Hybrid motor imagery and steady-state visual evoked potential based BCI for artificial arm control

P. Horki [1], T. Solis-Escalante[1], C. Neuper[1] , G. R. Müller-Putz[1]
E-mail: petar.horki@tugraz.at
[1]Institute for Knowledge Discovery, Graz University of Technology, Graz, Austria

INTRODUCTION

BCIs based on both induced and evoked EEG responses can be used for artificial arm control. The beta rebound after brisk feet motor imagery (MI) is suitable for a fast setup of a self-paced BCI [1]. Another type of BCI which requires little or no training is based on the SSVEP, elicited by presenting repetitive visual stimuli at a rate above 6 Hz. Here, we combine MI and SSVEP for the self-paced control of an artificial arm.

METHODS

The stimuli are delivered via two LEDs, flickering with 8 and 13 Hz respectively. The EEG is recorded from Cz (Laplace) and 6 subject-specific occipital channels [2]. In a self-paced experiment the subjects control an artificial arm according to verbal instructions. They toggle (open / close) the gripper by MI, and controll the elbow by focusing on one of the 2 LEDs (flexion / extension). Subjects have to perform the following predefined movement sequence (and correct false activations): open gripper (GO), close gripper (GC), elbow middle (EM), elbow extension (EE), GO, GC, elbow flexion (EF), EM, GO, EE, GC. The SSVEP frequency recognition is based on the canonical correlation analysis [3]; LDA is used to set up a classifier based on one logarithmic band power feature corresponding to the brisk foot MI [1]. The detection of MI and SSVEP is not mutually exclusive, that is, the control is simultaneous.

RESULTS

One out of six subjects was able to perform the whole movement sequence in the predefined order. On average, the subjects had to correct 3±2 movements while performing the sequence. The subjects rated, on a scale from 1 (low) to 10 (high), their ability to control the elbow with 7.7±1.6, to control the gripper with 6.3±1.8 and the ability of the system to detect non-control periods with 5.8±1.7.

DISCUSSION

Interestingly, even though the SSVEP control generally resulted in a higher number of false activations than the MI control, most of the subjects perceived their ability to control the elbow to be higher than their ability to control the gripper. Currently, new subjects as well as tetraplegic patients participate in this ongoing experiment.

References

[1] Müller-Putz et al., “Fast set-up asynchronous brain switch based on detection of foot motor imagery in 1-channel EEG,” Comp. in Biol. and Med., 2009, accepted.

[2] Horki et al., “Asynchronous SSVEP-Based BCI Control of an Artificial Upper Limb”, International Journal of Human-Computer Interaction, submitted.

[3] Lin et al., “Frequency recognition based on canonical correlation analysis for SSVEP-based BCIs,” IEEE Trans. on Biom. Eng., 54(6), 2007.