Integrated Lecture and Tutorials
"Brain-Computer Interfacing"

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Exercise Sheet 1

Materials

- `Data_Structures_Info.pdf`: Information on the structure of EEG data
- `oddballVPei.mat`: EEG data, can by loaded with `load('oddballVPei.mat')`
- `scalpmap.m`: Matlab function that plots a scalp topography, see the file's documentation for its usage
- `make_epochs.m`: Incomplete Matlab function for data segmentation
- `baseline_epochs.m`: Incomplete Matlab function for data baseline correction
- `average_epochs.m`: Incomplete Matlab function for ERP computation

Exercise 1 (6 points)

(a) Single trials of EEG (also called epochs) are short segments of EEG, all of the same length, that have a fixed time relation to marker positions.

- Complete the function `make_epochs.m` such that the missing structure fields `.x` and `.t` are computed. Given the structures `cnt`, `mrk` and a time interval `ival = [start ms, end ms]`, the function segments the EEG data into epochs, resulting in the 3D matrix `.x` of size `N x C x E`, where `N` is the number of samples in one epoch and `E` is the number of epochs. Each epoch corresponds to a marker event in `mrk`, therefore `E` is the number of events in `mrk`. `N` is the same length as the field `.t`, determined by the interval `ival` and the sampling frequency `.fs`. Note: Make use of the Matlab functions `reshape` and `permute`.

(b) In order to obtain epochs with the same baseline, each epoch needs to be baseline corrected. The baseline $b_{C,E}$ is computed for each channel and epoch individually and is the arithmetic mean of a particular baseline interval, typically first 100 ms of the epoch. If $\mathbf{X}_{C_i,E_i}(t)$ is the time course of channel C_i and epoch E_i, then $\overline{\mathbf{X}}_{C_i,E_i}(t) = \mathbf{X}_{C_i,E_i}(t) - b_{C_i,E_i}$ is the baseline corrected time course.

- Complete the Matlab function `baseline_epochs.m`.

(c) Events in `mrk` belong either to the class *target* or *non-target*, the membership of each event is given in the field `.y`.

- Complete the Matlab function `average_epochs.m`. For each class individually, this function computes the arithmetic mean over all epochs belonging to one class. Thus, the function returns in the field `.x` a matrix of size `N x C x M`, where `M` is the number of classes.

Exercise 2 (4 points)

(a) Using `ival = [-200 1000]` and `base_ival = [-200 -100]`, segment, baseline correct and average the EEG data with

```
epo = make_epochs(cnt,mrk,ival)
epo = baseline_epochs(epo,base_ival)
erp = average_epochs(epo)
```

(b) In a script `investigate_ERPs.m` do the following:

- Generate a figure with two plots. In each, plot on top of each other for channel `'Cz'` all epochs belonging to one class. Use the correct time units (`epo.t`). You may need to use the function `squeeze`.
- Plot the ERPs (from `erp`) of channel `'Cz'` in one figure on top of each other with different colors.
- In a figure with `2 x 2` plots, using `scalpmap.m` plot the scalp topographies of the ERPs of class *target* and *non-target* separately and for two time points each. Chose interesting time points given the ERPs (good choices are e.g. $t = 250$ and $t = 320$). Using the command `set(gca,'clim',[cmin cmax])`, adjust the limits of the color code to be equal in all four scalp maps, ranging approximately from the lowest to the highest common visible value.
- Shortly comment what you observe in the generated plots.