Sujet de thèse 2018

Fractional order modeling and identification for phantom EEG enhancement

Modélisation et identification fractionnaires pour le développement d'un prototype de fantôme EEG

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General context

EEG measurement systems are recognized tools that have been significantly developed and used for brain activity monitoring since the 1940s. But recovering the contribution of a specific set of neurons by such measurements for instance, remains a strong challenge, in particular due to the difficult modeling of propagation effect between neurons and EEG electrodes neural. Former studies have already emphasized *non integer* frequency dependency in dynamical responses of such measurement systems [1], which motivates for a non-conventional *fractional order modeling* approach [2]. This also gave rise to various researches on so-called 'phantom heads' to better understand the brain behavior. In Gipsa-lab, the idea has been extended to *brain and EEG recording*, leading to a candidate *phantom EEG* [3] still to be developed and exploited.

Scientific challenges

In view of the above general context, scientific challenges are twofold: **phantom EEG modeling**, and **neural activity recovery** from EEG measurements. Both challenges rely on information reconstruction, which can take advantage of both system-based methods and signal-based ones.
An originality in the approaches to be developed will here be the **non-integer feature of the dynamics**. The work will be developed in a **methodological perspective**, as well as in strong connection **with experiments** on the Gipsa phantom EEG under development.

PHD planning

The PHD work will be organized according to the following scientific main steps:

1. Bibliographical synthesis and Gipsa phantom EEG discovery;
2. Modeling developments, comparing black-box and knowledge-based approaches;
3. Confrontation with simulated neural activity recovery with Gipsa phantom head.

It will also include regular preparation of communications, and final report redaction.

Prerequisites

The candidate is expected to have a strong background in dynamical systems and signals, as well as a good taste for biology/electrophysiology applications and experimental practice.

Some references

[1] N. Dehghani, C. Bédard, S. Cash, E. Halgren, and A. Destexhe Comparative power spectral analysis of simultaneous electroencephalographic and magnetoencephalographic recordings in humans suggests nonresistive extracellular media. Journal of computational neuroscience, 1–17, 2010.
[2] A. Djouambi, A. Voda, P. Grangeat, P. Mailley, Fractional order modeling and identification for electro-chemical nanobiochip, Chap.7, p.197-220, in Micro-nanosystems & systems on chip, A. Voda Ed., Wiley, 2009.
[3] G. Becq, A. Voda, G. Besançon, P.O. Amblard and O. Michel, Experiments and analysis for fractional order modelling of an EEG recording process, Gipsa Report 2016 (under revision for ICINCO Congress 2017).