In the context of the program « PhD contracts of the Project AXIAUM Artificial Intelligence in Health and Environment » cofinanced by the French National Research Agency, University of Montpellier proposes a PhD position entitled:

Dynamical neurophysiological models and deep learning for the study of brain connectivity in healthy and brain injured subjects

SUPERVISION and INSTITUTIONS

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PROJECT DESCRIPTION

Scientific context

EuroMov Digital Health in Motion is a new research unit that was officially inaugurated in January 2021. This research collaboration involves the French institutions IMT Mines Alès and the University of Montpellier in partnership with the university hospitals of Montpellier and Nîmes. The research scope promotes cross-fertilization across three main domains of artificial intelligence, movement sciences and health. The research lab aims to understand the behavioral plasticity of humans in order to consider new therapeutic approaches and improve sensorimotor recovery, whilst providing a platform for innovation of new digital approaches.

Research topic

Progress in the development of devices for capturing human physiological signals in terms of spatial and / or temporal resolution, portability, ergonomics, autonomy and cost, suggests uses hitherto unexplored uses. In this context, we are interested in neurophysiological signals acquired via a brain-computer interface (BCI). Focus is on electroencephalography (EEG) and functional near infrared spectroscopy (fNIRS) signals to address neuroscientific issues. Neurophysiological signals are signals with a random component, the acquisition being disturbed by different types of noise and artefacts. To effectively process these signals, it is necessary to integrate multidisciplinary knowledge from physics, biology, neuroscience and medicine into the analysis pipeline, in addition to the disciplinary bases in signal processing, digital modeling and artificial learning.

For clinicians, evaluating disorders of consciousness (DOC) patients following severe brain injuries or conscious quadriplegic patients defined as "Locked in Syndrome" represents a fundamental challenge in responding to requests from patients' families and adapting treatment. The standardized Coma Recovery Scale Revised (CRS-R) assessment protocol consists of differentiating intentional and spontaneous behaviors (Giacino et al., 2004). These patients, suffering from a severe voluntary motor control deficit of the limbs and facial muscles, are often very limited in expressing self-awareness or the perception of their environment. Behavioral assessments are thus susceptible to diagnostic errors. A 2009 clinical study reveals that up to 40% of cases are misdiagnosed (Schnakers et al., 2009). The precise assessment of DOC patients is therefore essential for patients, their relatives and clinicians, with prognostic, therapeutic and ethical implications.

In this thesis, we wish to develop an original and multidisciplinary approach to processing neurophysiological EEG and fNIRS signals to help clinicians in their assessment of DOC. The planned research will focus on multi-channel, multi-modal, multi-acquisition, multi-scale spatial and temporal signal processing by integrating digital propagation and connectivity models associated with deep learning approaches. The interest of this coupling is to identify digital model parameters and patterns representative of neurophysiological signals.

Currently, the analysis of EEG or fNIRS signals is primarily performed using signal-processing techniques to extract signals of interest (Wolpaw et al., 2002) that are classified in a supervised or unsupervised manner. The extraction of informative features and the precise classification of these combined signals are considerably difficult due to physiological non-stationarity, low signal-to-noise ratio, and interference from various noises etc. On the other hand, the temporal aspect is poorly acknowledged in the literature, under the assumption that the signals of interest have the same patterns, which may not be the case in reality. The resulting temporality or spatiotemporal networks formed could provide information filtered by the conventional approach. The objective of our approach is to improve the multiscale analysis and the spatio-temporal synchronization of EEG and hemodynamic fNIRS signals by conjointly setting-up digital propagation models and deep learning approaches.

Expected impact

Our multimodal EEG-fNIRS BCI implements a deep learning algorithm that will allow a multi-scale analysis of cortical electroencephalographic and hemodynamic signals (and to a lesser extent subcortical) during cognitive mental imagery tasks (motor imagery and mental calculation). To our knowledge, only one study (Chiarelli et al., 2018) undertook a similar approach with a simple neural network (six layers) in 15 healthy subjects. Analysis of the spatio-temporal synchronization of EEG and fNIRS signals based on digital propagation models should allow clinicians to better understand the impacts of brain injuries on DOC.

In clinically challenging situations, where 40% of patients misdiagnosed in a vegetative state are in reality in a minimal conscious state or even conscious, we hope to help clinicians improve their diagnostic capabilities, provide better informed responses to families' requests and adapt patients care.

References

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- Schnakers C et al., 2009. Diagnostic accuracy of the vegetative and minimally conscious state: clinical consensus versus standardized neurobehavioral assessment. BMC Neurol. 9, 35.
- Wolpaw JR et al., 2002. Brain-computer interfaces for communication and control. Clin Neurophysiol. 113, 767-791.
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- Wannez S et al., 2017. The repetition of behavorial assessments in diagnosis of disorders of consciousness. Ann Neurol. 81 (6):883-889.
- Laureys S et al., 2010. Unresponsive wakefulness syndrome: a new name for the vegetative state or apallic syndrome. BMC Med. 8, 68.

Profile and skills

The candidate must hold a Master degree or equivalent in Computer science (Artificial Intelligence, data sciences) or control theory (Signal processing).

- the candidate holds interest in clinical research and sciences for health
- the candidate must be thorough, present capacities of analysis and synthesis, as well as writing skills in French and English.

Application

Applications are accepted until **April 14th, 2021**. Short-listed candidates will be asked to prepare an interview for the hiring committee, composed of members from the I2S graduate school of Montpellier. Interviews will take place at Montpellier on **May 5 and 6 2021**.
https://www.adum.fr/as/ed/page.pl?site=I2S&page=campagne_contratsDoc

The starting date is fall 2021. The position is for 3 years. Net salary is around 1500€ (not including possible teaching assistance), and includes the French social security/health package. All professional expenses (e.g., experiments / hardware / software / travel / publications) are covered by host laboratories.

For the position**,** applicants should (1) contact the supervisors to prepare their application and (2) send, in one merged PDF, a cover letter with a statement of research interests, CV, publications, relevant certificates (degrees, grades, honours), and (3) communicate the name and contact of at least two people who will provide a recommendation letter, to jacky.montmain@mines-ales.fr and stephane.perrey@umontpellier.fr.