EEG project research a-proiri plan [Apr 4]

This is **the first text** on the EEG ERP project with an a-priori description of possible models.

At first

1. Check this plan to approve
2. Align this plan to fit the project goals
3. Set the priorities on the papers and models listed below
4. For each paper, make a selling motivation (and detailed algorithm description)
5. Find similar open datasets to do an open computational experiment
6. Find programmers to code the computational experiment on the collected open data
7. Set computational experiment protocol in detail to compare various models
8. Check if this assembly of papers forms the final report

ERP feature extraction with Dynamic time Barycenter Averaging

The ERP signals are well-studied. Most likely, a decent library already exists to extract ERP features (time and value of P and N peaks and difference between signals in time and space). The Dynamic Time Warping clustering forms the model ERPs as centroids of aligned historical ERPs.
TODO: Find markup ERP code. Find the DBA code. Suggest the optimal model as a spline. Include SEMOR. We shall include a naive Bayesian model with prior ERP patterns to detect ERPs.
Note: assuming the main hypothesis “the ERP features classify the event” works, the comprehensive collection and the code library with analysis is a Nature-worth paper.

D4 and S4 diffusion models for ERP classification

The State-space representation models come from the differential representation of the state. It makes the usage of the infinite number of decoder layers natural. The controlled neural ODE makes variants of ERP signals; the spline representation is the most promising. The stochastic part of the SSM shall include diffusion models and normalization flows.
TODO: List the hypothesis and assumptions for the D4 Bayesian part. Then, check the components of the last D4 model, and analyze the importance of the components. Check the importance of the data ad parameter distributions for the ERP classification quality. Discuss if the D4 with the FREUD computational experiments can be a new paper.

Tensor representation of the Discriminative Direct Decoders

To investigate the spatial proliferation of the signal, we need the multiway tensor representation of the data. The tensor convolution model is a productive way to expand the decoder D4 model to consider the dependencies in space and time.

TODO: Proipse a tensor convolution model in the style of Singular Spectrum Analysis. Select a good library for tensor, tensor-train, and deep learning tensor decomposition.

ERP metric analysis and Riemannian geometry

The metric models recently delivered huge advancements in EEG signal analysis and classification. The idea was that the spatial propagation of the signal wave plays the main role in body control. The Riemannian model reveals functional groups in the brain, constructs graphs of signal transfer, and assigns importance weights to the electrodes. For example, a simple concept of distance between ERPs of between time series allows the removal of noisy electrodes.
TODO: Check if EEGNet and HTNet include the spatial component or the time component only. Check if the GRAND Graph Diffusion research and code are developed enough to yield fast results.

Multi-modeling of heterogeneous signals for ERP classification

The ERP signal quality highly depends on the stimulus-accompanied and concomitant manifestations. For example, literature declares the role of the eyes blink noise. Since the project has facial and eye-tracker data, it is worth including them in the EPR classification model. The multi-model could be a flip-flop structure, canonical correlation analysis, or convergent cross-mapping.
TODO: Prepare the criterion of concomitant-effect measurement.

EEG computational experiment and model comparison

The EEG EPR classification project requests a highly reliable model to declare a patient's state. It fixes the patient's observation protocol. We need a formal protocol for the computational experiment to compare models. The comparison criteria are accuracy (AUC in the project proposal and derivatives like F1 score), stability (in time, among patients, among trials and datasets), and complexity. The experiment results are in the table **Models** times **Datasets** times **Criterions**.
TODO: Specify the model comparison protocol and compare it with existing ones like INRIA Grenoble. Find the open datasets to exchange and publish results. (Search for a code to generate features. Gather a collection of models to compare with.)

Miscellaneous

The idea for computational research. There are many well-gathered ERP signal collections. The structure of ERP is stable and well-studied. After the great idea of HTNet to use signals from ECoG and EEG in the same model, it is reasonable to gather all EEG data across the internet and make a computationally exhaustive EEG transformer-like model to generalize all existing models of EPR classification.

~~**The idea for a startup.** How can one monitor personal neuroplasticity by a simple daily basis routine? For example, using an EEG capture device and a simple test. It shall work like people motor their weight over a long time.~~

Question. How precise are the stimulus markup and EPR signal placed in the timeline?
Question. Is there a useful library to collect a catalog of ERPs and extract features? ~~If not, check the main hypothesis on ERP importance.~~
Question. Are the trials sequence-dependent? Do we have statistics on it?

EEG folders

1. This folder Google Docs EEG and Colab ipynb
2. GitHub start the code collection EEG ERP
3. Local folders EEG with written notes and papers, EEGCode with mat-files, EEGData with open datasets
4. ~~Overleaf start the review~~