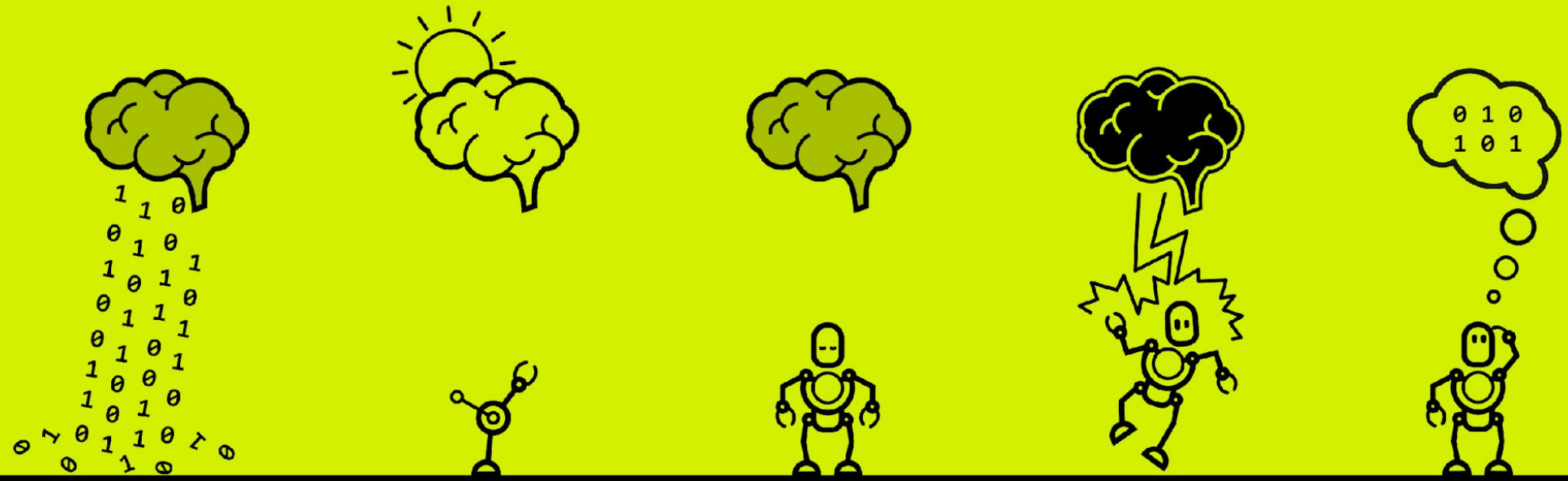

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Team ROCKET

Random Convolutional Kernels for SSVEP Feature Extraction

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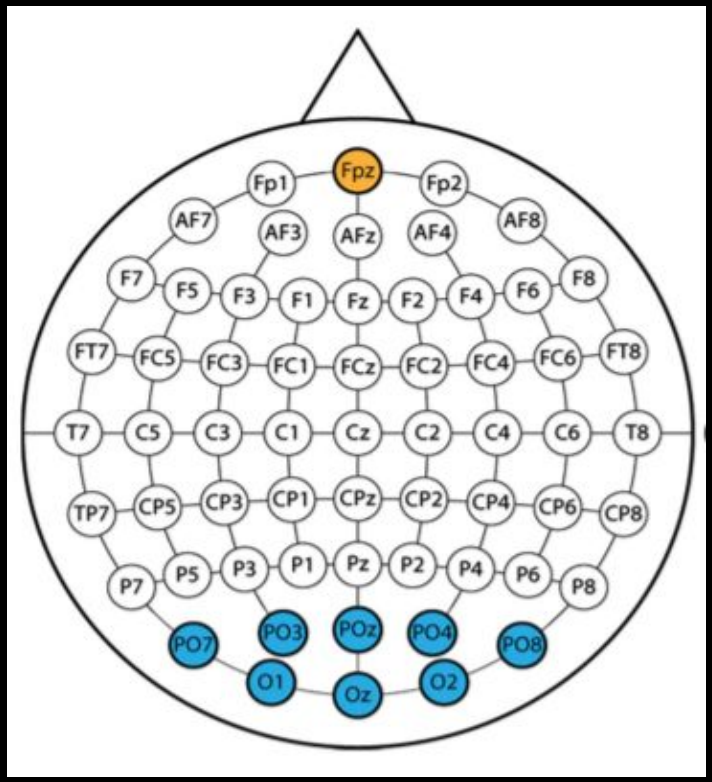
DATA DESCRIPTION

SSVEP BCI

- **EEG data**: 8 channels x time
- **40 trials (7s) for each patient**: four LEDs flickering at different frequencies
- **Stimulation frequencies**: 15, 12, 10, 9 Hz
- Problem: Multiclass Classification



Several seconds are required to identify each class [1].
Is it possible to reduce such temporal interval?

