EEG signal clustering for motor and imaginary motor tasks on hands and feet

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EEG Signal Clustering for Motor and Imaginary Motor Tasks on Hands and Feet

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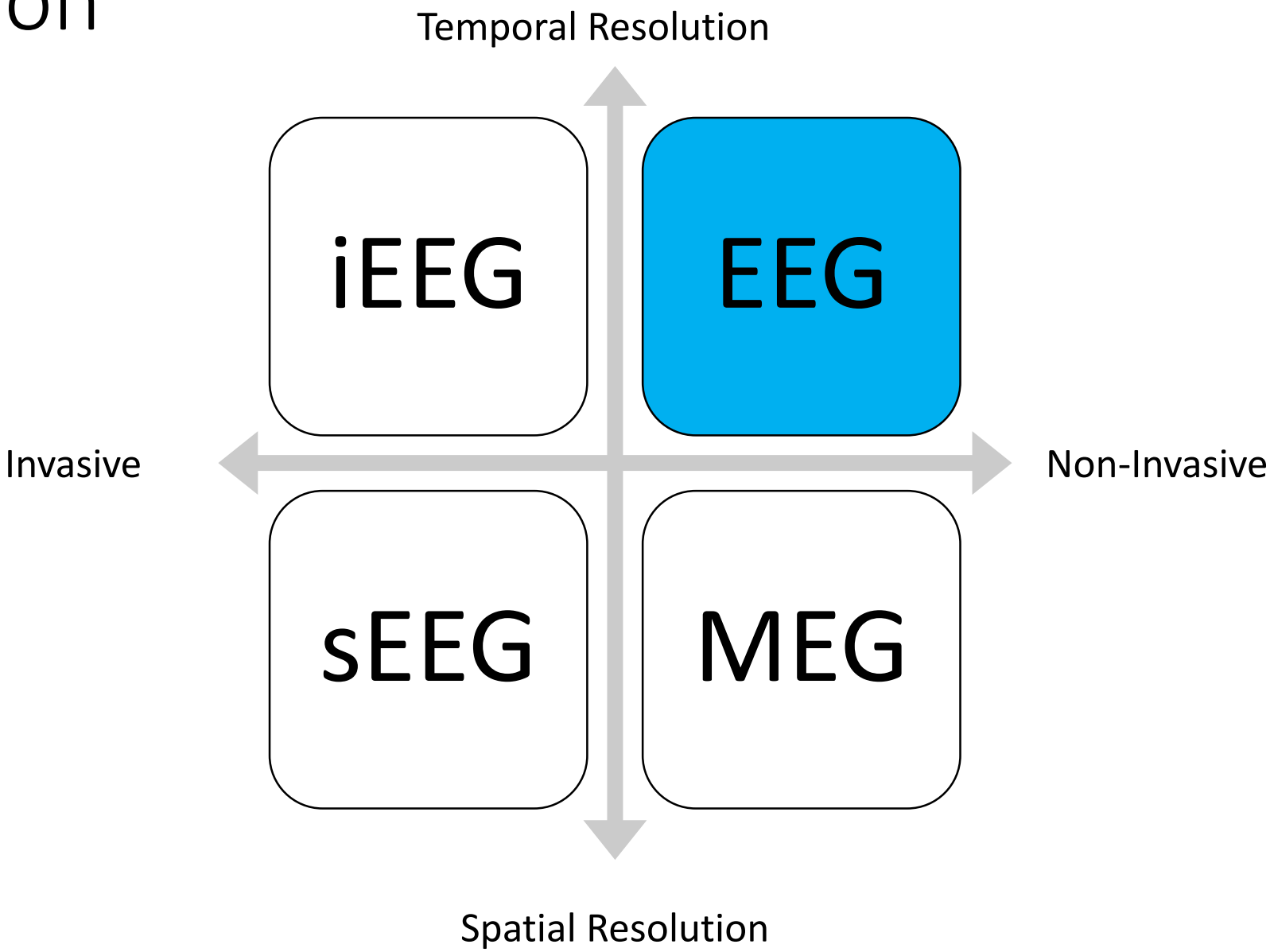
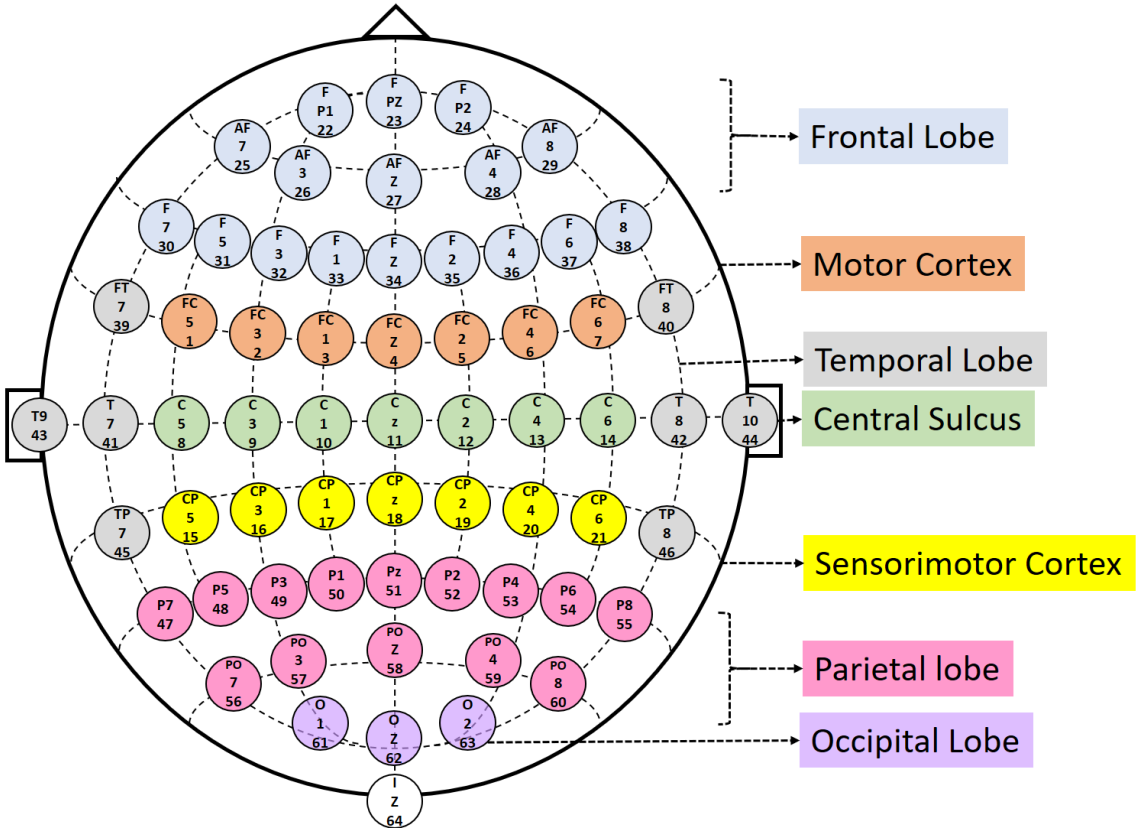
Introduction

