Cognitive Brain-Machine Interaction

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Introduction

Brain-Computer Interface (BCI) systems usually translate user intents, derived from EEG, into applications’ control signals. This approach is highly demanding in terms of user’s involvement, requiring a continuous generation of mental commands.

We discuss a new kind of brain interaction, based on the human-in-the-loop approach. In this approach, the user only cognitively monitors the performance of a semi-autonomous system, which carries out its task automatically; occasionally, it receives corrective signals, for key decisions’ delivery or performance improvements.

Error-Related Potentials (ErrP) evoked by error detection processes and slow cortical potentials related to anticipation of future events such as Contingent Negative Variation (CNV) can replace or complement asynchronous control commands issued by traditional BCI [3].

Human-in-the-loop

Multimodal Feedback

Error monitoring is crucial to improve performance for both humans and artificial cognitive systems. We have intensively studied the use of ErrP elicited in Brain-Computer interactions. Namely we have demonstrated the use of ErrP to correct erroneous decisions made by the BCI. Real-time simultaneous classification of mental imagery and ErrP detection, as shown in the table and image aside, yields a significant increase in the interface transmission rate [2].

Moreover, we have also studied the use of ErrP elicited when a human user monitors an external system upon which he has no control whatsoever [1].

Single trial classification of such signals (see table below) may then be used for improved interaction with semi-autonomous systems.

Error-Related Potentials I

Error-Related Potentials II

ErrP have been investigated also within the framework of the TOBI project, by means of 16-channel EEG recording the fronto-central channels.

Protocol

A cursor moves discretely towards the right target every two seconds; according to a fixed error rate, steps are taken towards the undesired direction. Whenever an error is detected, the last step is corrected within one second.

Pilot experiments have been performed on one subject, and a brief demonstration has been presented during the TOBI midterm review meeting. Preliminary classification results are presented aside, as a confusion matrix.

Anticipation-related Negativity

Anticipation is a cognitive state reflecting expectation of a relevant future event based on past experience. Anticipation-related potentials derived from human EEG can be used for adapting the controller of semi-autonomous navigation system.

EEG correlates of anticipation and realtime recognition on single trials

Peak accuracies up to 85% and 80% and averages of 69 ± 7.9 and 58 ± 8.5 are observed for two subjects respectively [4].

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References


