BCI ASSIGNMENT - INDIVIDUAL IMAGERY

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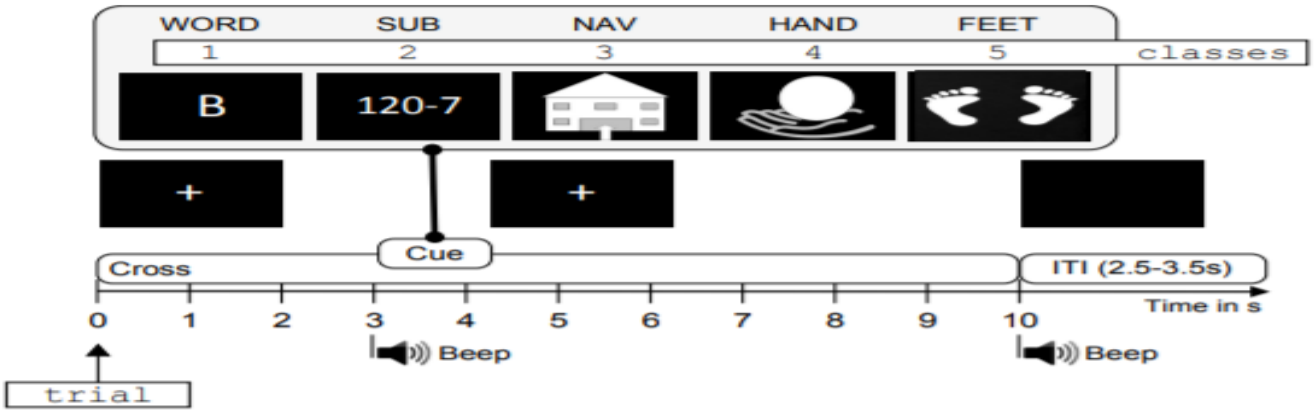
Introduction:

- This is a classification task.
- Users are presented with Visual Cue , Users will be thinking about the visual cue and at that time using those brain signals, we need to classify what they are thinking.
- **INPUT:** brain signals generated
- **OUTPUT:** one of five distinct mental tasks (MT).



Experimental setup:

- Users performed, following a cue-guided experimental paradigm, five distinct mental tasks (MT). MTs include mental word association (condition WORD), mental subtraction (SUB), spatial navigation (NAV), right hand motor imagery (HAND) and feet motor imagery (FEET).
- The cue indicating the requested imagery task, one out of the graphical symbols, was presented from t =3 s to t = 4.25 s.
- The session for a single subject consisted of 8 runs resulting in 40 trials of each class for each day.
- EEG was recorded from 30 electrode channels placed on the scalp according to the international 10-20 system.
- Total 9 users participated in this experiment.

Dataset description:

Each file consists of a cell array data which includes two structs, each corresponding to one session (day). Within each struct, the following variables are defined

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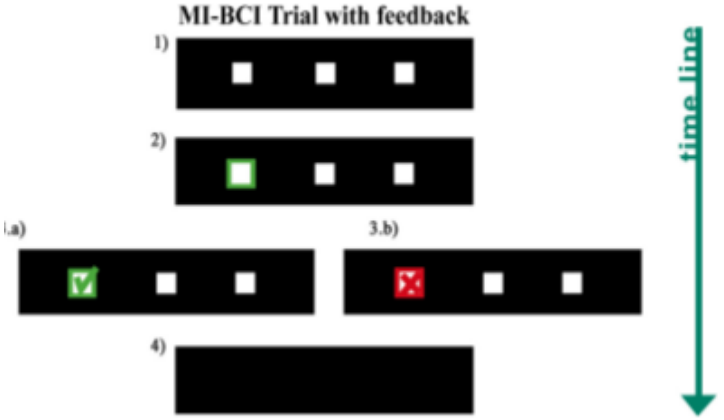
- X: EEG data matrix (dimension samples x channels).
- fs: Sampling frequency in Hz (scalar).
- trial: Begin of trial array (length number of trials). Position in data points where the i th trial starts.
- y: Class label array (length number of trials). True class label according to the visual cue for each trial. See Fig.1. Labels are assigned as follows: 1 equals WORD, 2 equals SUB, 3 equals NAV, 4 equals HAND and 5 equals FEET.
- classes: Cell array of class description (string).

