EEG Signal Processing and Classification of brain intentions

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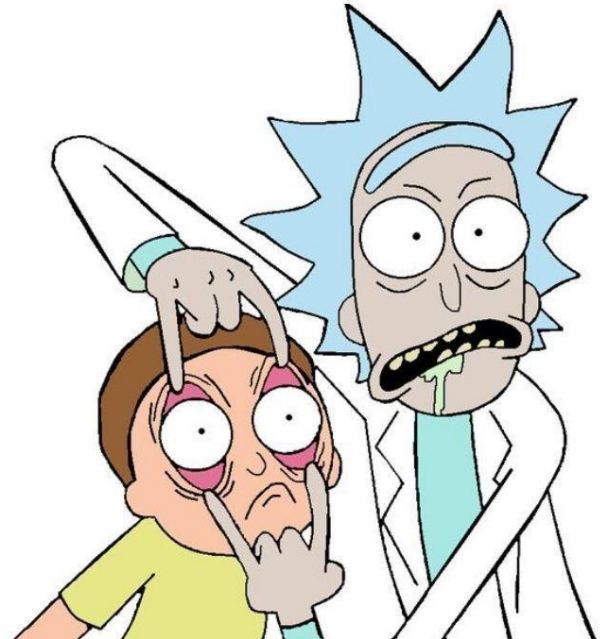
Signal Processing Course

CS UCU 2021

A G E N D A

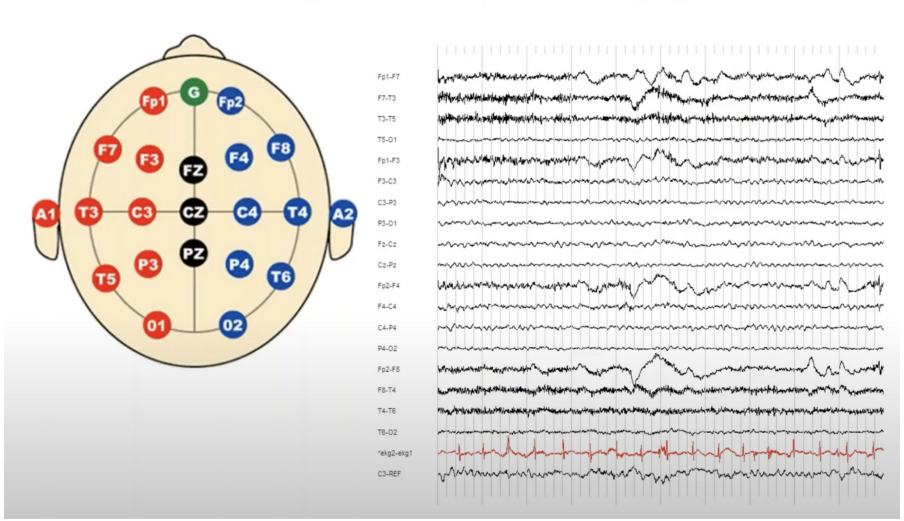
1. EEG signal [**I N T R O**]
2. [**D A T A**] collection
3. Data pre-processing
4. Feature engineering
5. Classifier [**M O D E L**] training & evaluation



What is [**E E G**]?

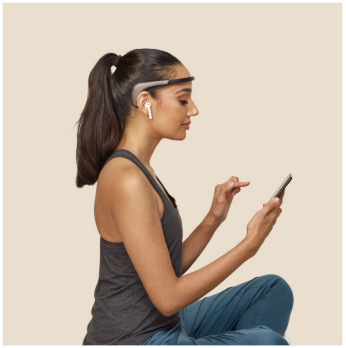
An electroencephalogram (EEG) is a test used to evaluate the electrical activity in the brain. Brain cells communicate with each other through electrical impulses. An EEG can be used to help detect potential problems associated with this activity.

We can see the basic electrode placement of 22 electrodes on the right hand, and on the left hand, we can see EEG signal recorded.

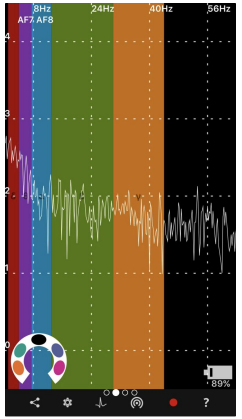


DATA COLLECTION

We used Muse 2. It is a brain-sensing headband that uses real-time biofeedback in form of 14 EEG channel signals.



To collect the data from Muse I had to use third-party software called Mind Monitor.



setup of the [**E X P E R I M E N T**]

The setup was as follows (the following is copied from the paper):

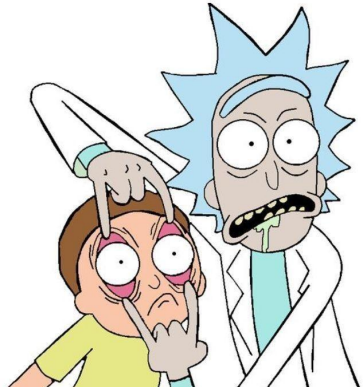
1. The participant is sitting down on a chair with arms extended in parallel, resting on a table.
2. Two bottles of water are on the table. One of them is approximately 5 cm to the left of the left hand and the other bottle is 5 cm to the right of the right hand.
3. The participant's head faces forward, while the eyes rotate to the left, looking to the bottle.
4. We asked the participant to imagine picking up the bottle with the left hand, but without moving the hand; only thinking about it for 6 s.
5. Then, we asked the participant to look at the bottle on the right and imagine picking up the bottle with the right hand, but without moving the hand, only thinking about it for 6 s.
6. We repeated steps 4–5 for 3 times for each participant: 1 min in total.
7. Then, we repeated steps 1–6 for 5 times.