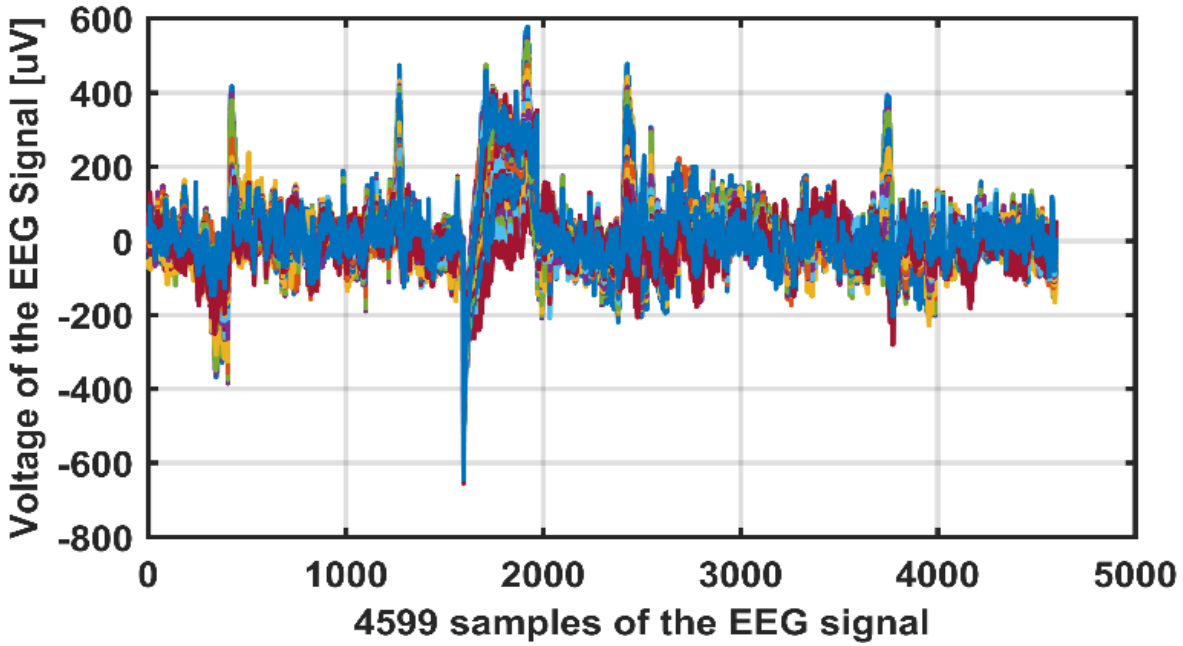


Some methods to measure brain activity

Introduction



64 surface EEG Electrodes
International System 10-20



DC artifact present on the 64 electrodes of the EEG signal

Related Work

0.5–4 Hz

- Delta waves
- Sleep REM

4 –8 Hz

- Theta waves
- Meditation

8 –13 Hz

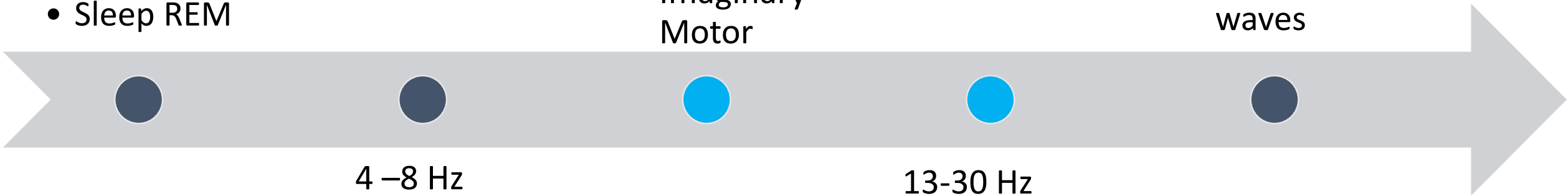
- Alpha waves
  - Relax
- µ waves
  - Imaginary Motor

13-30 Hz

- Beta waves
- Alert

30 –110 Hz

- Gamma waves



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Related Work

Compare Criteria	Feature	Classification Result
Accuracy (%)	PSD	LS-SVM > Linear-SVM > PNN > MLNN > LVQ
		Linear-SVM > LDA
	ERD/ ERS	Linear-SVM > ELM > LDA
		Adaboost-ELM > Adaboost-SVM > Adaboost-LDA
Computational time (s)	PSD	LS-SVM < PNN < LVQ < MLNN < Linear-SVM

