2025-2026 | Neurorobotics

Lab05 | Spatial filters on logarithmic band power

1. EEG Data

Import all the offline **GDF files** provided in the previous assignment. Write a MATLAB script that performs the following steps:

1. **Load** the offline GDF files.
2. **Concatenate** the GDF files.
3. **Extract and concatenate** the corresponding event information.

2. Data Processing

At this point, you should have a single matrix of size **[samples × channels]** containing all the data from the different GDF files. You should also have an **`EVENT`** structure with all the events (**`TYP`**, **`POS`**, **`DUR`**) correctly concatenated.

Write a MATLAB script to process the data and compute the **logarithmic band power**.In particular, implement the following steps:

a. **Filter** the signal in the μ and β bands
   - Use a Butterworth filter (choose the order and cutoff frequencies).
   - Apply zero-phase filtering with MATLAB's `filtfilt` function.
   - To verify the stability of the filter, you may use the `fvtool()` function.

b. **Rectify** the signal (square it).

c. Apply a **moving average** using a 1-second window.

d. Apply a **logarithmic transform** to the result.

3. Trial Extraction

Extract trials corresponding to the **two motor imagery (MI) tasks**.

a. Use the event types (**`EVENT.TYP`**) to identify which tasks correspond to which class.

b. You may assume that a trial lasts from the **fixation cross** to the **end of the continuous feedback** period.

4. Visualization

a. Select **three meaningful EEG channels**.

b. Plot the **raw** and **filtered** signals for a given trial and for the selected channels

c. Plot the power of the three channels after **averaging across all trials** for each class.

5. Spatial Filtering

Redo the entire process by applying two different **spatial filters** to the raw data:

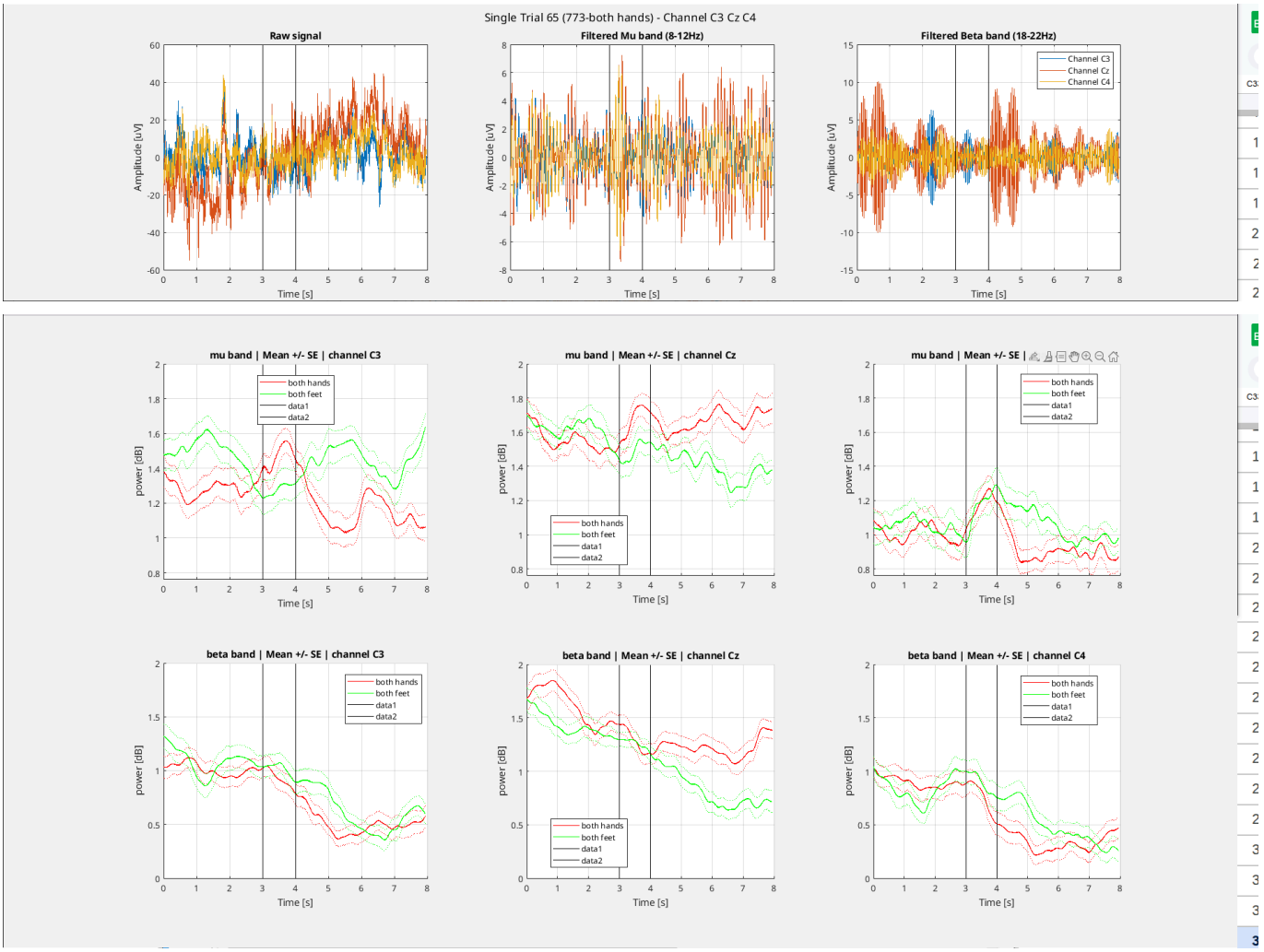
a. **Common Average Reference (CAR) filter**
   - Apply the CAR filter to the raw data.
   - Repeat steps 2 to 4 (Data Processing → Visualization).
   - Compare the results with the unfiltered data.

b. **Laplacian filter**
   - Apply the Laplacian filter to the raw data (the Laplacian mask is available on Moodle).
   - Repeat steps 2 to 4.
   - Compare the results with both the unfiltered and CAR-filtered data.

