BCI-competition IV – Data set IIa and IIb

Algorithm Description

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Preprocessing:

1. Neural Time Series Prediction Preprocessing (NTSPP) was applied to all signals all subjects using the self-organizing fuzzy neural network (SOFNN). In a few cases subject performed slightly better without NTSPP however for the majority of subjects significant increases in the average accuracy were provided by NTSPP. NTSPP has been extended to work with any number of classes and any number of channels
2. The signals predicted via NTSPP are then spectrally filtered in subject specific frequency bands – a coarse tuning of frequency bands via a heuristic search and a selection criterion based on overall classification accuracy in five-fold cross validation.
3. The Common Spatial Patterns approach was then applied to the Spectrally Filtered NTSPP signals to reduce dimensionality and improve separability further.

Feature extraction:

1. The CSP filters were varied from 1-4. With NTSPP each class can contain 88 channels (4 * 22 for a 4 class dataset and 6 for the 2 class dataset (3channels * classes) because a predictor is trained for each call and each channel thus producing additional data. NTSPP produces predicted signals which have higher interclass variability than the originals signals but can result in large dimensionality with redundancy. CSP is an ideal approach to reduce this dimensionality and further increase separability. Most of the subjects in dataset 2a and 2b benefited from a NTSPP-Spectral Filter-CSP combination.
2. The log variance of each filtered channel is calculated with a one second sliding window across all time points and used as features. A new set of CSP filters is built for each time point also using a one second data window.

Classification:

1. Various classifiers were tested including 3 different variants of LDA, SVM (1vs1 and 1-versus-the-rest) for multiclass datasets and all five combined in a committee system. In addition to LDA and other classifier available in the BioSig tool box were employed in addition to a Bates based classifier. In most cases a single classifier worked the best although in some cases the committee system improved performance. For the competition entry the committee system was not entered. The classifier and overall systems which achieved the highest mean classification accuracy for the peak time points was used for the competition entry.

[1] D. Coyle, A. Satti, G. Prasad and T.M. McGinnity, "Neural times-series prediction preprocessing meets common spatial patterns in a brain-computer interface", *Proceedings of the 30th International IEEE Engineering in Medicine and Biology Conference*, pp. 2626-2629, 2008.

[2] D. Coyle, T.M. McGinnity and G. Prasad, "A multi-class brain-computer interface with SOFNN-based prediction preprocessing", *IEEE World Congress on Computational Intelligence*, pp. 3695-3702, June, 2008.

[3] D. Coyle, *Intelligent Preprocessing and Feature Extraction Techniques for a Brain Computer Interface*, PhD Thesis, University of Ulster, N. Ireland, 2006.

[4] D. Coyle, T.M. McGinnity and G. Prasad, "A time-series prediction approach for feature extraction in a brain-computer interface", *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 13, no. 4, pp. 461-467, Dec. 2005.

[5] A Schlogl, BIOSIG – an open source software library for biomedical signal processing, 2008, online: http://biosig.sourceforge.net/

[6] B. Blankertz, R. Tomioka, S. Lemm, M. Kawanabe, and K-R. Müller, "Optimizing spatial filters for robust EEG Analysis", *IEEE Signal Processing Magazine*, pp. 41-56, Jan., 2008.

[7] A. Schlogl, F. Lee, H. Birschof and G. Pfurtscheller, "Characterization of four-class motor imagery EEG data for the BCI-competition 2005, *J. of Neural Engineering*, Vol 2, L.14-L.22, 2005.