BCI Motor Imagery Classification: Practical Assignment

Overview

In this assignment, you will explore the PhysioNet EEG Motor Movement/Imagery Dataset to understand the variability in BCI performance across different subjects, tasks, and frequency bands. Building on the analysis demonstrated in the lecture, you will investigate how these factors affect classification accuracy and pattern clarity.

Objectives

- Understand individual differences in motor imagery BCI performance
- Compare the effectiveness of different motor imagery tasks
- Identify optimal frequency bands for specific subjects and tasks
- Develop practical experience with BCI data analysis techniques

Tasks

1. Subject Variability Analysis

- Test the provided notebook on at least 5 different subjects (your choice)
- Compare CSP patterns and feature distributions across subjects
- Identify at least one "good performer" and one "poor performer"
- Calculate and compare classification accuracy for each subject
- Analyze what makes certain subjects more classifiable than others

2. Task Comparison

- For your identified "good performer" subject, compare:
    - Left hand vs. right hand imagery classification
    - Both hands vs. both feet imagery classification
- Determine which task yields higher classification accuracy
- Analyze ERD/ERS patterns for both paradigms
- Discuss why one task might produce better results than the other

3. Frequency Band Optimization

- For your best subject and best task, experiment with different frequency bands:
    - Mu rhythm only (8-12 Hz)
    - Beta rhythm only (13-30 Hz)
    - Combined mu and beta (8-30 Hz)
    - A custom band of your choice
- Determine which frequency range provides optimal classification
- Explain your findings in terms of neurophysiological mechanisms

Deliverables

1. Your modified Jupyter notebook(s) containing all analyses and code
2. A report (max 5 pages) that includes:
    - Summary of your methodology
    - Key findings for each task
    - Visualizations of the most important results
    - Discussion of what you learned about BCI variability
    - Recommendations for optimal subject selection, tasks, and frequency bands

Evaluation Criteria

- Correct implementation of analyses (30%)
- Quality and clarity of visualizations (20%)
- Interpretation of results (30%)
- Creativity and insight in extended analysis (10%)
- Report organization and scientific writing (10%)

Submission Guidelines

- Submit both the notebook(s) and report as a single zip file
- Naming convention: BCI_Assignment_YourName

Helpful Resources

- PhysioNet EEG Motor Movement/Imagery Dataset: https://physionet.org/content/eegmmidb/1.0.0/
- MNE-Python Documentation: https://mne.tools/stable/index.html
- Blankertz et al. (2008). Optimizing Spatial Filters for Robust EEG Single-Trial Analysis
- Pfurtscheller & Neuper (2001). Motor imagery and direct brain-computer communication
- Lotte et al. (2018). A review of classification algorithms for EEG-based BCIs: A 10 year update