Combination of Manual Control and Motor Imagery to Move an Artificial Limb

A. Kreilinger¹, C. Neuper¹,², G.R. Müller-Putz¹

¹ Institute for Knowledge Discovery, Graz University of Technology, Austria
² Department of Psychology, University of Graz, Austria

Introduction

Brain-Computer Interfaces (BCIs) provide an additional channel to communicate for severely disabled people. However, the performance of pure BCIs is usually lower than that of comparable muscle controlled applications (e.g., by the shoulder, eyelids, or the cheek). Nevertheless, using brain signals is often more comfortable for patients because their muscles do not get tired in that way. Therefore, a useful application for BCIs might not be a complete replacement of muscle-controlled assistive devices, but a smart upgrade of such by appending BCI channels. This combination is called hybrid BCI (hBCI). This poster shows a basic approach by the example of combining a shoulder joystick to control grasping and a brain switch for elbow movement in a neuroprosthetic application.

Methods

The brain switch was realized by detecting the beta rebound [1, 2], an event-related synchronization (ERS) of neural networks after motor activity and motor imagery (MI), after imagination of brisk foot movements (dorsi/plantar flexion). The electroencephalogram (EEG) was recorded from one Laplacian derivation, centered around Cz. With this recorded data a subject-specific online classifier (LDA) was used to detect the characteristic increase of band-power of the selected frequency bands and to trigger the brain switch after a certain threshold was exceeded. The setup of the experiment is demonstrated in Figure 1. The progress of events during one run of the experiment was as follows: after a first 60 s of rest, an object was presented to the participants which they were told to grasp with the artificial gripper. After that, the objective was to move the arm up and down, both movements triggered by the brain switch. Finally, the object was to be given back to the operator by releasing and closing the grip. Having waited for another 30 s, the exact same progression was repeated, followed by another break of 60 s. These long periods of non-control states were necessary to check for false positive (FP) activations caused by unintended brain switches.

Results

Two out of three participants produced significant ERS patterns, demonstrated in Figure 2. Additionally, the averaged output of the classifier is plotted with subject-specific dwell times. For evaluation, three measures are given: the percentage of true positives (TPs) and false negatives (FNs) depending on the context and the rate of FPs during the breaks. On average, the subjects achieved TP = 75.6 %, FN = 24.4 %, and 0.43 FP/min. Table 1 demonstrates the particular results for each subject.

<table>
<thead>
<tr>
<th>Subject</th>
<th>TP [%]</th>
<th>FN [%]</th>
<th>FP/min [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>90.6</td>
<td>9.4</td>
<td>0.07</td>
</tr>
<tr>
<td>S2</td>
<td>82.1</td>
<td>17.9</td>
<td>0.82</td>
</tr>
<tr>
<td>S3</td>
<td>54.0</td>
<td>46.0</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Discussion

For subjects with distinctive ERS patterns, a reliable, working classifier was computed and used online to allow a combination of both muscle- and brain-control. The participants were able to control the elbow correctly within the given time. Due to long breaks between the movements, some FPs occurred that had to be corrected afterwards by another brain switch. To conclude, the demonstrated application serves as a basic implementation of an hBCI and future work can be built on this prototype. The used joystick can simply be replaced by any kind of assistive device. Further, the BCI channel is not limited to a brain switch based on foot MI. Additionally, instead of only two different channels, other channels (sensors, biosignals or brain signals) could be integrated into the system to control more dimensions. Other than signals used to directly control movements, mental state monitoring could be included (e.g., measurement of fatigue or error potentials to correct false events).

References:


Acknowledgements: This work is supported by the European ICT Programme Project FP7-224631. This paper only reflects the authors’ views and funding agencies are not liable for any use that may be made of the information contained herein.