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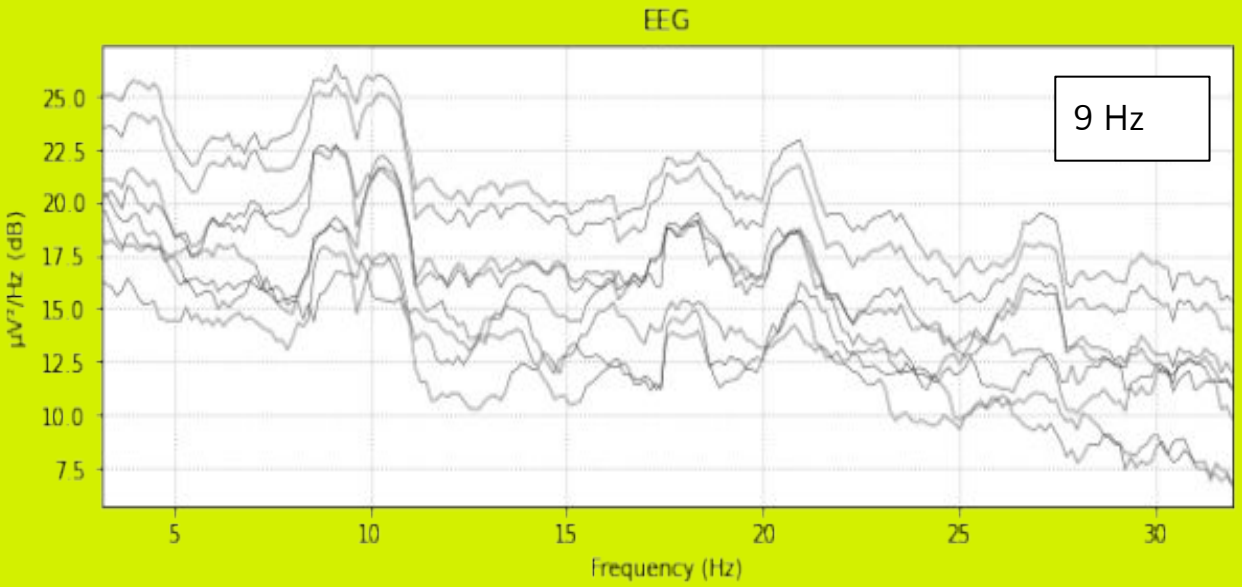
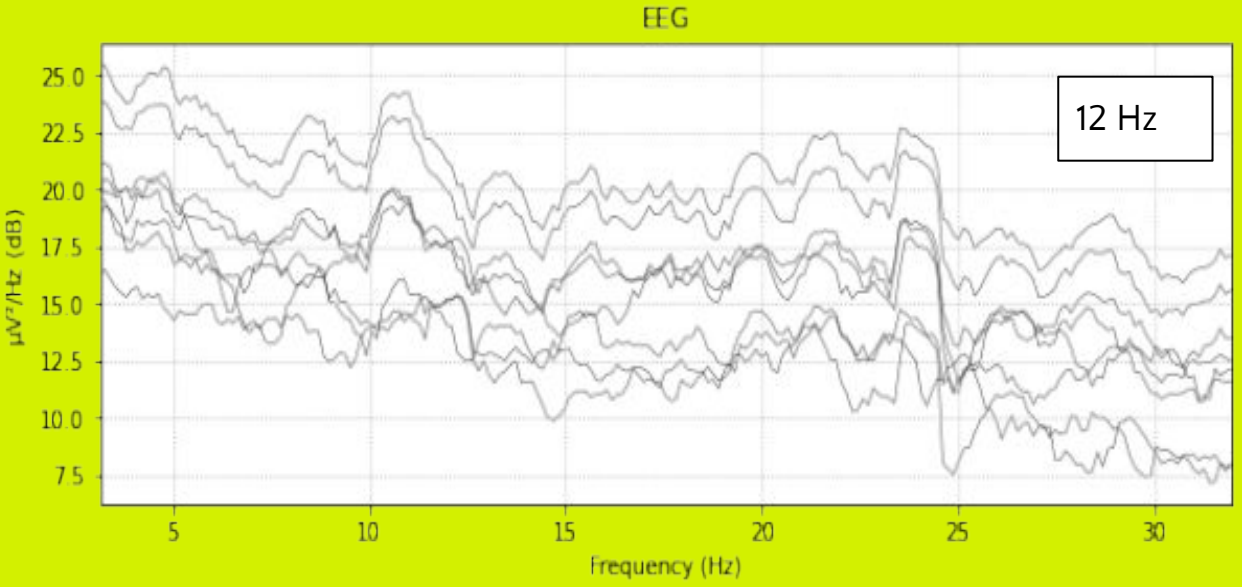