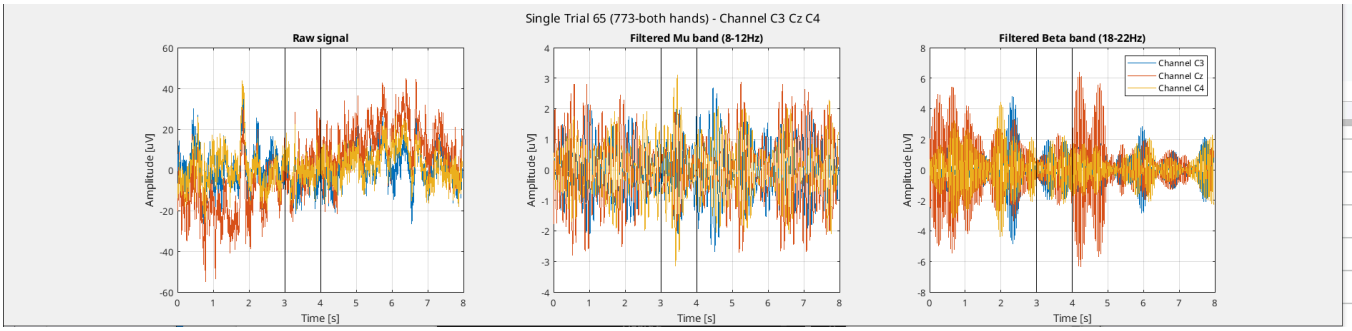
Expected Results

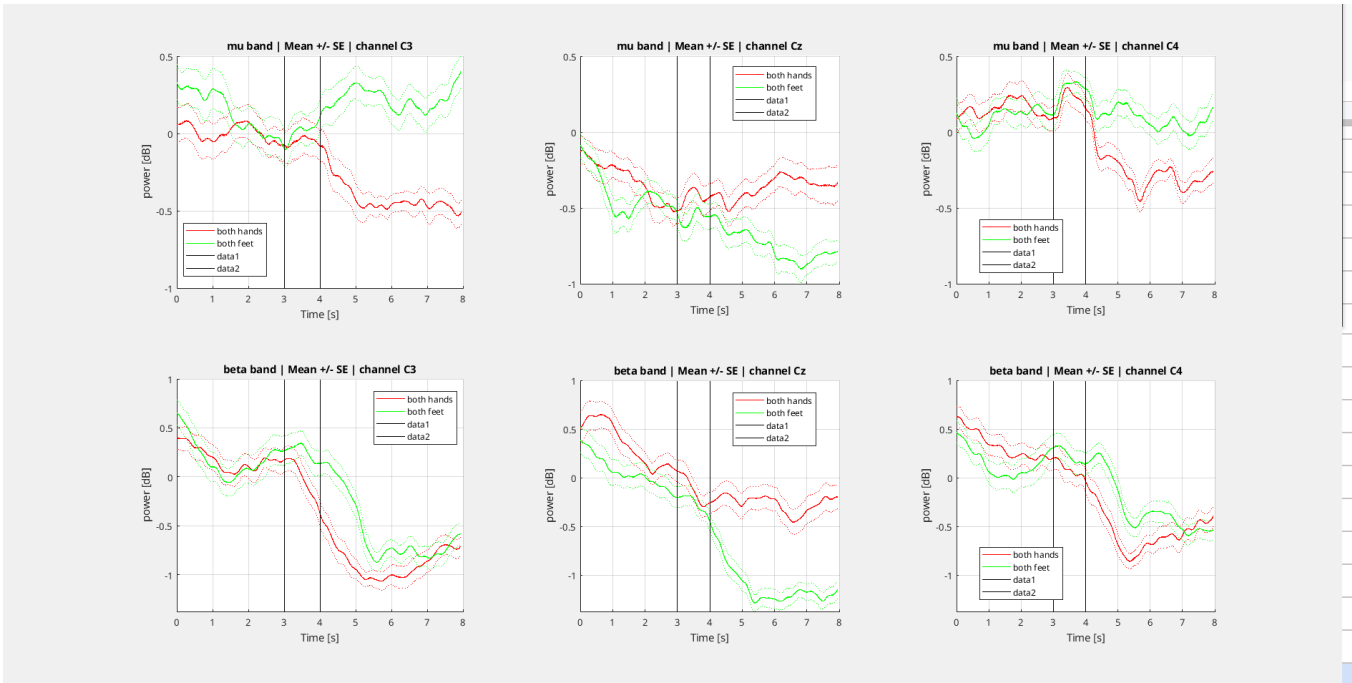
You should obtain and analyze the **averaged logarithmic band power** in the **μ** and **β** frequency bands for the two MI classes.

No spatial filters



Car Filter


Single Trial 65 (773-both hands) - Channel C3 Cz C4
Raw signal
Filtered Mu band (8-12Hz)
Filtered Beta band (18-22Hz)
Amplitude [uV]
Time [s]
Channel C3
Channel Cz
Channel C4


mu band | Mean +/- SE | channel C3
mu band | Mean +/- SE | channel Cz
mu band | Mean +/- SE | channel C4
beta band | Mean +/- SE | channel C3
beta band | Mean +/- SE | channel Cz
beta band | Mean +/- SE | channel C4
power [dB]
Time [s]
both hands
both feet
data1
data2

Laplacian Filter