Integrated Lecture
"Brain-Computer Interfacing"

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In total there are 40 points for the actual tasks. Bonus points may be obtained for very well explained solutions.

Task 1 – Description of a practical BCI system for binary choices (10+5 Points)

(a) Conceive a BCI system that could allow a severely paralyzed person to select one out of two choices (like answering a yes/no question). Describe the functioning of the system, in particular the stimulus presentation, the task that the patient has to perform to make a selection, the expected modulation of the brain signals, and the features and classification. (about six to ten sentences).

(b) In order to make the system more practical for daily life application, the number of EEG sensors should be reduced. Assume that a labelled data set with 64 channel setup is available from initial experiments. Describe a method to determine a subset of 10 electrode in view of good classification performance. (about three sentences)

Task 2 – Artifact removal based on a disturbance recording (6+3 Points)

This task is about removing artifacts which are caused by horizontal head movements. We assume that the induced disturbance has a fixed spatial pattern, i.e., it can be modelled by one component in the linear model.

(a) Assume a spatial filter **w** for extracting the artifact is given. Describe a method for removing the head movements artifact from EEG data. (about three sentences and formulas)

(b) Describe a method for determining a spatial filter as required in (a) based on a data set with one set of segments containing aforementioned artifacts and another set of segments without those artifacts. (about four sentences and formulas)

Note: You may **not** assume that this artifact has a higher amplitude in the measured signals than all other components.

(more tasks on page 2)

Task 3 – Distribution of ERP features
(6 Points)

Make a scatter plot of the distribution of two dimensional ERP features as obtained from the *target* class of an ERP speller. Consider the time point of the P300 peak, and put the potential at channel Cz on the x-axis and the potential at channel Fz on the y-axis. Indicate the assumed Gaussian distribution with the corresponding Eigenvectors and Eigenvalues. Annotate the axes.
There is no unique true solution, of course. The task is about sketching a plausible distribution, taking into account general properties of those ERPs.

Task 4 – Quick questions
(2+2+2+2+2 Points)

This task consist of **'quick questions'**. Each should be answered briefly to the point with one sentcence (or sketch), or with some bullet points.

(a) Why is baseline correction important for plotting ERP topographies?

(b) Assume two filters are applied to EEG data. One filter extracts eye movements and the other the P3 components. What is your expectation about the amplitudes of those components (with statement of reasons).

(c) Sketch a case in which the LDA classification coincides with the NCC classification, although the class distributions are not spherical. A Gaussian distribution is called 'spherical', if its covariance matrix is a multiple of the identify matrix.

(d) Why can two sources which are in locations that are close on the cortex induce quite different patterns on the scalp?

(e) Assume a BCI controls the *go* / *stop* command of a wheelchair with a linear classifier. How can the classifier be adapted to reduce the risk of false positive *go* commands for a more conservative control behavior?

Good luck!