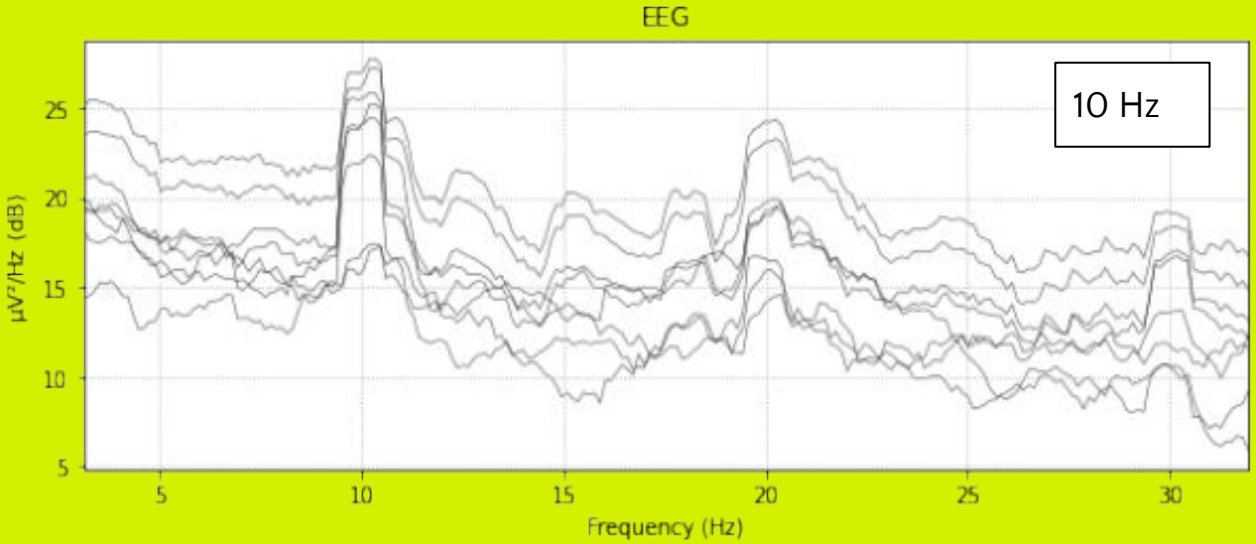
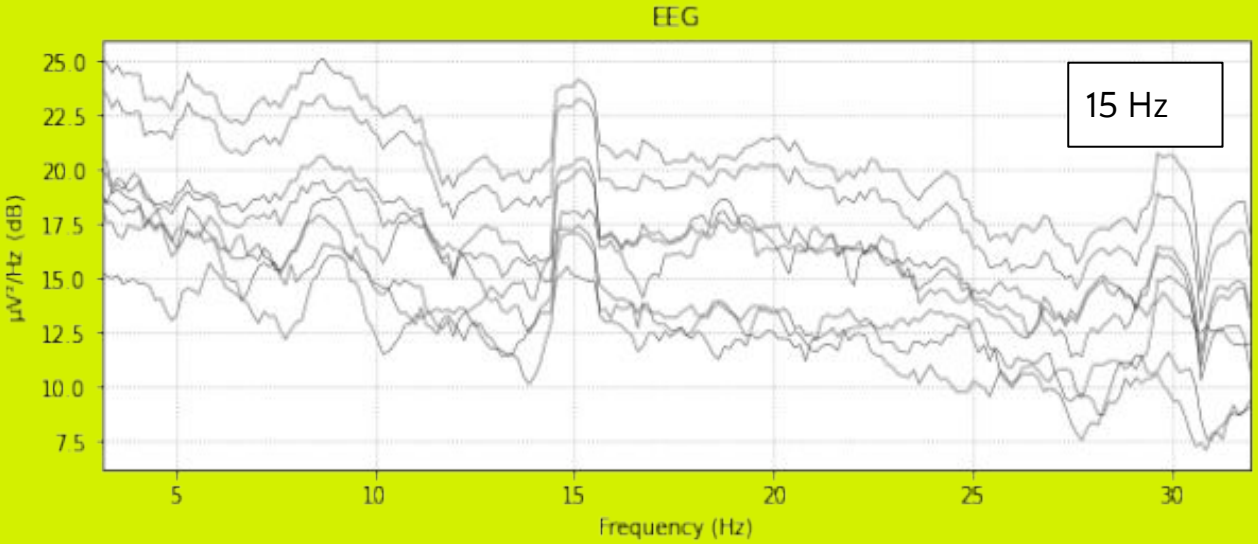
SPECTRAL ANALYSIS (Time frequency PSD Welch)

