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Exercise #4 – Identifying individual alpha frequency

Background

- The alpha frequency band usually refers to brain activity in the range of 8-12 Hz. However, the peak frequency and the width of the peak vary from one subject to another.
- The goal of this exercise is to extract the Individual Alpha Frequency (IAF) of a subject, namely the peak frequency of his alpha activity.

1. Data handling

- The data for each of the 3 subjects contain two files with resting state EEG, one with eyes open (EO) and one with eyes closed (EC). Each data file contains a matrix, in which each row corresponds to a different channel and each column to a different time point. We will focus on channel 19 (electrode Pz). The sampling rate is 256 Hz.
- Place all subjects' folders with their data files in one directory and name it `'..\DATA_DIR\'` (note the `'..'` prefix and its meaning).
- Go through subjects' folders one by one and handle each subject EO and EC data. Data file name must contain subject number and an `'EO'` or `'EC'` tag, and end with an `'.edf'` extension (in this specific order). There are no other restrictions on the file name format.
  - This part should be done automatically.
  - Use the **`dir`** function to get a list of files in a folder. Use Wildcard character `'*'`.
  - Use the **`strfind`** and **`regexp`** functions to test whether a file name matches the naming format and to extract subject number.
- Load the files using the command **`edfread`** (the file can be found on moodle).

2. Drawing power spectra

- For each subject, plot the EC and EO power spectrum on a single plot and compare them.

- Define a frequency band to picture Alpha waves (at least 8Hz wide). From now on show the results only in that range. The spectrum should be one-sided.

- First, calculate the power spectrum using the **`fft`** command in a similar way as it way presented at the class exercise. Normalize the FFT output by it's length.
- Next, calculate the power spectrum using the **`pwelch`** function, which divides the data into windows and then averages the power spectra over these windows.
  Play with the parameters of this function. For example, to obtain the spectrum for the frequencies 4–14Hz with windows of 5 seconds and no overlap between windows use:
```
f = 4:0.1:14;
fs = 256;
window = 5*Fs;
noverlap = [];
pwelch(x, window, noverlap, f, fs);
```
- Finally, calculate power spectrum based on the DFT formula presented at the class:
$$\mathcal{F}_k = \sum_{n=0}^{N-1} f_n e^{-\frac{2\pi i}{N}nk}$$
  - Use windows with overlaps (similar to **`pwelch`**) to obtain an average power spectrum.
    - In case that window size is bigger than input signal length, or the last overlapping window exceeds the input signal, pad the input with zeros.
  - Present the Fourier transform as a matrix $W \in M_{N\times N}(\mathbb{C})$. Multiply the matrix by the windowed input vector to obtain the DFT result.
  - Avoid loops during the calculation.
  - To test yourself, compare your DFT output for a single window to the output of **`fft`** on the same window. The outputs should be identical.
  - Do not forget to normalize the outputs by their length.

3. Finding the IAF

- Calculate the difference spectrum by subtracting the EO spectrum from the EC spectrum.
- Find the frequency at which the difference spectrum attains its maximum. This frequency is defined as the IAF of the subject.

- Perform this analysis using all the three methods mentioned above (**`fft`** approach, **`pwelch`** approach, DFT formula approach).

4. General reequipments and deliverables

- You must use at least 2 functions.
- Avoid using magic numbers!
- Submit according to the submission guidelines in Moodle.
- Describe **briefly** what you have done and accompany your results with discussion.
- Include the following figures for each of the 3 subjects:

  1. EC and EO power spectra plots for each of the three power spectrum methods.
  2. Difference spectra plots with a vertical line marking the IAF for each of the three power spectrum methods.

  Include subject number in the figure name.