Analysis of EEG with Machine Learning

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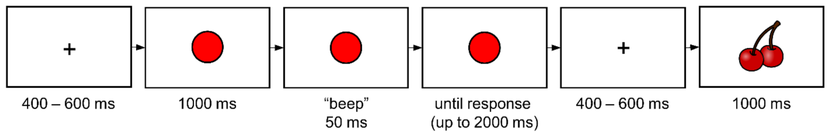
The goal of this project was to train a machine learning model to accurately classify an EEG event (electrical activity on our brain) after training on past events.



01. Introduction

Our capstone project was done in collaboration with Dr. Cameron Hassall from the Psychology department at MacEwan University. Our research was based on one of Dr. Hassall's papers on "Task-level value affects trial-level reward processing", where he wanted to determine if the Anterior Cingulate Cortex was responsible or involved in decision making. To determine this, the following task sequence as shown in Figure 1 was carried out 427 times using 12 participants over a 50 minute period. While the participants completed these tasks, brain activity was being measured using an electroencephalogram (or EEG). For our project, the goal was to train a machine learning model to accurately classify an EEG event after training on past events.

03. Methodology

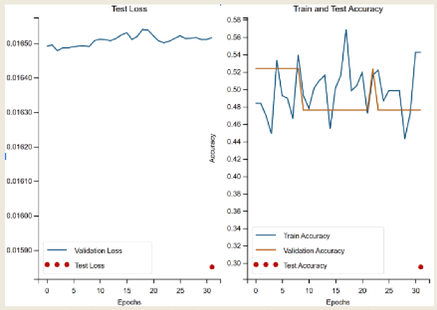
- Preprocessing with MNE-Python (Minimum norm estimation)
- Randomization of Data
- Analysis
  - Linear Discriminant Analysis (LDA) with Python Scikit library
  - Convolutional Neural Network (CNN) with Pytorch and Tensorflow deep learning libraries

04. Results/Findings

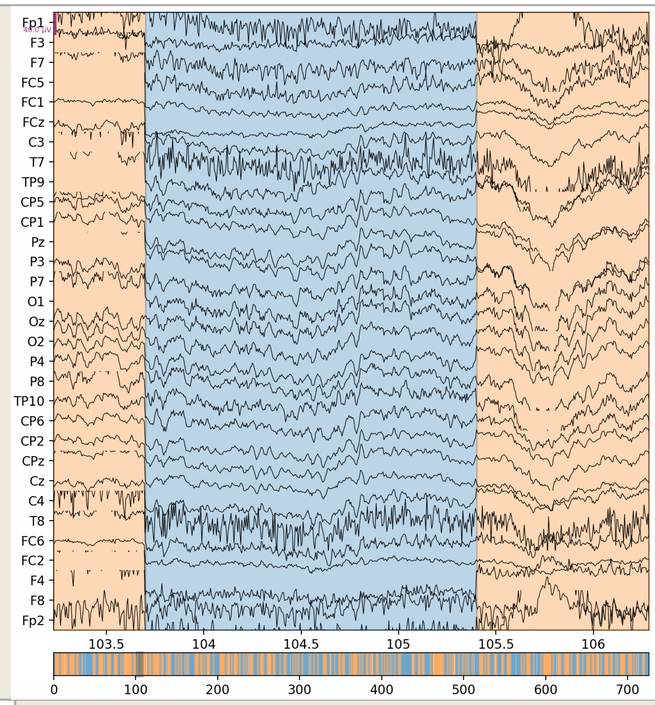
- **Traditional Machine Learning: Linear Discriminant Analysis (LDA)**

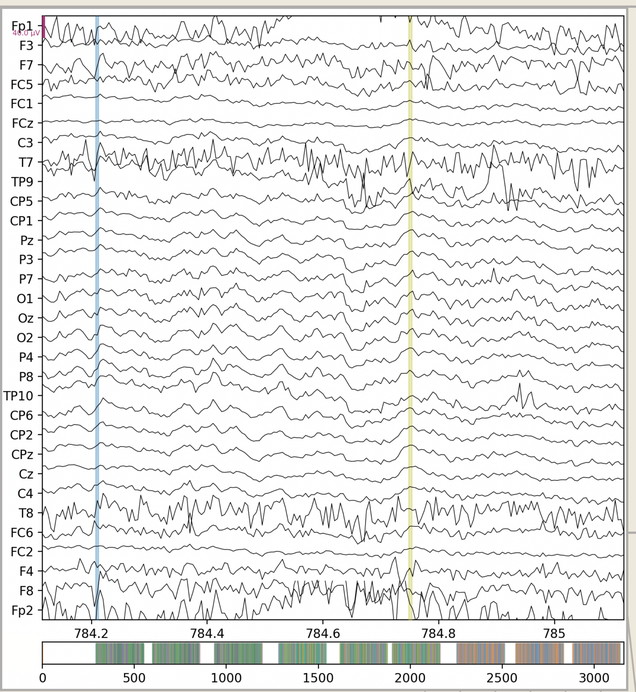
  - model overfits
  - possibly due to lack of data or over-smoothing the data

- **Deep Learning with Convolutional Neural Network (CNN)**
  - the model fails to train



Results for our Convolutional Neural Network Model





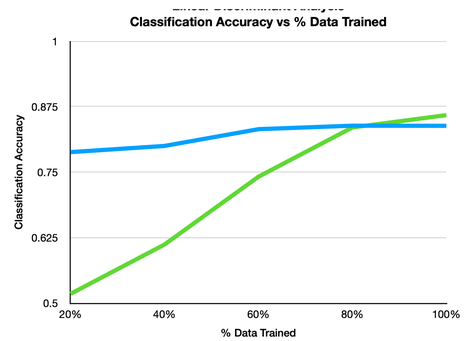
02. Objective

We wanted to successfully classify different events using machine learning

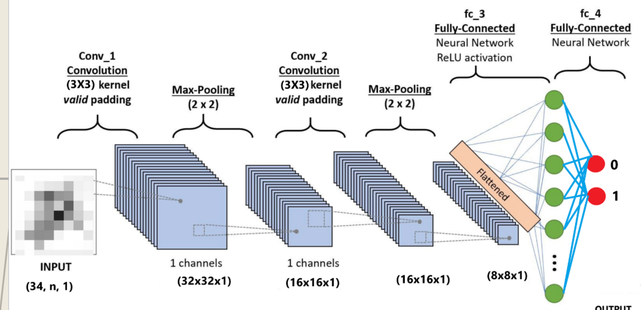
05. Analysis

There are some possibilities to consider on why LDA did not perform well

- Improper preprocessing of the data. we did not remove noise, look for "bad" events, or get rid of unnecessary frequencies.
- The signal did not have enough information - could use frequency decomposition or a spectrogram analysis.



Results for our Linear Discriminant Analysis (LDA)



Convolutional Neural Network Architecture

For CNN, there are several reasons that it did not work.

- when the first convolution is formed, the channels for the electrodes would be lost.
- convolutions were done both spatially and across channels resulting in mixing of the channels data

06. Conclusion

Although some of our results worked in the end, this project has a significant potential for improvement with further investment of time and resources. Specifically, the result of the Linear Discriminant Analysis. Yet, working with a Convolutional Neural Network (CNN) may not have been the best approach. We suggest investing more in applying further the potential methods such as altering the Deep Learning models to either 1-Dimension or treating the data as sound, so that we can classify EEG events more effectively.