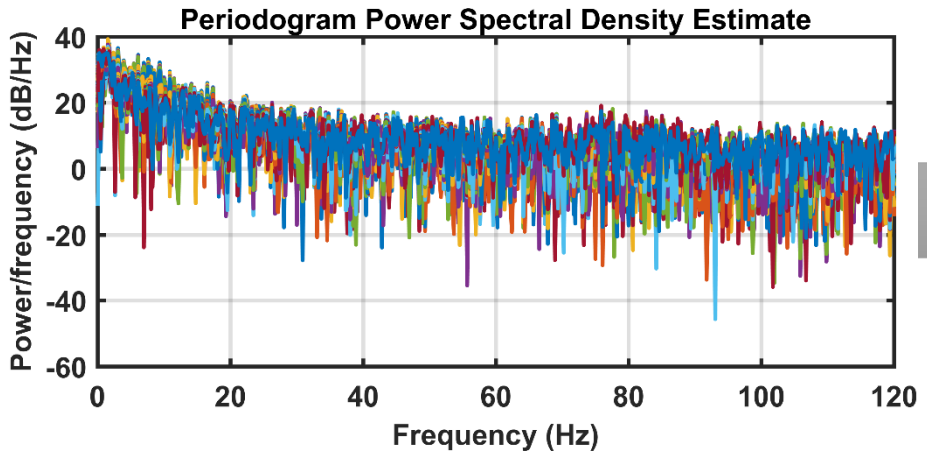
BCI-EEG Classification algorithm comparison

Data Set

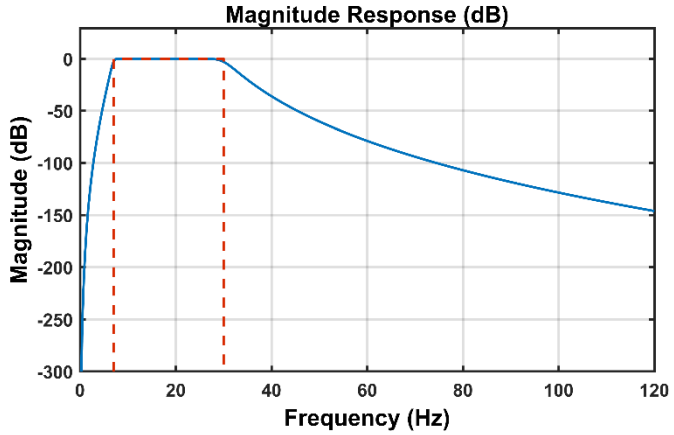
- 25 Healthy subjects using a BCI-2000 system
  - Available on the Physio Net website
  - Https://www.physionet.org/physiobank/database/eegmmidb/
  - Each one with 14 European Data Format (EDF) files.
- Sampling frequency of 160Hz
- task 1 (open and close left or right hand)
- task 2 (imagine opening and closing left or right hand)
- task 3 (open and close both hands or both feet)
  - Motor activity/tasks of both hands (T3)
  - Motor activity/tasks of both feet (T4)
- task 4 (imagine opening and closing both hands or both feet).
  - Imaginary motor activity/tasks of both hands (T1)
  - Imaginary motor activity/tasks of both feet (T2).