The limitation is the length of the time window









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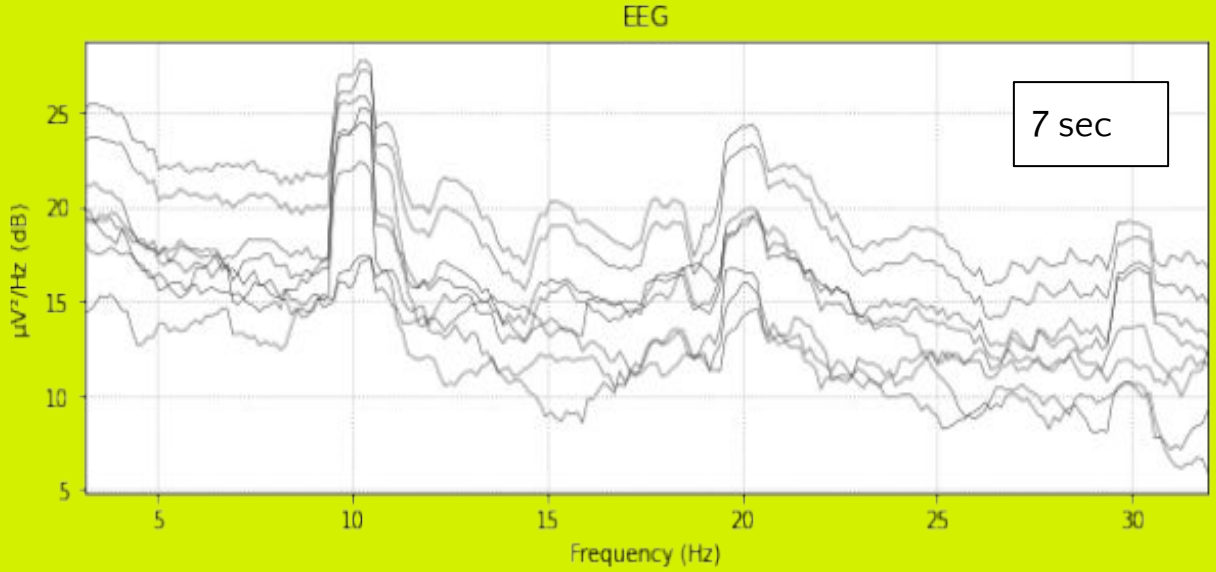

