

Mini Project for Exam Preparation: EEG Classification

In this mini project, you will be working with the **EEGMMIDB dataset** from PhysioNet. This is a dataset of brain activity data, captured through Electroencephalography (EEG)¹. The human participants in the recorded experiment conducted "Motor Imagery", a common EEG paradigm: They imagine moving a limb (the left/right hand/foot) without actually executing the motion. However, the motor cortex of the brain, which issues motor commands to the responsible muscles for actual movements, is also active when the movement is only imagined. As different regions of the motor cortex are responsible for different body parts, the brain activity can be used to decode the limb for which motor imagery was performed. This can allow paralyzed patients with severe motor impairments to issue control commands, for example to a wheelchair or computer cursor.

1) Download the EEGMMIDB dataset. You may use data from one or a few participants and focus on the motor imagery runs (where subjects imagine left/right hand or feet movement). Hint: The MNE library has programmatic support to load the data from within your code:

https://mne.tools/stable/generated/mne.datasets.eegbci.load_data.html

2) Implement a classification pipeline to conduct a classification task, taking the raw EEG data as input. One example for a classification task would be: Discriminating "imagine opening and closing both fists or both feet" for a single participant (this corresponds to "Task 4" of the dataset). Your pipeline should include data loading, basic preprocessing (e.g., filtering²), data splitting (train/test), model training, hyperparameter tuning (optional), and evaluation.

3) You should include two different network architectures for this purpose: a) The EEGNet architecture (<https://arxiv.org/abs/1611.08024>), and b) the Shallow ConvNet architecture (<https://onlinelibrary.wiley.com/doi/10.1002/hbm.23730>).

4) What are conceptual similarities and differences between the two architectures? Write down a list of at least 5 characteristics that are similar/different

5) Generate at least two different types of plots to compare the classification performance (e.g., accuracy box plots, learning curves, confusion matrices, ...). Write a short interpretation of these plots, addressing the performance of both models and the reliability of the results (e.g., consistency across runs/participants, statistical significance of results, ...)

¹ You can find a 5-minute introduction to EEG here: <https://www.youtube.com/watch?v=GDglnyAn-C8>

² A typical EEG preprocessing step is frequency filtering. This can be achieved via the MNE function https://mne.tools/stable/generated/mne.filter.filter_data.html. Find out which lower and upper frequency limits are common for Motor Imagery EEG data.