Methodology and Results

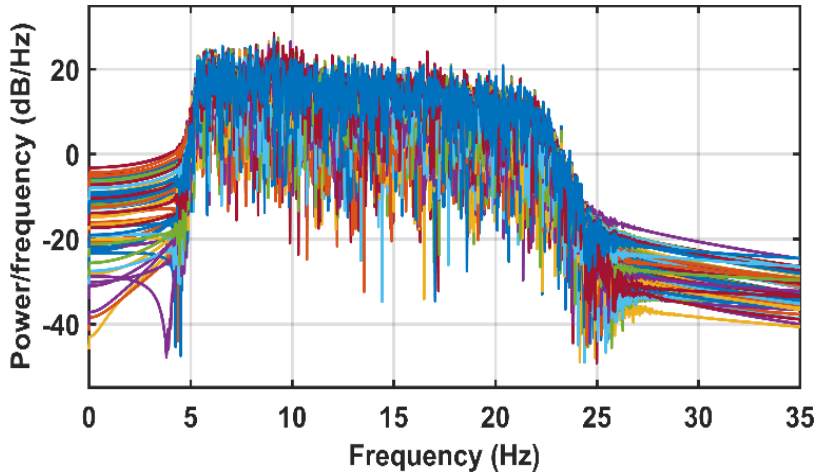
EEG Signals → Signals Preprocessing → Features Extraction → Features Selection → Classification



Frequency analysis with the FFT of the original EEG signals



Bandpass filter
Buttherworth-IIR, 7-30 Hz



Frequency analysis with the FFT of the filtered EEG signals

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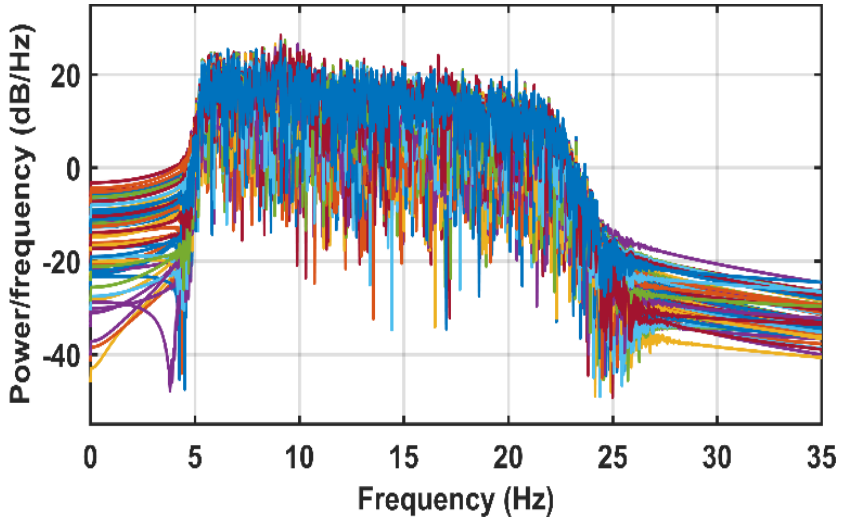
Methodology and Results

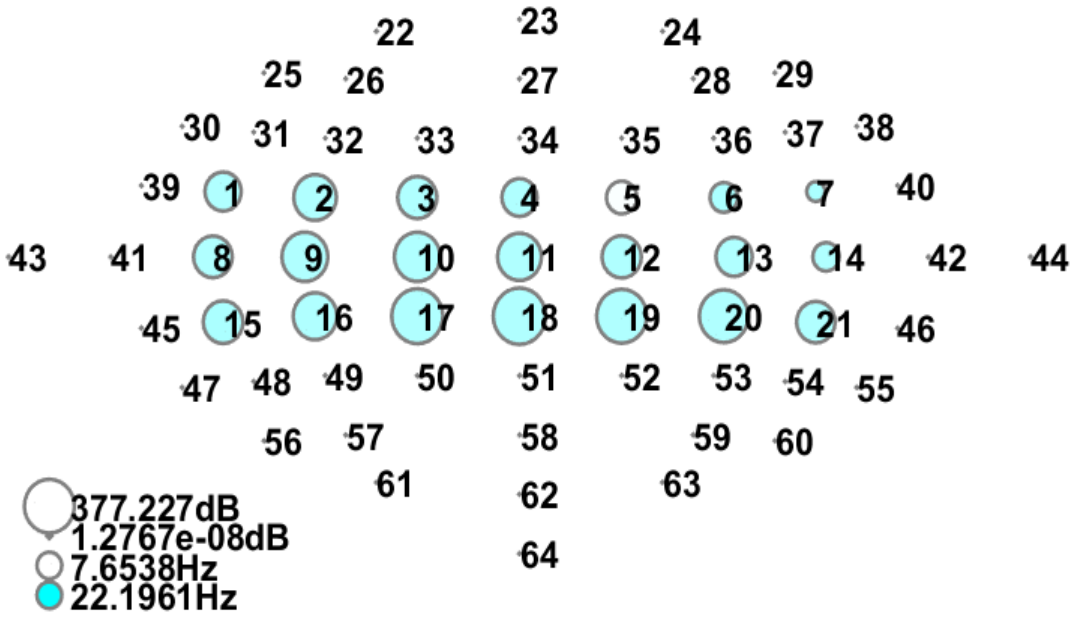
EEG Signals → Signals Preprocessing → **Features Extraction** → Features Selection → Classification



