Common Filters, Feature Extractor and Classifier Used In BCI Experiments

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| s/no | Research  Item | Filtering  Technique | Feature Extraction Technique | Feature Parameter | Classification Technique | Classification  Variable |
| 1. | Adaptive online brain-computer interface for interpretation and visualization of desired reach | high-pass and low-pass FIR filters,  ICA,  CSP | subsampling, frequency filtering, channel scaling, channel selection, spatial filtering, frequency  decomposition (AR), and post-processing,  Power estimates using filter bank | Slow Cortical Potential  Movement Related Potential | support vector machines  *L*1-Regularized Logistic Regression  Meta-classifier | left versus right hand self-paced typing |
| 2. | Accurate hand trajectory prediction by real and  Synthetic EEG | Stable elliptic filter | Brain Model for generating synthetic EEG |  | A model in which the hand position coordinates  (the dependent variable) are written as a function  of the neural activity (independent variable). | The hand coordinates |
| 3. | ENGINEERING THE BRAIN SIGNALS – PREPROCESSING | FIR equiripple stable filter | PCA | Spectral band power | SVM | left small finger or the tongue |
| 4. | EEG single-trial classification of four classes of imaginary  Wrist movements based on gabor coefficients | EOG was removed using ICA,  High pass, low pass and stopband filters | Gabor  transformation for  features |  | Recurrent Elman neural networks | four direction distinctive imaginary wrist movements |
| 5. | Crossectional investigation of wrist movement intention  Classification in eeg signals | Band-specific Butterworth zero-phase filters (6th and 12th orders) |  | Amplitude variance of the signal  Windowed amplitude variance of the signal  Maximum/minimum power and dominant frequency  of autocorrelation  6th order autoregressive model, 6 coefficients and noise variance  4th order autoregressive moving average model, 4 coefficients and noise variance  Total signal power | Multilayer Perceptron | Right and Left hand movements |
| 6. | Decoding Individual Finger Movements from One Hand  Using Human EEG Signals | Elliptic IIR 3Hz HPF (with forward and reverse filtering to avoid distortion)  60Hz notch filter for power line removal with the transition band of 0.3Hz  ICA for artifact rejection | Movement related spectral changes | PCA applied to Power Spectral Density data to determine weight of movement variations | Support Vector Machine with radial basis kernel basis from LIBSVM package | Different finger movements decoding |
| 7. | Reconstructing Three-Dimensional Hand Movements from  Noninvasive Electroencephalographic Signals | low-pass, antialiasing filter with a cutoff frequency  of 40 Hz |  |  |  |  |
| 8. | Brain EEG Signal Processing For Controlling a Robotic Arm | Band pass filter 0.5-45Hz 5th order Butterworth | Three movements (close, open arm and close hand) | Wavelet Transform (WT), Fast Fourier Transformation (FFT) and Principal Component Analysis (PCA) | Back Propagation (BP) Neural Network |  |
| 9 | Relationship between Speed and EEG Activity during Imagined  and Executed Hand Movements | band-pass filtered from 1 Hz to 30 Hz using a zero-phase FIR filter | Speed and hand information as variables | linear model and linear regression with wavelet analysis |  |  |
| 10. | How Many People are Able to Operate an EEG-Based  Brain-Computer Interface (BCI)? | Band pass filtered 0.5 to 30Hz | Power and spectral dynamics | AAR (ecursive-least-squares) and Band power estimation | LDA | Right hand and both foot |

[1] Current motor-imagery-based BCI systems suffer from long learning periods and unintuitive mappings between mental state and system feedback.

Information transfer rate

Mirror neurons

Event-related spectral changes also occur in the *\_* frequency band in the range of 14-25 Hz during motor execution and imagery

We test all combinations allowed in Table 2.1, resulting in 1 × 4 × 2 × 2 × 4 × 4 × 2 = 512 different feature vectors.

Figure 2.1: This figure shows the motivation for high-pass filtering and channel scaling with the ECoG-ERD data.The test data have a higher amplitude and considerable offset compared to the training data. After high-pass filtering, the test data still exhibit a higher variance than the training data. A final step of scaling the filtered channel data fixes this.

[2] To avoid visually evoked potentials, the recording started 0.5 s after the visual cue.

Thus, Principal Component Analysis (PCA) studies on the multi-channel data acquire importance for the selection of the appropriate channels with maximum information. Furthermore, the paper covers object oriented filter design which gives better trade off analysis between the stop band attenuation and the filter order which is perceived to have positive effect on the transfer rates of BCIs.

[5]The 10 best feature/channel sets as determined by the Davies-Bouldin Index (linear separability) were used

[7] https://en.wikipedia.org/wiki/Decimation\_(signal\_processing)