2022-05575 - Master 2 Internship – EEG signal processing of signal recorded during EEG-fMRI acquisition

Level of qualifications required : Graduate degree or equivalent
Fonction : Internship Research

About the research centre or Inria department

The Inria Rennes at Rennes University is one of Inria's eight centres and has more than thirty research teams. The Inria Center is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Context

Electroencephalography (EEG) directly measures changes in electric potentials occurring in the brain in real-time with an excellent temporal resolution (milliseconds), but a limited

spatial resolution (around a centimetre), due to cortical currents volume conduction through head tissues, and the ill-posed inverse problem of source localisation. On the other hand, functional magnetic resonance imaging (fMRI) offers a better spatial resolution (a few millimetres) but has slow dynamics (one or two seconds) as it measures hemodynamic

activities, which occur in general, a few seconds after a neural event. Both EEG and fMRI are non-invasive methods that are indirectly coupled and measure complementary aspects of human brain activity.

Simultaneous EEG-fMRI recording has been used to understand the links between EEG and fMRI in different states of brain activities and has received recognition as a promising multi-modal measurement of brain activity. Furthermore, recent studies [Perronnet et al. 2017] have shown the high potential of combining EEG and fMRI in a bimodal Neurofeedback training (i.e., feeding back in "real-time" a subject with a score reflecting his or her own brain activity to self-regulate brain areas or networks, targeted by a neural rehabilitation) to achieve advanced self-regulation, by providing a more specific estimation of the underlying neural activity.

However, EEG-fMRI analysis is limited by the corruption of EEG signals under the MRI environment. During EEG-fMRI acquisition, EEG signals are altered by extremely strong gradient artefacts and, as the motion of a closed electrical circuit in a magnetic field induces an electric current (Lenz-Faraday law), the signal is also affected by artefacts induced by any motion or vibration in the strong static magnetic field (MR motion-related artefacts) such as head motion, the pulsatile motion of scalp arteries, the vibration of the ventilation system, and cardiac activity. Gradient artefacts can be fairly by a hybrid mean and median moving average corrected [Grouiller et al. 2016] or Optimal Basis Sets [Niazy et al. 2005] approaches. For MR motion-related artefacts, methods were proposed based on Optimal Basis Set [Wu et al. 2016] or ICA [Mayeli et al. 2016]. However, the evaluation of artefact correction
methods' performance is not trivial since the true EEG signal without artefacts is unknown. Also, most studies evaluate the reduction of the artefacts but without addressing the problem of signal preservation, and it has been shown that over-filtering degrades the EEG signal [Steyrl et al. 2019].

Assignment

Supervisors: Claire Cury, Empenn team:claire.cury@inria.fr, Julie Coloigner, Empenn team: Julie.coloigner@irisa.fr, Julien Modolo, LTSI: julien.modolo@inserm.fr

Scientific environment: Empenn team, IRISA-Inria, Campus de Beaulieu, 35042 Rennes Cedex, France https://team.inria.fr/empenn

Duration: 5 to 6 months, starting in 2023

Keywords: Signal processing, EEG, bi-modal, Neurofeedback

Objectives:

The goal of this internship is first, to implement and compare the different state-of-the-art approaches found in the literature that allows reducing the noise on EEG signals when recorded under fMRI. Then the aim of the internship is to explore different metrics related to the EEG signal that can help to assess the quality of the EEG signal correction and determine the metrics or the combination of metrics that best describe the quality of the corrected EEG signal. We will focus on the artefact correction related to cardiac activity.

Main activities

- Bibliographic research
- Processing EEG signals with different software
- Implementation of a state-of-the-art method
- Designing an EEG signal processing pipeline
- Definition of adapted metric to measure the EEG signal quality
- Take part in the acquisition of EEG-fMRI data (with or without neurofeedback training)
- Present the work progress during lab seminar
- Interact with other researchers

additional activities:

- Take part in the acquisition of EEG-fMRI data (with or without neurofeedback training)
- Present the work progress during lab seminar
- Interact with other researchers

Skills

General Information

- **Theme/Domain :** Computational Neuroscience and Medicine
  Biologie et santé, Sciences de la vie et de la terre (BAP A)
- **Town/city :** Rennes
- **Inria Center :** Centre Inria de l'Université de Rennes
- **Starting date :** 2023-03-01
- **Duration of contract :** 6 months
- **Deadline to apply :** 2023-03-31

Contacts

- **Inria Team :** EMPENN
- **Recruiter :**
  Cury Claire / claire.cury@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

Please send us the following information and documents:

- Updated CV

- Your grades and ranking of your master degree

- A motivation letter

- A recommendation letter, or the contact of a teacher or a supervisor who could recommend your application.

- The 6 months during which you are due to complete your master internship.

Instruction to apply

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

- Good knowledge in applied mathematics and/or computer science.

- Strong interest in neuro-imaging.

- Knowledge in signal processing.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs

Remuneration

Grant of 3.90 € per hour