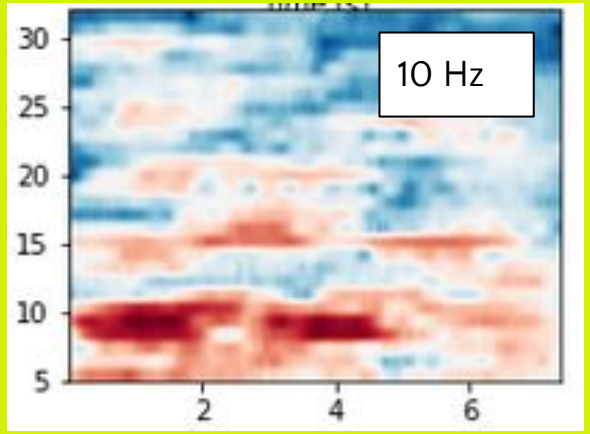

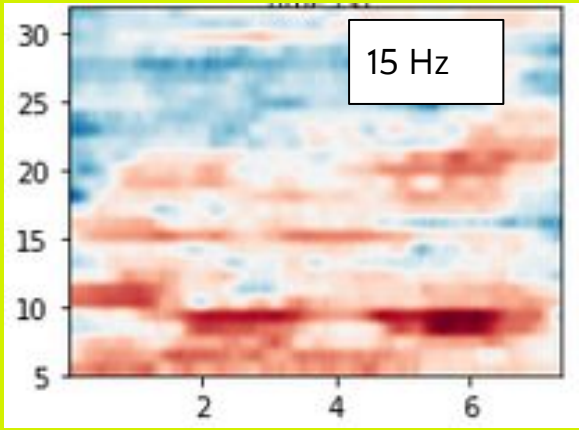

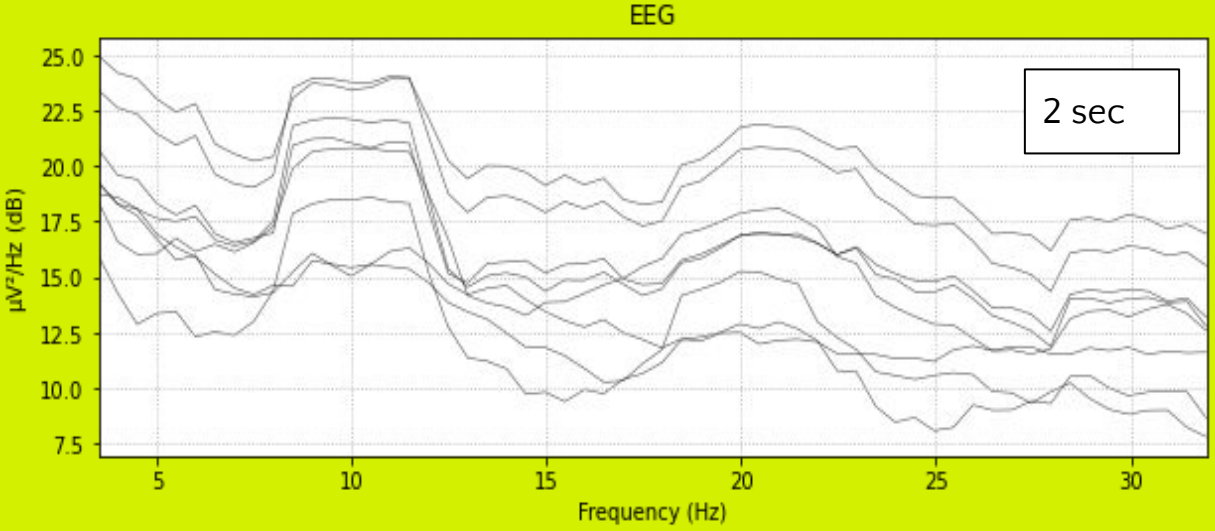

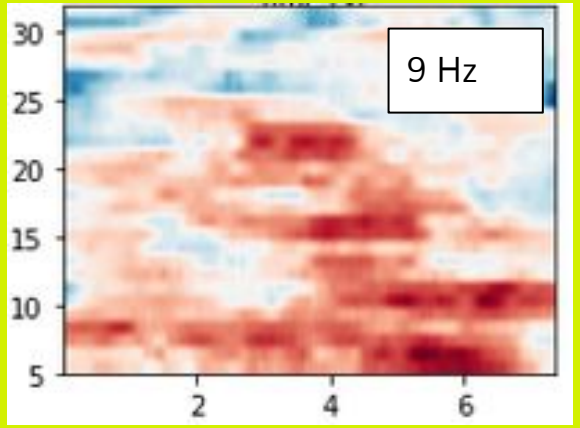

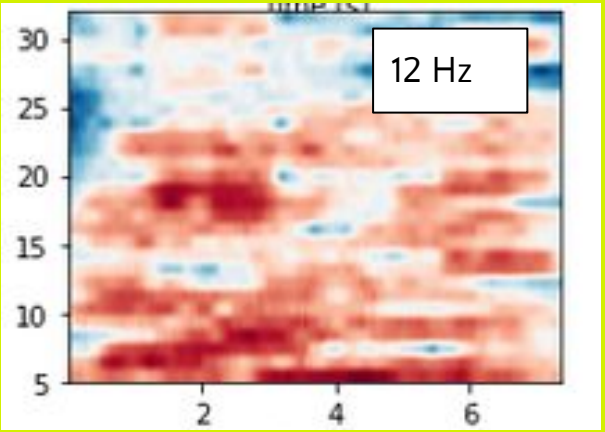

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OUR INSIGHT

Extract features from the preprocessed time series with the ROCKET ALGORITHM: RandOm Convolutional KErnel Transform [2].

It is a time series classification method that uses random convolutional kernels.


ROCKET: exceptionally fast and accurate time series classification using random convolutional kernels

Springer

September 2020 · Data Mining and Knowledge Discovery 34(3) ·

DOI: 10.1007/s10618-020-00701-z

Angus Dempster · François Petitjean · Geoffrey I Webb

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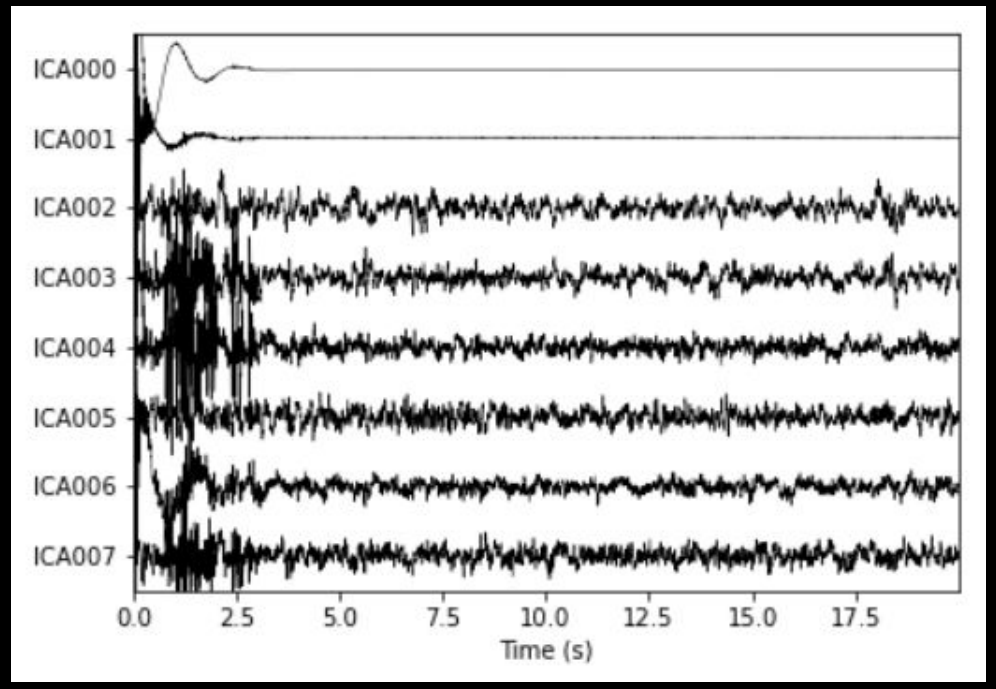
IMPLEMENTATION

We developed our work in three steps:

1. **Preprocessing:** we filtered the signals [3]
2. **Features extraction:** to capture significant characteristics of data [2]
3. **Classification:** to determine which frequency each trial corresponds to

STEP 1: PREPROCESSING



- High pass Temporal filter – 1 Hz: to eliminate slow drifts
- Spatial Filter: Common Average Reference (CAR)
- Independent Component Analysis (ICA)

Moreover, we segmented the dataset into 40 trials: 10 for each stimulation frequency. We are dealing with a 4 class problem.