Literature survey:

[1]. Motor imagery based brain-computer interface: A study of the effect of positive and negative feedback:

- In this paper, they investigate the influence of visual feedback on human response using the classical left/right hand MI-BCI paradigm
- All subjects were exposed to the positive and negative feedback conditions counterbalanced.
- Negative feedback was found to have greater learning effects for MI-BCI than positive feedback.
- 3 boxes are shown. A box will be highlighted , based on the box highlighted User should think left or right.
- Based on the thought model marks it as right or wrong (1st box left thinking left correct).
- Then take that as feedback and update the model.
- On experiment Negative feedback works better than positive feedback.



[2]. Predicting Mental Imagery-Based BCI Performance from Personality,

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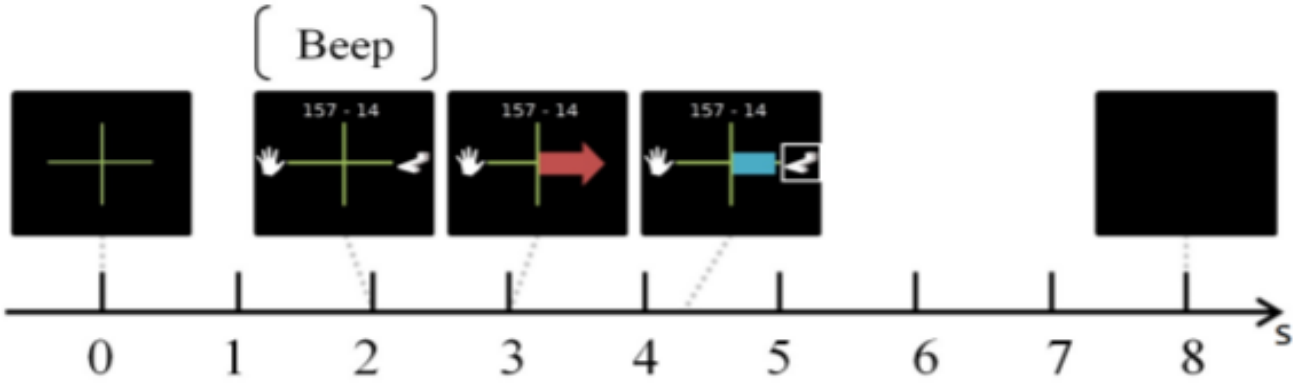
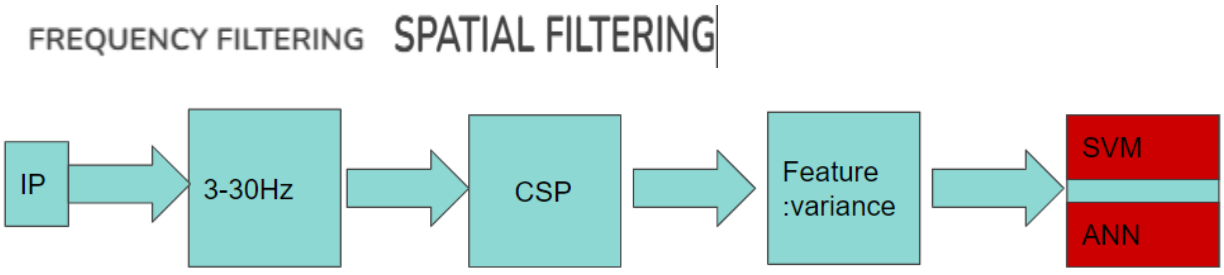
Cognitive Profile and Neurophysiological Patterns

