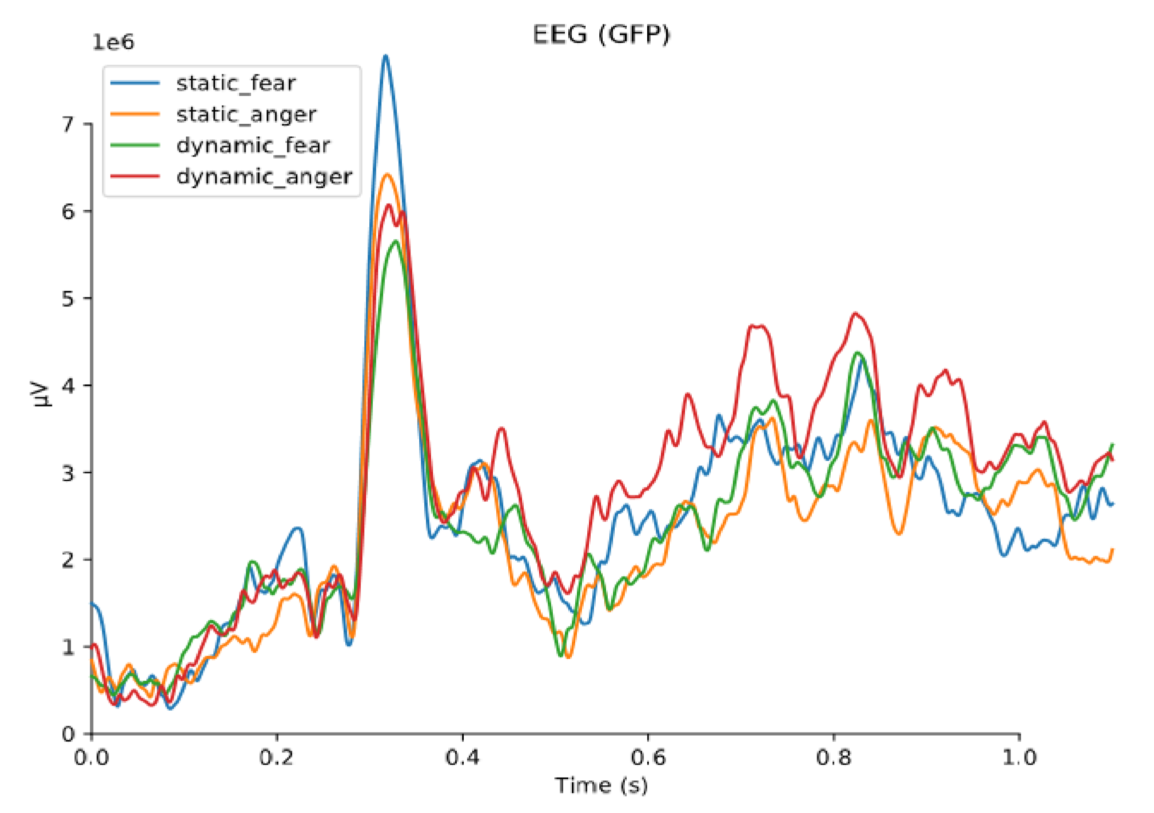


Figure G: Graph comparing the EEG signals of the four classification types for a single user



Conclusion

Looking at the EEG signals for each user, the conclusion is formed that the signals for each of the stimuli were too similar to each other for the models to detect any clear pattern to differentiate between them. As a result, we were not able to achieve above a 60% accuracy with this dataset.

The electrical brain activity caused by images of fear and anger are too closely related. The hope is that with a dataset containing two stimuli that are not closely related, the accuracies could be much higher.

References

1. Idowu, Oluwagbenga Paul, et al. "Towards Control of EEG-Based Robotic Arm Using Deep Learning via Stacked Sparse Autoencoder: Semantic Scholar." *Semantics Scholar*, 1 Jan. 1970, www.semanticscholar.org/paper/Towards-Control-of-EEG-Based-Robotic-Arm-Using-Deep-Idowu-Fang/2d1320b19f8e9fce80d0efac6d06619ddb8d89f6.

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