4.5.28. ON-LINE AUTOMATIC SUPPRESSION OF ARTIFACTS IN MULTI-DIMENSIONAL SIGNALS USING ICA

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Variety of procedures have been proposed for on-line correction of multidimensional signals, including methods based on regression, principal component analysis and others. One of the most promising methods is Independent Component Analysis (ICA) providing blind separation of independent sources activities (BSS). The method proposed in the paper deals with multi-dimensional recording of electroencephalogram (EEG) during on-line signal acquisition for purposes of Brain-Computer Interface (BCI). BCI is a system intended to establish a channel for direct communication of human brain activity with technical devices. One of the approaches is based on the recognition of EEG patterns specific for different mental tasks. When the subject imagines voluntarily the performance of a task, the corresponding EEG pattern is recognized and transformed into the command to external technical device. The suppression of artifacts in multi-dimensional signals is important in variety of tasks but it is known to be crucial for BCI performance. One of the most corrupting EEG artifacts relates to eyes movements and blinking. The origin of these artifacts is the electrical processes in the retina that can be presented in terms of equivalent current source dipoles. Eyes movements result in the change of dipoles directions and blinking changes the conductivity of the medium due to lowering of the eyelids. Both effects produce corruption in multi-dimensional EEG signal overlapping in amplitude as well as in frequency band with signals corresponding to brain activity related to motion imaginary.

In our experiments data was acquired with using 0–30 Hz bandwidth ADC, with 32 channels, located accordingly to international 10–20 EEG registration system. Figure 1 represents row EEG recording (blue) in channels F3 (lower one) and F4 (upper one). Figure 2 represents the same for the blink artifacts in O1 (lower one) and O2 (upper one) channels.

As shown these artifacts are only slightly correlated with brain activity during BCI mental tasks and have non-Gaussian nature. Thus they can be easy revealed by ICA methods. At most 11 significant independent components were extracted from 32-di-mensional EEG recordings.

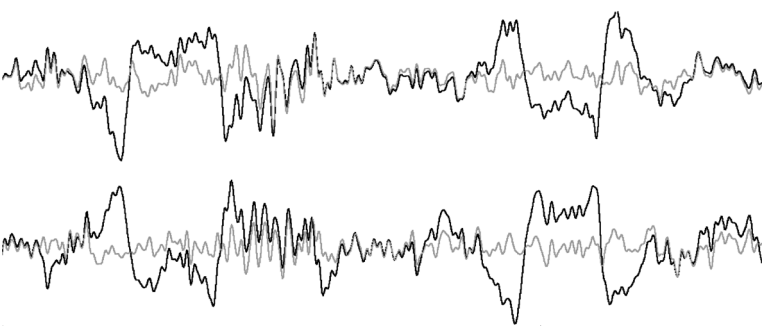

Fig. 1. Eye movement artifact suppression

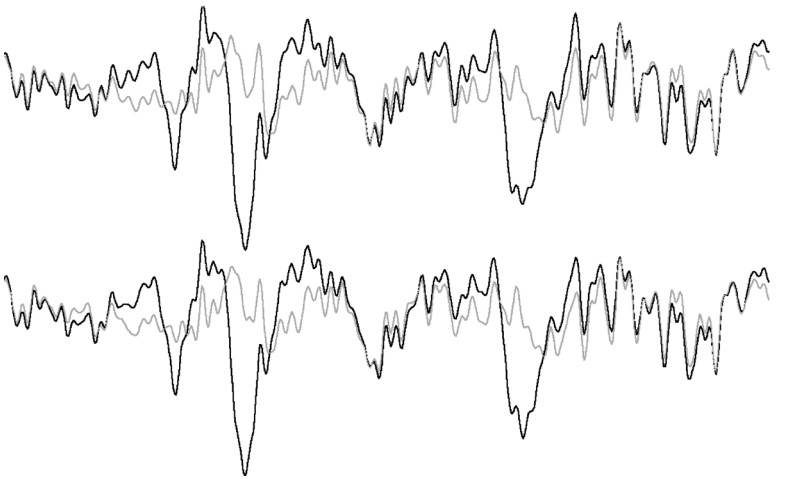

Fig. 2. Blink artifact suppretion

Component interpretation was based on computer head model consisting of several volumes of different electrical conductivity including two eyes. The contribution of the ocular artifacts into EEG was evaluated by solving forward EEG problem using Boundary Elements Method (BEM). Two ocular dipolar sources were used. Five ICA components were interpreted as ocular artifacts related to eyes movement in four directions and blinking. As shown in fig. 1 and fig. 2 in red lines the subtraction of the five components results in considerable suppression of the ocular artifacts. The on-line suppression of the ocular components significantly influenced to the BCI performance. The direction and magnitude of the influence appeared to be subject dependent.