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STEP 2: FEATURE EXTRACTION

ROCKET ALGORITHM

(RandOm Convolutional KErnel Transform)

1. Kernels initialization: length, weights, bias, dilation, and padding were randomly set
2. Each kernel is applied to each input time series, producing a feature map
3. Two aggregate features from each feature map were computed:
   - The maximum value (global max pooling)
   - The Proportion of Positive Values (PPV)

Max Pooling: dimensionality reduction and temporal invariance

PPV: captures the positive / negative proportion which matches a given pattern.

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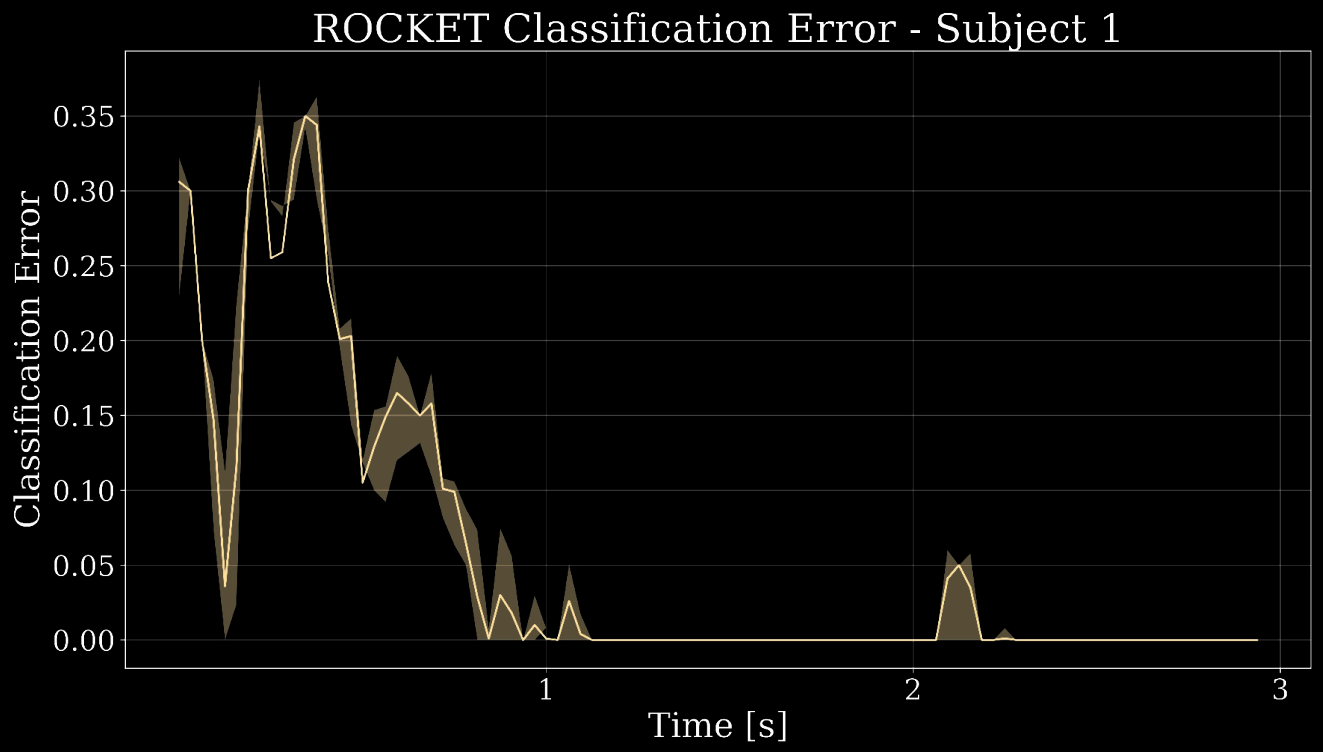
STEP 3: CLASSIFICATION

- We trained a ridge classification model for each class applying one versus rest classification, with a L_2 regularization.
- We evaluated the performance of the classifier using 5-fold Stratified Cross Validation.
- We used 20 trials for the training set (training with cv) and 20 for the test set. We repeated the study on the second patient.

