Proposition de recherche doctorale

Cognitive brain-computer interface

Mots clés :

- Directeur de thèse : François-Benoit VIALATTE
- Co-encadrant(s) :
- Unité de recherche : Laboratoire d'Informatique Signal et Image Electronique et Télécommunication
- Ecole doctorale : Ecole Doctorale Informatique, Télécommunications, Electronique de Paris
- Domaine scientifique principal : Sciences de l’information et de la communication

Résumé du projet de recherche (Langue 1)

In order to study the most subjective cognitive functions, we need to interact directly with them. From a neuroengineering perspective, this means that we need a technology allowing us to monitor and interact with cognitive functions in real-time. We will investigate a novel paradigm: the cognitive brain-computer interface. EEG signals have been shown to contain information correlated to cognitive functions (see e.g. Gazzaniga, 2009), which could be observed even in single trial acquisitions, for instance using time-frequency representations (Vialatte et al., 2007; Vialatte et al., 2009). Our working hypothesis is that it is possible to monitor the markers of such cognitive activity on short time scales (between 0.1s and 10s) with sufficient reliability. The goal of this research project is to monitor the neural correlates of cognitive functions in real-time. We will specifically study the local and large-scale synchrony effects (time-frequency structure, complexity measures, stationarity and non-linearity measures, mutual information, coherence and correlation, state-space based synchrony, etc.), as they are likely to convey key information about the neural correlates of cognition. These investigations will be performed within the boundaries of real-time constraints.

Résumé du projet de recherche (Langue 2)

EEG signals will then be modelled in three steps, integrating machine-learning and cognitive neuroscience: - Intelligent feature design. We will identify the most significant properties for the real-time detection of cognitive correlates. - Supervised feature investigation and machine learning. Machine learning algorithms (e.g. artificial neural networks, see Dreyfus 2005) will be used to create semi-physical models for prediction of the brain state in regard to a given cognitive function. - Experimental tests. The cognitive BCI will be tested, while objective and subjective reports of the subject neurophenomenological experience are monitored using psychometric scales and physiological measures. This step will validate the models developed.

Informations complémentaires (Langue 1)

This project will benefit from our present network of collaborations, providing an access to international experts: - The Dauwels lab (Singapore, NTU, EEE department), specialized in biomedical engineering; - The laboratory for advanced brain signal processing (Riken Brain Science Institute, Japan), specialized in EEG/fMRI signal modeling and processing, and data analysis; - The Department of Digital Technologies and Information (University of Vic, Spain), for signal processing.

Informations complémentaires (Langue 2)

From an engineering perspective, developing processing methods for multiple channel EEG recordings can lead to the creation of new models for related problems such as online artifact rejection using blind source separation (BSS), independent component analysis and temporal concatenation applied to multiple channel detection to increase signal to noise ratio, time-space-frequency representation, etc. Real-time cognition monitoring could be of use in several domains. First, the monitoring of cognitive functions can be used as a tool for neurological disorders diagnosis and for cognitive dysfunction therapy (using neurofeedback) with applications to ADHD, depression, and schizophrenia (within the framework of cognitive remediation therapies). Then, with the price fall of EEG systems and the development of dry electrodes and other innovative measurement systems, we can imagine that these sensors could be easily available in the future and could be of use for instance in any activity that requires cognitive monitoring (such as driving).