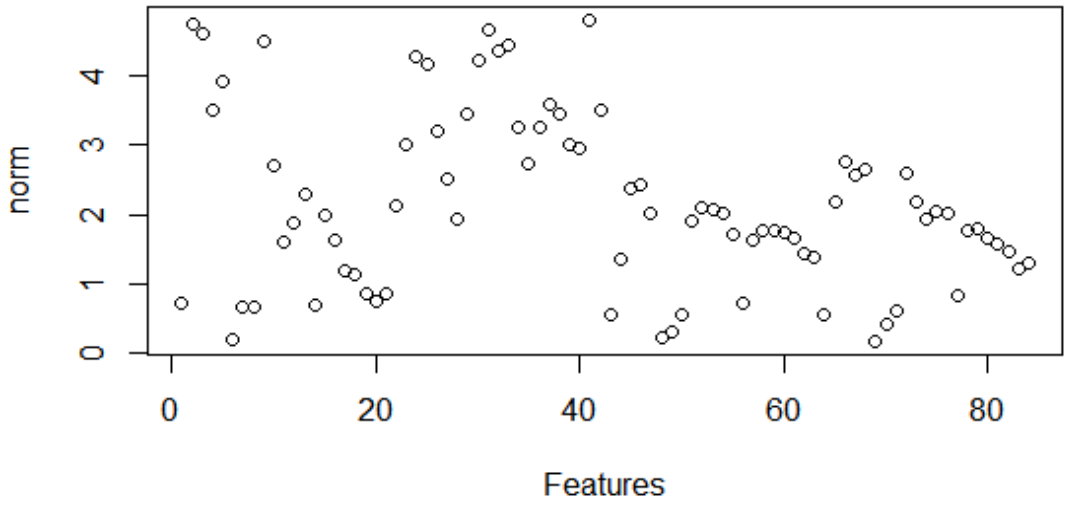
- A periodogram (Welch PSD)
- Power Spectral Density (PSD) features
  - Maximum PSD value
  - Frequency
  - Arithmetic mean
  - Variance
- 64 electrodes x 4 features

Methodology and Results

EEG Signals → Signals Preprocessing → Features Extraction → **Features Selection** → Classification



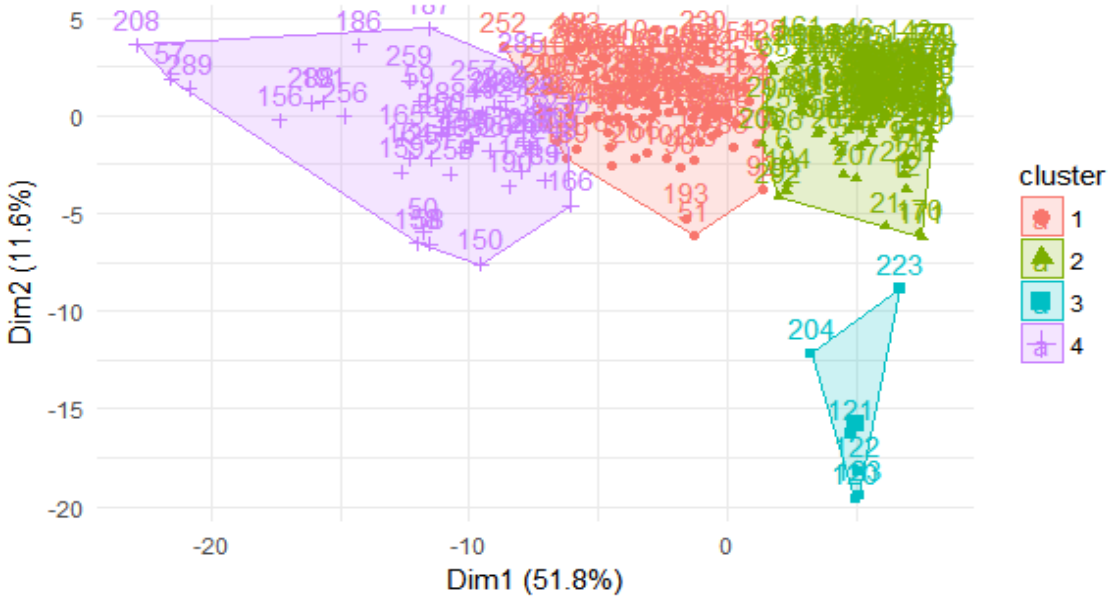
Maximum PSD value and frequency occur in the 21 electrodes located in the motor cortex