RESULTS – SUBJECT 1

- We obtained an accuracy of 1.00 on the test set, by using only 1 second for each trial:



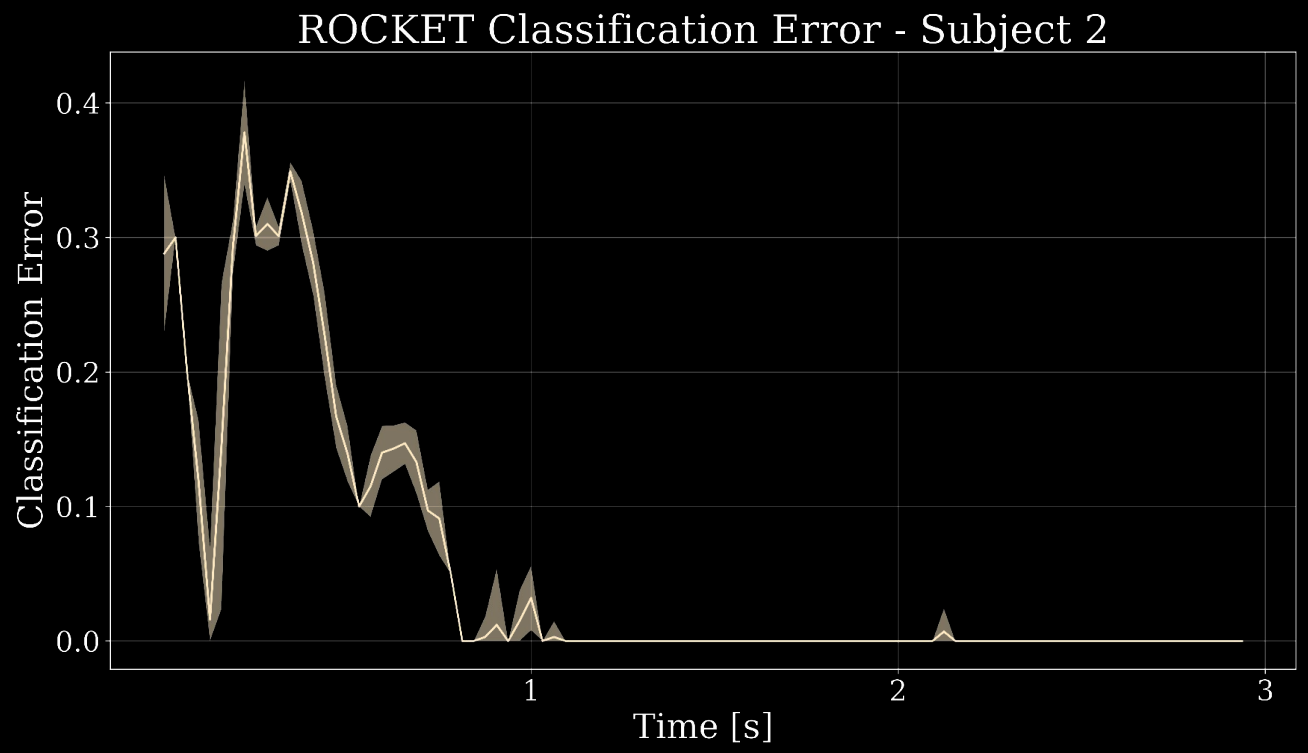
LDA baseline [1]:
95.5 %

On raw data:
95 % on 1 s

On filtered data:
100% on 1 s

RESULTS – SUBJECT 2

- We obtained an accuracy of 1.00 on the test set, by using only 1 second for each trial:



