P147_EEG beamforming to extract better features of motor imagery in a two-class real-time BCI

Staljanssens W.[1], Strobbe G.[1], van Mierlo P.[1], Van Holen R.[1], Vandenberghe S.[1]
[1] *Dept. of Electronics and Informations Systems, Ghent University, Sint-Pietersnieuwstraat 41, Ghent, 9000, Belgium*

A general problem in the design of an EEG-BCI system is the poor quality and low robustness of the extracted features, affecting overall performance. However, BCI systems that are applicable in real-time and outside clinical settings require high performance. Therefore, we have to improve the current methods for feature extraction.

In this work, we investigated EEG source reconstruction techniques to enhance the extracted features based on a linearly constrained minimum variance (LCMV) beamformer[1]. Beamformers allow for easy incorporation of anatomical data and are applicable in real-time. A 32-channel EEG-BCI system was designed for a two-class motor imagery (MI) paradigm. We optimized a synchronous system for two untrained subjects and investigated two aspects. First, we investigated the effect of using beamformers calculated on the basis of three different head models: a template 3-layered boundary element method (BEM) head model, a 3-layered personalized BEM head model and a personalized 5-layered finite difference method[2] (FDM) head model including white and gray matter, CSF, scalp and skull tissue. Second, we investigated the influence of how the regions of interest, areas of expected MI activity, were constructed. On the one hand, they were chosen around electrodes C3 and C4, as hand MI activity theoretically is expected here. On the other hand, they were constructed based on the actual activated regions identified by an fMRI scan. Subsequently, an asynchronous system was derived for one of the subjects and an optimal balance between speed and accuracy was found. Lastly, a real-time application was made. These systems were evaluated by their accuracy, defined as the percentage of correct left and right classifications. From the real-time application, the information transfer rate[3] (ITR) was also determined.

An accuracy of 86.60 ± 4.40% was achieved for subject 1 and 78.71 ± 0.73% for subject 2. This gives an average accuracy of 82.66 ± 2.57%. We found that the use of a personalized FDM model improved the accuracy of the system, on average 24.22% with respect to the template BEM model and on average 5.15% with respect to the personalized BEM model. Including fMRI spatial priors did not improve accuracy. Personal fine-tuning largely resolved the robustness problems arising due to the differences in head geometry and neurophysiology between subjects. A real-time average accuracy of 64.26% was reached and the maximum ITR was 6.71 bits/min.

We conclude that beamformers calculated with a personalized FDM model have great potential to ameliorate feature extraction and, as a consequence, to improve the performance of real-time BCI systems.

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