

Dataset IIIa: 4-class EEG data

Short description:

cued motor imagery (multi-class) with 4 classes (left hand, right hand, foot, tongue)
three subjects (ranging from quite good to fair performance)
EEG, 60 channels, 60 trials per class
performance measure: kappa-coefficient

EEG recording:

The recording was made with a 64-channel EEG amplifier from Neuroscan, using the left mastoid for reference and the right mastoid as ground. The EEG was sampled with 250 Hz, it was filtered between 1 and 50Hz with Notchfilter on. Sixty EEG channels were recorded according the scheme in figure 2. The data of all runs was concatenated and converted into the GDF format [1].

Paradigm:

The subject sat in a relaxing chair with armrests. The task was to perform imagery left hand, right hand, foot or tongue movements according to a cue. The order of cues was random. The experiment consists of several runs (at least 6) with 40 trials each each; after trial begin, the first 2s were quite, at $t=2s$ an acoustic stimulus indicated the beginning of the trial, and a cross “+” is displayed; then from $t=3s$ an arrow to the left, right, up or down was displayed for 1 s; at the same time the subject was asked to imagine a left hand, right hand, tongue or foot movement, respectively, until the cross disappeared at $t=7s$. Each of the 4 cues was displayed 10 times within each run in a randomized order.

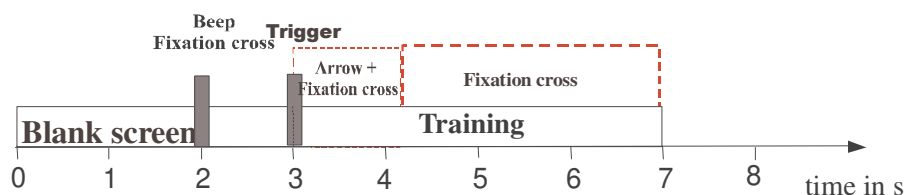


Figure 1: Timing of the paradigm.

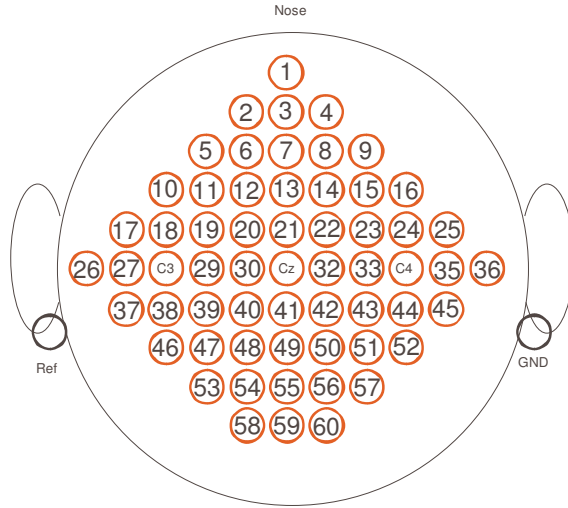


Figure 2: Position of EEG electrodes.

Format of the data

The data is stored in the GDF format [1] and can be loaded into Matlab or Octave with Biosig-toolbox [2] (version 0.81 or higher) using the command `[s,HDR] = sload(filename)`. The data `s` can contains NaN's; these NaN's indicate the breaks in between the runs or saturation of the analog-to-digital converter.

All events are stored according to the Table of eventcodes [3]. The beginning of each trial ($t = 0s$ according to Fig. 1) can be obtained from `HDR.TRIG`; the classlabels are stored in `HDR.Classlabel`, and the `HDR.ArtifactSelection` indicates trials with artifacts which were visually identified. `HDR.Classlabel` can contain the values '1','2','3','4', and 'NaN'. Values '1','2','3','4' indicate the labels of the training set, NaN indicates the trials of the test set.

For visual artifact processing the source derivation based on the center and the four nearest neighbor electrodes (Hjorth, 1975) was calculated. For boundary electrodes an equivalent calculation was made based on the first, second or third nearest neighbors – single trials were visually inspected for muscle and ocular artifacts. Trials containing artifacts were marked. Artifacts in boundary electrodes were not considered.

Evaluation:

Participants should provide a continuous classification output (continuous in time as well as magnitude) for all 4 classes. In other words the classifier should provide 4 continuous traces for the whole data set (including labeled trials, and trials marked as artifact). At each point in time, the trace with the largest value determines the corresponding class.

Then, a confusion matrix is built from all trials for each time-point $0.0 \text{ s} \leq t \leq 7.0 \text{ s}$. From these confusion matrices, the time course of the accuracy and the time-course of the kappa coefficient can be obtained. The algorithm for evaluation is provided in BIOSIG and will be called:

```
X=bci4eval(tsd, trig(testset), classlabel(testset), 0, 7*Fs, Fs)
```

If the sampling rate is reduced, `trig` and `Fs` need to be modified accordingly. For each 0.2s-segment, the average kappa will be calculated; the winner is the algorithm with the largest kappa value `X.KAP00`.

Remark:

Optional, the algorithm can be submitted for inclusion into BIOSIG. Each algorithm which performs better than the standard classification algorithm [2] is eligible to be included in BIOSIG.

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References:

[1] A. Schlögl, O. Filz, H. Ramoser, G. Pfurtscheller, GDF - A general dataformat for biosignals, Technical Report, 2004. available online at: http://www.dpml.tu-graz.ac.at/~schloegl/matlab/eeg/gdf4/TR_GDF.pdf.

[2] A. Schlögl, BIOSIG - an open source software library for biomedical signal processing. 2003-2004. available online: <http://BIOSIG.SF.NET>

3] available online:
<http://cvs.sourceforge.net/viewcvs.py/biosig/biosig/t200/eventcodes.txt>

[4] Hjorth B. An on-line transformation of EEG scalp potentials into orthogonal source derivations. *Electroencephalogr Clin Neurophysiol*. 1975 Nov;39(5):526-30.