LDA baseline [1]:
95.5 %

On raw data:
95 % on 1 s

On filtered data:
100% on 1 s

Confusion Matrix

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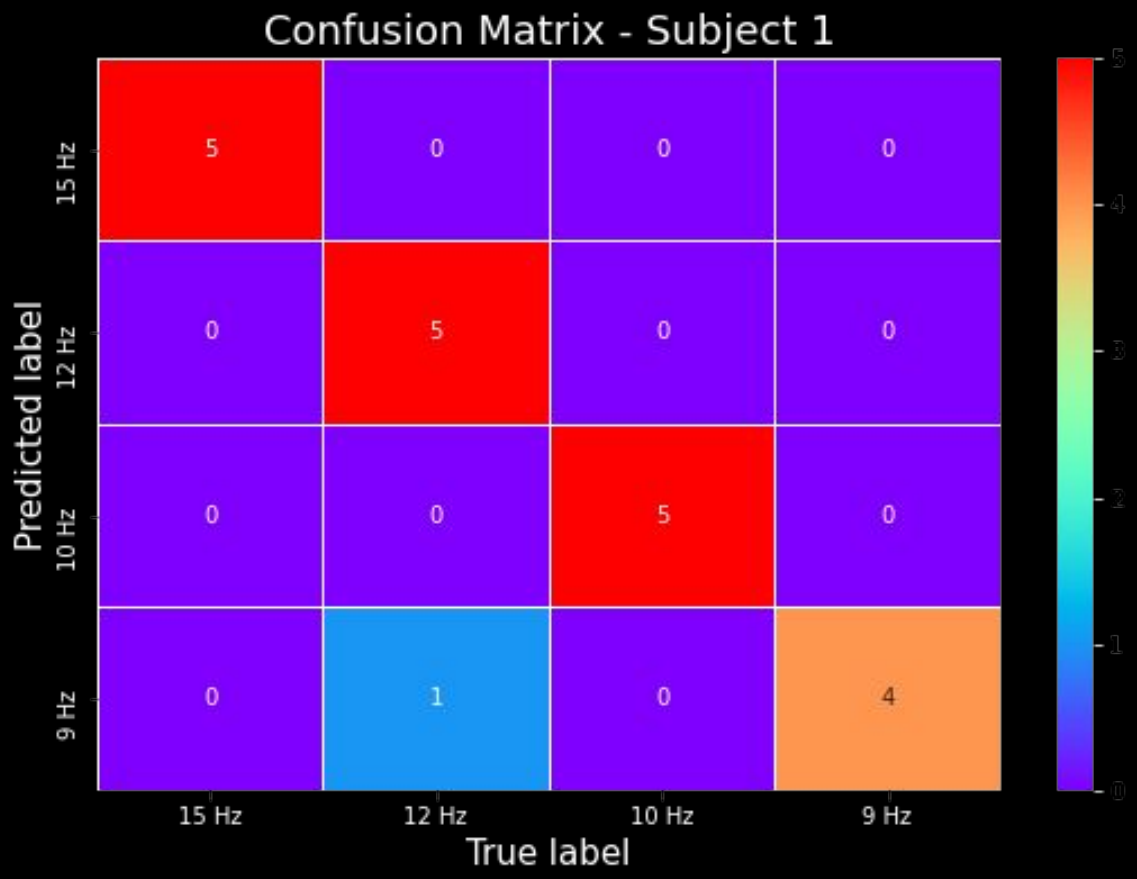
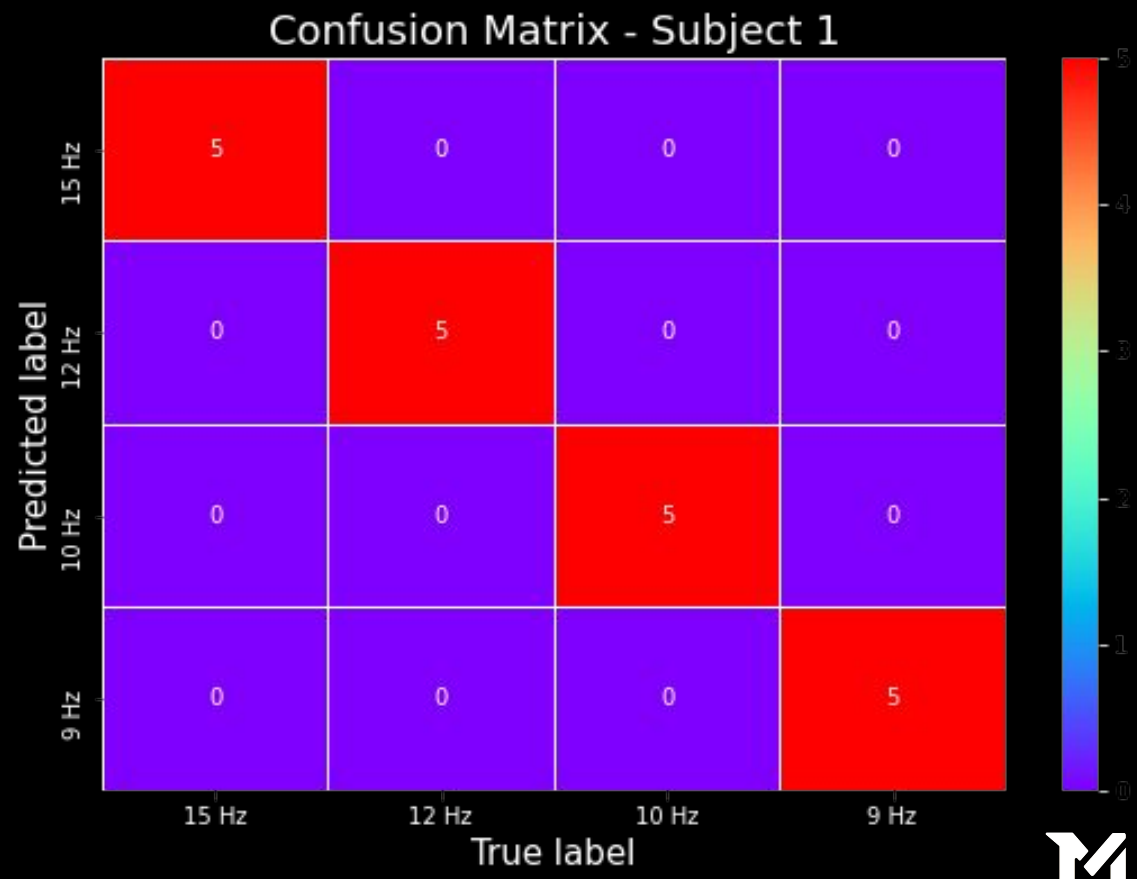
Non-Filtered



Filtered ICA CAR



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REFLECTION AND FUTURE DIRECTIONS…

The ROCKET ALGORITHM proves to be an appropriate technique to extract useful features from temporal series. This can be generalized to other types of biosignals, like ECOG or ECG, and could be used for further developing advanced tools.

What's next?

- Real time (mini-rocket is 75x faster) / Online learning
- Feature importance (SHAP, LIME)
- Investigate generalization power on different patients

https://github.com/MachineLearningJournalClub/SSVEP_IEEE_SMC_2021

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