- The aim of this study was to evaluate the impact of different psychological and neurophysiological parameters on MI-BCI performance in healthy participants
- in order to propose a model that could predict MI-BCI performances
- The MI-tasks (i.e., left-hand motor imagery, mental rotation and mental subtraction) were chosen according to Friedrich who showed that these tasks were associated with the best performance.
- “Left-hand motor imagery” (L-HAND) refers to the kinesthetic continuous imagination of a left-hand movement, chosen by the participant, without any actual movement .
- “Mental rotation” (ROTATION) and “mental subtraction” (SUBTRACTION) correspond respectively to the mental visualization of a 3 Dimensional shape rotating in a 3 Dimensional space and to successive subtractions of a 3-digit number by a 2-digit number both being randomly generated and displayed on a screen



Methodology:



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FEATURE EXTRACTION:

- **SIGNAL CONDITIONING :**
  - We have also taken the signal from 3 secs (3*256 cell)- 7 secs (7*256 cell) because the user is ideal the remaining time and we don't need it.
  - **Frequency range filtering:**
    - As the activity involves mental activity , it will mostly resemble beta, alpha, gamma patterns . Alpha has frequency range of 4-8 Hz and beta has frequency range of 8-15 hz and gamma has frequency range of 16-30 hz. This is the reason we filtered from 3-30 Hz. And to remove the noise ,like remove 50 Hz contamination due to the AC interference.
    -
  - **Spatial filtering:**
    - We applied Common spatial pattern(CSP) to project into a better space where data is more separable.
- **EXTRACTION OF FEATURE FROM CONDITIONED SIGNAL:**
  - We used the Variance of each sample in the time series domain and got those as features.
- **FEATURE CONDITIONING:**
  - Applied Log Normalization Transform.

CLASSIFICATION:

- For Classification, We have used Random Forest and Artificial Neural Network.
- We then pass the feature vector from the previous stage to these classification models, then train on them and predict the results.
- The below is the Architecture we are using for ANN.

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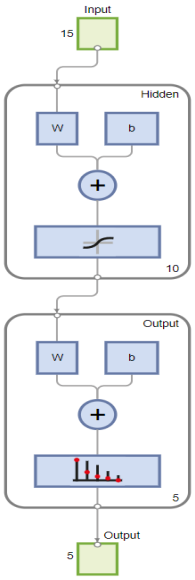

- The input will be of R^15 and the output is R^5.

RESULTS , COMPARISON:

- As this is a classification task , the evaluation metrics are Accuracy, F1 score, precision, recall.
- **OUR METHOD:** the results are using ANN,RF (the best we got is ANN when compared to Random Forest).
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User	RF(Accuracy)	ANN(Accuracy)
A	80%	85%
C	83%	84%
D	88%	77%
E	78%	80%
F	81%	86%
G	77%	83%
H	78%	85%
J	83%	79%

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L	80%	83%

- **[1].** Motor imagery based brain-computer interface: A study of the effect of positive and negative feedback **Method:**
    - **Accuracy : 92 %**

DISCUSSION OF YOUR WORK AND FUTURE WORK:

- We have used a basic setup - fft- csp, where we can improve by using different wavelets in wavelet transform and use them.
- For classifiers we can do bagging and boosting methods to improve the accuracy.
- In Future we will use better feature extraction and classification methods than present.
- We will do the experiment
    - **MULTI CLASSIFIERS** : predicting from multiple classifiers and picking the class by majority . by this method we can more confidently say our results are more accurate. Because getting results from one model may be biased. Considering from a group will remove biaseness.
    - **MULTI FEATURES:** we will take multiple features from the conditioned signal(variance, mean,skewness etc..) and pass the classifier and get the prediction. This can give better results as we are considering more than one feature to represent the input.

REFERENCES:

[1].**González-Franco, M., Yuan, P., Zhang, D., Hong, B., & Gao, S. (2011, August). Motor imagery based brain-computer interface: A study of the effect of positive and negative feedback. In *2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (pp. 6323-6326). IEEE.**

[2].**Jeunet, C., N'Kaoua, B., Subramanian, S., Hachet, M., & Lotte, F. (2015). Predicting mental imagery-based BCI performance from personality, cognitive profile and neurophysiological patterns. *PloS one*, *10*(12), e0143962.**