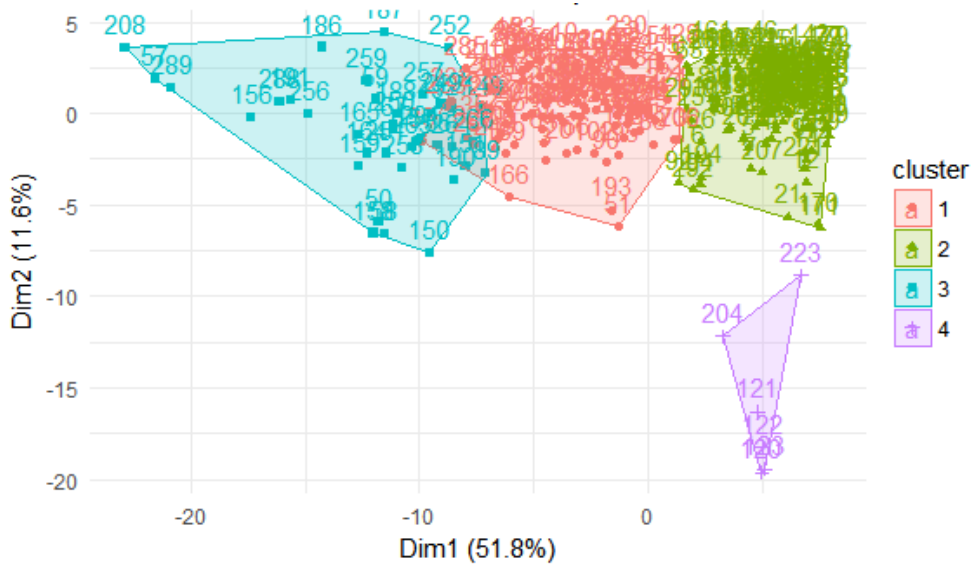
21 x 4 features in the imaginary motor task both hands

Methodology and Results

EEG Signals → Signals Preprocessing → Features Extraction → Features Selection → **Classification**



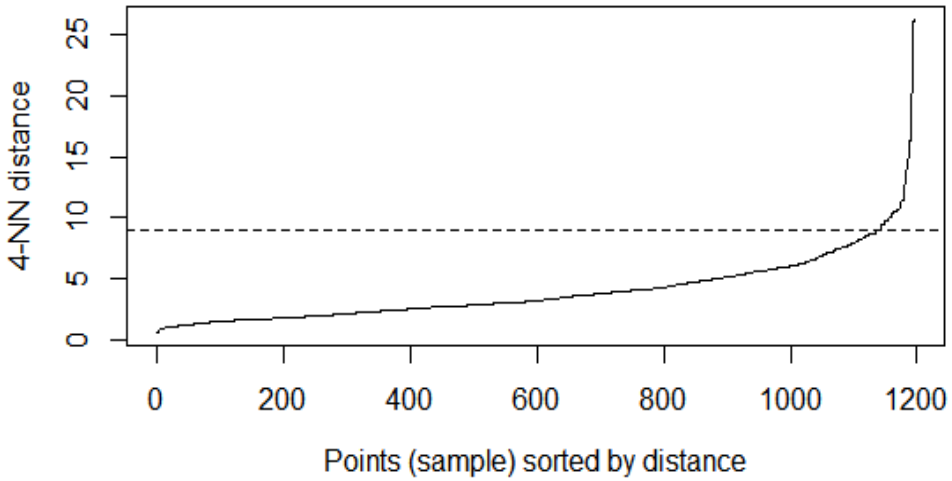
K-means algorithm, with nine centroids



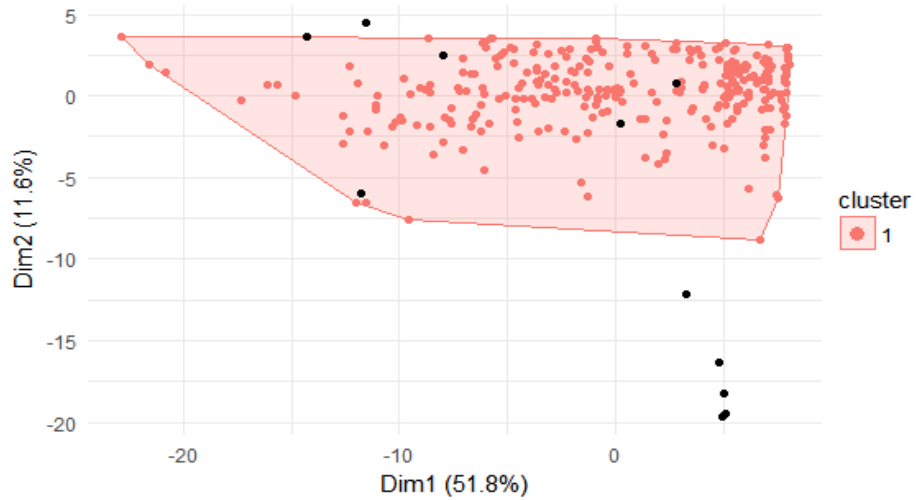
K-medoids algorithm, with nine centroids

