2018-00735 - PhD Position/ Modeling the influence of vigilance state on the mesio-temporal lobe epileptic networks [S]

Level of qualifications required : Graduate degree or equivalent
Fonction : PhD Position

Context

The thesis will be conducted in LORIA (Laboratoire LOrrain de Recherche en Informatique et ses Applications), Neurosys team, and CRAN (Centre de Recherche en Automatique de Nancy), Neurosciences des Systèmes et de la Cognition team, with an equitable time spent in both laboratories and weekly meetings with the supervisors, as well as regular meetings with other members of the two teams, including CHU neurologists.

The work will include both computational modeling and signal processing aspects. The expertise of LORIA will be particularly involved in the modeling part, as one of the main research themes is the biologically realistic modeling of hippocampo-cortical networks. The CRAN contribution will take advantage of recent advances in computational realistic models.

The proposed project is part of a broader research project, including an already started Ph.D. project focusing on computational modeling and simulation of the (peri-)hippocampal healthy/epileptic networks, and it aims to continue and complete this modeling approach.

The developed modeling and data analysis techniques will be designed and validated by confronting them to real human in vivo recordings performed at the University Hospital (CHU) from Nancy, on drug-resistant temporal lobe epileptic patients. During routine presurgical evaluation of these patients, intracranial EEG recordings (SEEG) are commonly performed with several contacts located in brain structures of interest. In particular cases, electrophysiological activities are explored using simultaneously micro and macro (SEEG) depth electrodes (sometimes bilaterally implanted). This investigation offers a unique opportunity to analyze and model multi-scale phenomena both in the epileptic hemisphere and, possibly, in the healthy contralateral one. As the investigations last for several days, awake-sleep differences can also be assessed.

The proposed research is organized in two main blocks: modeling and data analysis.

The keys to success

Prior knowledge in signal processing with a strong interest in neuroscience is expected.

Application deadline

May 1st, 2018 (Midnight Paris time)

How to apply

Upload your file on jobs.inria.fr in a single pdf or zip file, and send it as well by email to laure.buhry@inria.fr and serban.ranta@loria.fr

Your file should contain the following documents:

- Your CV.
- A cover/motivation letter describing your interest in this topic.
- A short (max one page) description of your Master thesis (or equivalent) or of the work in progress if not yet completed.
- Your degree certificates and transcripts for Bachelor and Master (or the last 5 years).
- Master thesis (or equivalent) if it is already completed and publications if any (it is not expected that you have any). Only the web links to these documents are preferable, if possible.

In addition, one recommendation letter from the person who supervised(s) your Master thesis (or research project or internship) should be sent directly by his/her author to laure.buhry@inria.fr.
We propose to develop a large scale computational model of the mesial temporal lobe that would be coherent with previous experimental findings both at the micro- and meso-scale levels. In order to keep the full model tractable, we will seek to use as simple as possible models, still preserving the relevant neuronal dynamics and network properties. At the the micro-scale level, our model will be based on realistic neurons derived from Hodgkin-Huxley equations, including also persistent firing neurons [5]. The cells will then be arranged in a large network and their positions, orientation, and synaptic projections will respect the topology and functional connectivity of the different regions of the mesial temporal lobe. The influence of the wake or sleep status, as well as the changes seen in epileptic brains, like hippocampal deafferentation, will be included in the model at both the neuron and network levels. Finally, the influence of external electric fields (ephaptic effect [6], either due to electrical stimulation or to neighboring synchronized populations) will also be taken into account.

This work will be based on the healthy hippocampus models already under development in the team, and the main goal is to introduce epileptic phenomena models. Multichannel/Multiscale analysis of epileptic sources and networks

Because of the contributions of distant generators (volume conduction), the validation of the proposed computational model relies on the mapping of the recorded activities in a combination of local generators, identifying the isolated activity of the targeted structures. On this inverse problem side, a combination of statistical and model based methods can be used. The problem is ill-posed: the contributors are sources of different natures, propagated through the volume from different locations and recorded at different scales (microelectrodes and SEEG). Two main steps are then considered: to disentangle the local from propagated sources and to estimate local contributors to the local part of the LFP. For the first step, we propose to solve the source inverse problem from the SEEG measurements [7, 8]. By retro-propagating the solution at the site of the microelectrodes, we intend to estimate the distant macroscopic contributions to these measurements. This already developed solution will be confronted to novel multimodal microelectrode / SEEG decomposition approaches based on Canonical Correlation Analysis (CCA) and its recent developments [9, 10]. Once a local LFP estimate is obtained, we will focus on the different local contributors to microrecordings.

We intent to propose despiking/spike sorting approaches, aiming at detecting, extracting and classifying the spikes from the raw signal in a fully integrated Bayesian framework, possibly combining wavelets and multichannel approaches [11, 12]. Once the distant propagated activities and the multunit activities are extracted, the remaining contributors to the LFP will be estimated by optimal/regularized regression [13] on a modeled dictionary.

REFERENCES


Main activities

Prior knowledge in signal processing with a strong interest in neuroscience is expected.

Python and Matlab programming are necessary.
Skills
Technical skills and level required:
Python and Matlab programming are necessary.
Languages:
French desirable, English required

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- French courses

Remuneration
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)