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NeuroTS: Embodied based Motor Imagery Brain-Computer Interface feedback system for neurorehabiliation

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Abstract

Motor-Imagery based BCI (MI-BCI) neurorehabilitation can improve locomotor ability in patients affected by neurological disorders with motor deficits (such as Stroke and Parkinson's disease).

Advanced Motor-Imagery BCI methods are needed to overcome the accuracy, time-related MI BCI calibration challenges, appropriate visual feedback to facilitate the motor imagery task and its impact on the rehabilitation process in such patients. In particular, the standard feedback defined by Graz protocol (Pfurtscheller et al. 2001) represented by simple modulation of the direction and the length of the bar visualized on the screen might not be fully suitable for the neurorehabilitation as it was shown to be suboptimal for skill teaching and requires longer training (Jeunet et al. 2016).

The embodied visual feedback approach, where the realist feedback is presented to a subject, can facilitate comprehension and the Motor Imagery task performance.

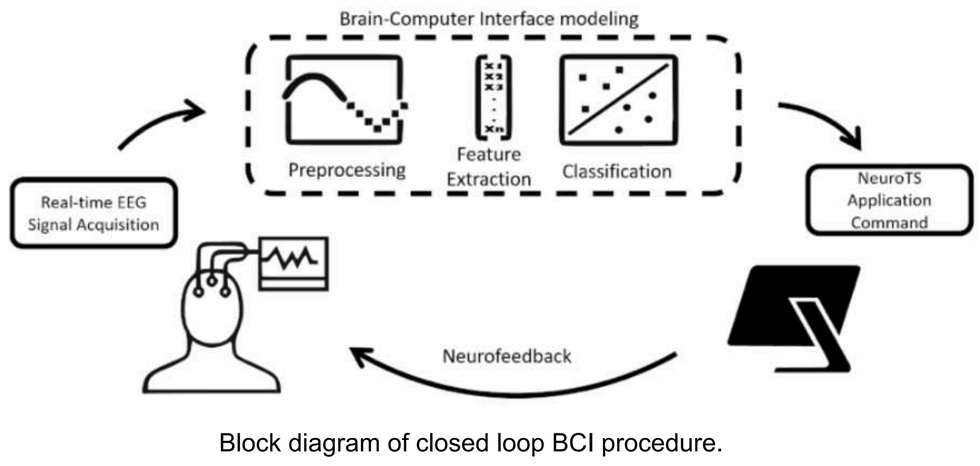
This work aims to describe the developed NeuroTS feedback system which implements the characteristics of Embodied based Motor Imagery. The system was successfully tested on healthy subjects and in early neurorehabilitation of Stroke patients.

NeuroTS Description

The MI-BCI neurorehabilitation refers to the closed-loop detection of EEG MI Event-related desynchronization/synchronization (ERD/S) and its transformation via spatial filtering and machine learning techniques to the visual feedback presented to the subject in real-time.

The subject becomes aware of the voluntary modulation of EEG oscillatory activity, and when coupled with the adequate stimulus and electrode settings, can target desired brain regions.

Furthermore, such an approach creates a more controlled rehabilitation environment since the MI induced oscillatory activity can be also monitored to assess whether the patient performs the rehabilitation task correctly.



Block diagram of closed loop BCI procedure.

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Emobdied visual feedback provided by NeuroTS during EEG based MI- BCI online session.

- To provide more realistic feedback the embodied visual feedback approach was designed and developed to facilitate comprehension and the Motor Imagery task performance.
- The NeuroTS is a software designed for interactive stimulus presentation and visual feedback for Motor-Imagery based Brain-Computer Interface.
- The software has been designed to communicate with different BCI processing frameworks, including BCILAB, OpenViBE, BCI2000 via LSL protocol.
- The software accepts the output of the classifier in form of the series of numbers, where in the case of two classes Motor Imagery experiment the negative numbers correspond to one and positive to other class

Impact

The described system was successfully tested in healthy subjects and the in early post-stroke rehabilitation providing embodied self-explanatory feedback, which made the system east to use for subjects and operates, allowing high motor imager performance in short training time.

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