Methodology and Results

EEG Signals → Signals Preprocessing → Features Extraction → Features Selection → **Classification**



Optimal EPS distance calculation for DBSCAN with minimum distance = 9



Clustering results with DBSCAN

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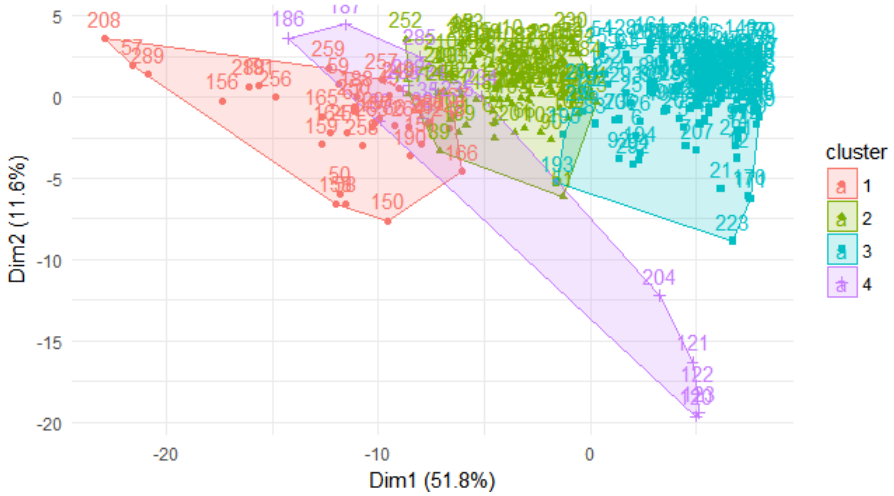
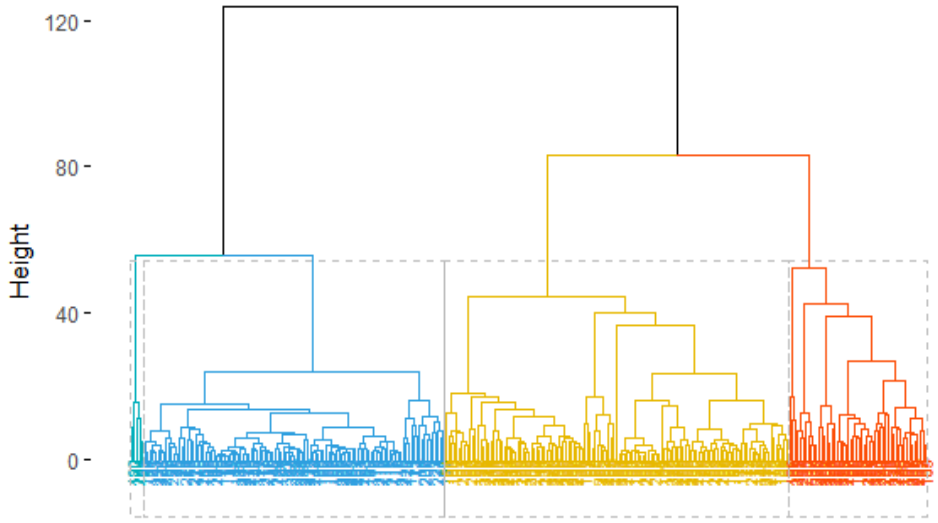
Methodology and Results

EEG Signals → Signals Preprocessing → Features Extraction → Features Selection → Classification