[DATA]

This is the data we have collected.

As you can see, quite noisy.

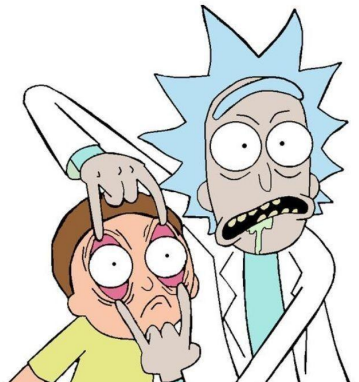
Let us process the data ;)



[**D A T A**] pre-processing

1. Set labels
2. Aggregate values of each EEG channel for each 100 milliseconds
3. Clean the data: Outlier detection and removal with GMM
    a. Butterworth Filter Frequency Response
    b. Using Nyquist Frequency
    c. Gaussian Mixture Model
4. Feature engineering
    a. Dimensionality reduction with PCA
    b. Dimensionality reduction with ICA
    c. Add moving windows statistics values
    d. Apply Fourier transform

Now it is much more smooth <3

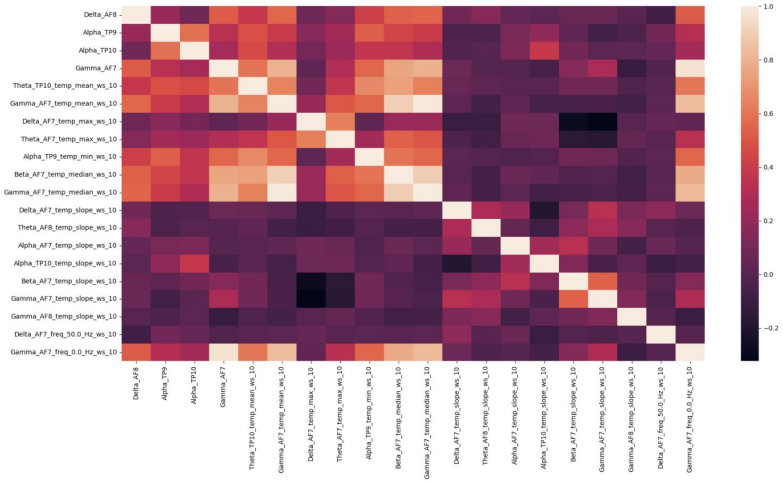


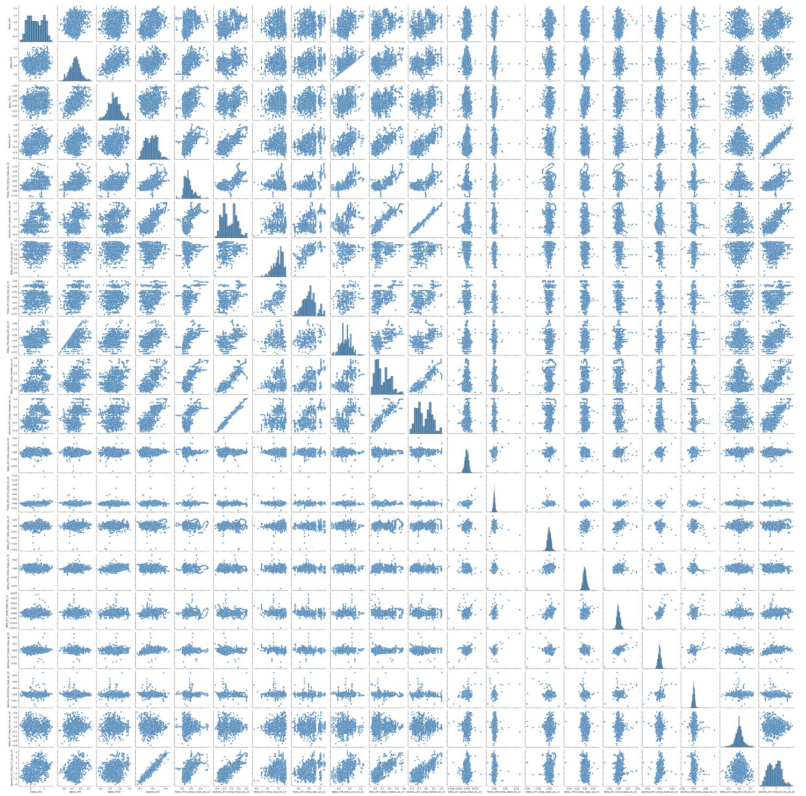
Classification of brain process based on the [**E E G**] signal

We trained a Random Forest Classifier. There were three experiments:

Experiment	Number of features	Accuracy on test dataset
Large RFC model	344	87%
RFC with selected by RFC features	20	86%
RFC with selected by RFE features	20	85%

Correlation among the [**T O P**] 20 features





Conclusion:

In this work, **we did all the processes from scratch.** This work contains:

- data collection,
- dataset creation,
- data pre-processing,
- data cleaning,
- and modeling the data.

We have seen that it is possible to collect the data with EEG channels doing a set of experiments, we also cleaned the data in the way to build a Random Forest Classifier on top of the data collected.

Pre-processing of the data needed a lot of different techniques:

- we used the sliding window approach,
- statistics aggregation,
- PCA & ICA dimensionality reduction,
- and FFT to represent the signal with a wider feature range.

The whole path lead us to the classifier model, that we successfully trained on **344** features, getting **accuracy 87%** and using 20 features to get 85% and 86% accuracy values.

Thank u very much for ur attention!

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