Brain-Computer Interfacing

WS 2018/2019 – Lecture #13

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30 · Jan · 2019

Today's Topics

- Retrospective overview of this course
- Warming-up tasks for the exam
- Questions & answers
- Feedback questionnaire *Student Evaluation of Educational Quality* (SEEQ)

Overview of the Course

Linear Model of EEG

- sources in the brain
- → volume conduction (conductivity of different tissues)
- → potentials at the scalp
- forward model, backward model, patterns, filters, formulas
- issue in interpreting a spatial filter
- determine a pattern that corresponds to a given filter

Different Occurrences of Neural Activity

- transient activity: ERPs
- spontaneous oscillations, e.g., SMR
- induced oscillations, e.g., SSVEP, ASSR

Overview of the Course

Investigation of ERPs

- segmentation, averaging across trials for each condition (law of increasing SNR)
- time course of ERPs; peak amplitude and latency of components
- spatial maps
  - at time points, e.g., peak latency
  - or within intervals (of approx. constant topography)
- measures of separability between conditions

Investigation of oscillations

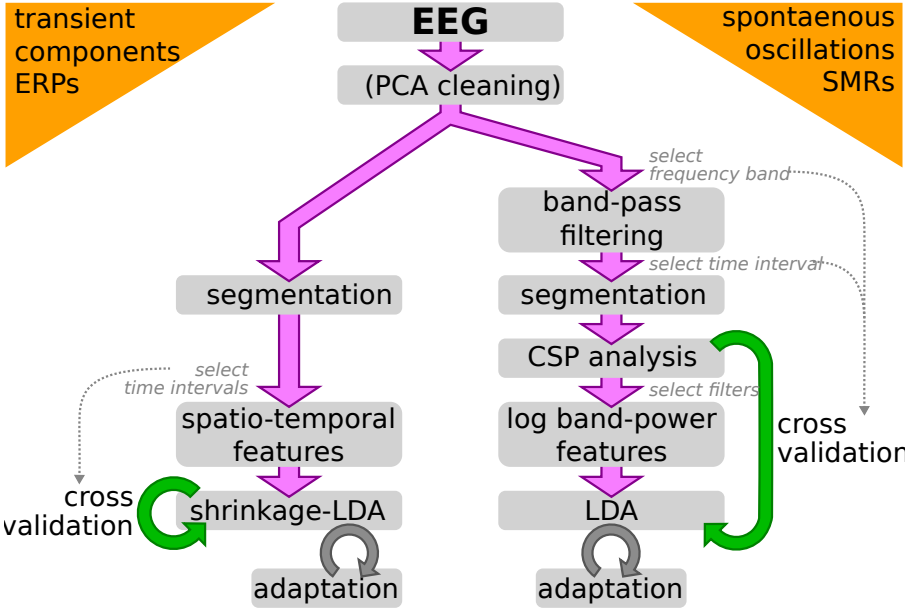
- segmentation, Laplace (or CAR) filtering
- average spectra (PSD) across trials
- find frequency band of discriminative rhythms
- spatial maps of PSD and ERD/ERS
- band-pass filtering
- time course of modulations: ERD/ERS curves
- measures of separability between conditions

Overview of the Course

Methods for preprocessing and classification

- measure of separability (AUC, $\pm r^2$)
- linear model with PCA (likewise ICA), e.g., for cleaning data
- extraction of spatio-temporal features
- investigation of feature distributions with EVD
- classification with NCC and LDA (correspondence via whitening)
- shrinkage of empirical covariance matrix, shrinkage-LDA
- using LDA to obtain spatial filters
- standard spatial filters (bipolar, Laplace, CAR)
- log band-power features
- Rayleigh coefficient, Min-Max theorem, GEVD
- CSP analysis
- validation of the classifcation process: *cross-validation (CV), loss function (AUC based), CSP within CV, other pitfalls*
- SSD, TDSEP
- adaptation (unsupervised: PMean, PMean-PCov; supervised: Mean-PCov)

Single-Trial Classification



BCI Approaches

ERP based

- stimuli required
- synchronous
- decisions discrete in time
- spatial filters implicit in classifier
- CV for classifier only
- shrinkage advisable
- user training less important
- low deficiency rate

based on spontaneous rhythms

- stimuli not required
- asynchronous
- continuous control
- spatial filters explicit, e.g. CSP
- CV for CSP + classifier
- shrinkage not required
- user training more important
- higher deficiency rate

Warming up for the Exam - Neurophysiology

- Sketch the event-related de/synchronization (ERD/ERS) curve wrt. the 8 to 12 Hz frequency band during *left hand* motor imagery in the time interval from 0 to 6 s in a representative channel.
  There is no unique true solution. The task is about sketching a plausible case, taking into account general neurophysiology.

Warming up for the Exam – Quick Questions

The quick questions should be answered very briefly and to the point, one sentence or some bullet points.

- When the so-called median nerve is electrically stimulated, the amplitude of the sensorimotor rhythm (at about 11 Hz) is attenuated for 2 seconds. Given a dataset in which the median nerve is stimulated every 5 seconds, how should CSP be applied to obtain a spatial filter that shows this modulation best?
- If there is the choice between one CSP filter with generalized Eigenvalue of 0.6 and another CSP filter with generalized Eigenvalue of 0.25, which one would you expect to contribute more to classification?