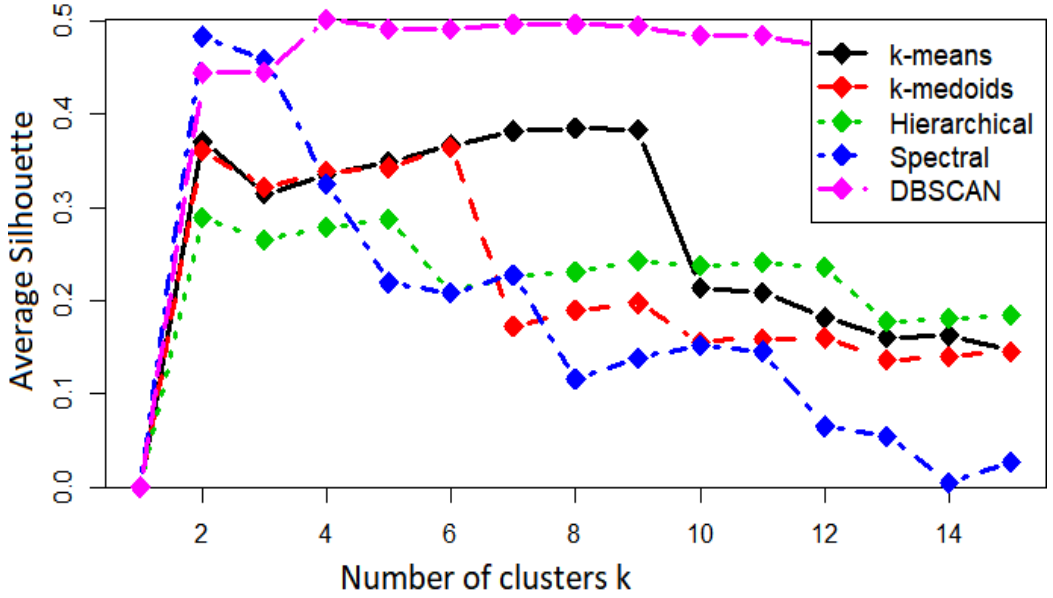


Spectral Clustering results

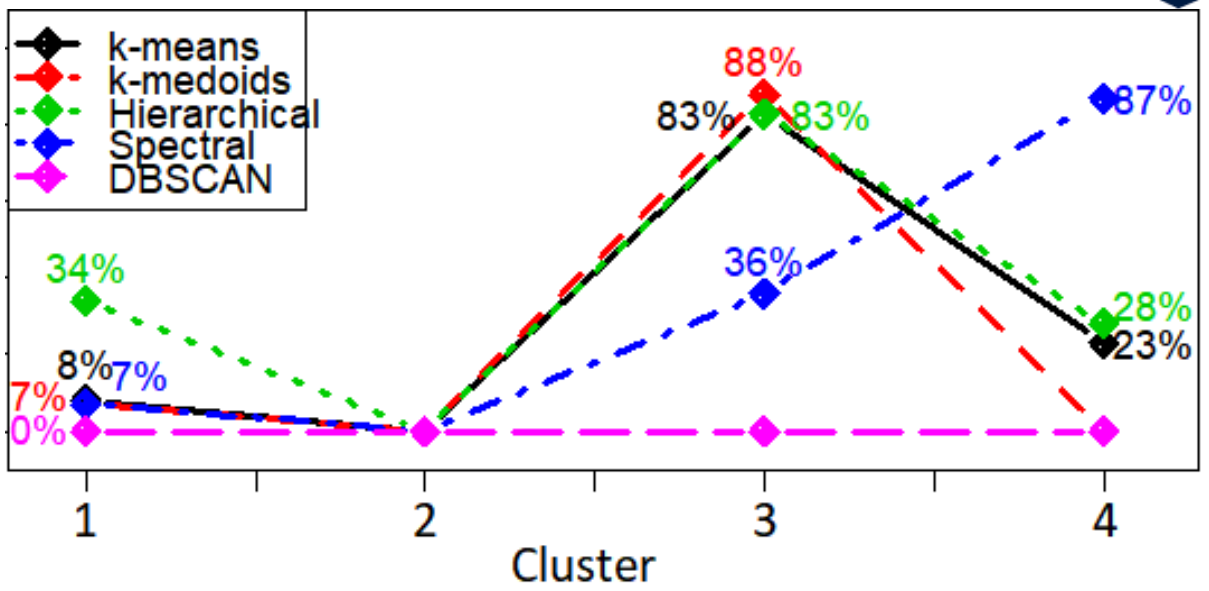


Results of Hierarchical Clustering

Analysis of Results



Explore the optimal number of cluster for all cluster algorithm



Percent success of all clustering algorithms

Clusters:

1. T1 Imaginary motor activity/tasks of both hands
2. T2 Imaginary motor activity/tasks of both feet
3. T3 Motor activity/tasks of both hands
4. T4 Motor activity/tasks of both feet

Discussion and Conclusions

- Butterworth filter
  - PSD features in the frequency range of 7-30 Hz
- k-means, k-medoids and Hierarchical clustering algorithms
  - Motor tasks of both hands (success > 80%)
- Hierarchical clustering algorithm
  - Imaginary motor tasks of both hands (34% success rate)
- Spectral clustering algorithm
  - Detection of motor tasks of both feet (87% success rate)
- In our experiments, none of the algorithms evaluated could perform a detection of both feet motor imaginary tasks

Future work

- Event Related Desynchronization (ERD) and Event Related Synchronization (ERS), also called (ERD / ERS).
  - Motor activities of both hands / feet.
- Redefine Regions of Interest (ROI).
  - Imaginary Motor Activity
- Use first hand data and redefine experimental methodology
  - Motion Execution (ME)
  - Kinesthetic-Motor Images (KMI)
  - Observation of the Movement (OOM)
  - Motor Visual Images (VMI)

To learn more about this work:

- Doctoral thesis of student belonging to the program Doctorado en Ciencias Computacionales Aplicadas (DCCA), FIEC - ESPOL (2015-2019)
- Centro de Tecnologías de Información, CTI – ESPOL
- Paper: http://ieeexplore.ieee.org/document/8247451/