Novel high performance computing bio-electromagnetic solvers for high fidelity intracranial imaging

Keywords: integral equations, bioelectromagnetism, imaging, electroencephalography, high performance computing

OFFER DESCRIPTION

As part of the CominLabs research project CYCLE we have an opening for one early stage researcher (ESR) to carry out a PhD thesis at IMT Atlantique in the LabSTICC laboratory. The thesis and project will be carried out in close collaboration with the Brest University Hospital through the LaTIM laboratory and the IETR institute.

The CYCLE project

The CominLabs project CYCLE (functional to structural to functional imaging: a feedbaCked strategY for intraCraniaL widEband assessments) will investigate a new paradigm for the imaging of the brain's anatomy and electrophysiologic activity which are critical to numerous applications including electromagnetic dosimetry, neurostimulation, brain computer interfaces, and the diagnosis of diseases such as cancer, epilepsy, and Parkinson's.

By devising a new family of high-fidelity bio-electromagnetic models of the head that will leverage on the latest developments in computational electromagnetic, and on the flexibility introduced by automated learning, CYCLE will create and exploit a new synergy between structural imaging that targets the brain structures and material properties and functional imaging that focuses on the brain's (electrochemical) activity.

Indeed, until now, structural imaging has served a basis for most functional modalities that are improved by better structural knowledge. CYCLE proposes to close the loop and, for the first time, to reverse the process by improving structural imaging with functional imaging. Iterating this cycled scheme would be game-changing since plethora of functional and anatomical imaging techniques and their applications would be improved at low and high frequencies.

ESR Position

Objectives

One of the fundamental theoretical and technological barrier to achieving the ambitious objectives of CYCLE is to develop the first broadband numerical model of the head's bio-electromagnetic behavior, leveraging the most advanced techniques in computational electromagnetics (CEM). This new model will supersede all current modeling technology and offer the first high-resolution, broadband model of the head tissues, capable of modeling in a uniform manner very low frequency phenomenons such as the brain activity itself, or the effect of externally imposed electromagnetic activity at higher frequencies, such as transcranial magnetic stimulation, or electromagnetic exposure assessments. This is in contrast with the state-of-the-art in which a combination of disparate solvers must be used in

different frequency ranges, which makes the cross-spectrum transfer of information of the head's properties extremely challenging.

Expected results

1. a new broadband formulation for the bio-electromagnetic modeling of the head that will match or exceed the performances of spectral-domain-specific solvers;
2. the algorithmic acceleration (complexity reduction) of the solver to make it compatible with the most resolved MRI-derived anatomic models; this includes the development and deployment of the solver on a super-computing architecture;
3. the integration of the new solver into a properly designed inverse-source scheme to enable high-resolution EEG source imaging of the brain activity that will serve as the building block of the new cycled imaging technique.

Selection process

All applications will be evaluated by a hiring committee that will select the candidates whose profile best match the needs of the project. The candidates on this short list will be asked to complete a simple assignment that they will present as part of a (remote) interview meeting.

To apply for this position, please send the following documents to adrien.merlini@imt-atlantique.fr:

1. a CV detailing your academic background and relevant experiences;
2. a list of up to 5 reference contacts;
3. a motivation letter;
4. transcripts of all Bachelor and Master level exams, if available.

A particular attention will be given to the gender aspects throughout this selection process.

Offer Requirements

- REQUIRED EDUCATION LEVEL
  Computer science: Master Degree or equivalent
- REQUIRED LANGUAGES
  ENGLISH: Excellent

Skills/Qualifications

Experience and a strong background in computer science are required.

Specific Requirements

All candidates must have received a Master's or equivalent degree from an officially recognized academic institution.