IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

Novel high performance bio-electromagnetic solvers for broadband and high fidelity intracranial imaging

The Project is funded by the European Union.

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

Lab

Research at IMT Atlantique involves nearly 800 people, including 290 teachers and researchers and 300 PhD students, and focuses on digital, energy and environmental technologies. It covers all disciplines (from the physical sciences to the humanities and social sciences, including information and knowledge) and covers all areas of science and information and communication technologies.

The thesis will take place at the Lab-STICC laboratory (UMR CNRS 6285), on the Brest campus, in collaboration with the LaTIM.

Starting date: October 2023

Funding: European Union (CEREBRO project)

Description

Consortium:

As part of the Horizon Europe's EIC Pathfinder research project CERBRO, we have an opening for one early stage researcher (ESR) to carry out a PhD thesis at IMT Atlantique in the Lab-STICC laboratory. The thesis and project will be carried out in close collaboration with Politecnico di Torino, the LaTIM laboratory, the École Polytechnique Fédérale de Lausanne (EPFL), g.tec, and the Brest University Hospital.

Description of the project:

The EIC Pathfinder project CEREBRO (an electric Contrast medium for computationally intensive Electroencephalographies for high REsolution BRain imaging withOut skull trepanation) will target the development of a new modality imaging 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.

The traditionally, imaging of the brain activity is performed using an electroencephalograph (EEG), but because of the shielding effects of the skull, the spatial resolution of the readings is limited. One frequent solution to overcome this problem is to implant electrodes directly under the skull (ECoG) or on the cortex. The resulting imaging is of higher quality, but is only local.

CEREBRO will see the conception and design of a new imaging modality based on an electromagnetic contrast medium that will allow for the shielding effect of the skull to be circumvented, thus allowing for

a high spatial resolution imaging of the whole brain activity, while preserving the high temporal resolution of modalities directly imaging the electrophysiologic activity.

The information that will be made available to the medical community has never been extracted before, and should allow for significant breakthroughs in the field of neuroscience and patient care.

Description of the position:

One of the fundamental theoretical and technological barrier to achieving the ambitious objectives of CEREBRO is to develop a new broadband numerical model of the head's bio-electromagnetic behavior, in the presence of the complex contrast medium by 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 phenomenon such as the brain activity itself, or the effect of externally imposed electromagnetic activity at higher frequencies, and the response of the contrast medium.

- Net salary/month: ~1700€.

Expected results:

1. a new broadband formulation for the bio-electromagnetic modeling of the head and of a complex contrast medium (in close collaboration with Politecnico di Torino);
2. the algorithmic acceleration (complexity reduction) of the solver to make it compatible with the most resolved MRI-derived anatomic models; this includes the parallelization, 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;
4. the fabrication of wideband head phantoms, for validating the solvers with or without contrast medium.

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 with in an email with subject "Application for PhD: CEREBRO/Lab-STICC":

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.

Bibliography

- C. Henry, A. Merlini, L. Rahmouni, and F. P. Andriulli, “A Regularized Electric Flux Volume Integral Equation for Brain Imaging,” presented at the 2020 IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting, Montréal, Québec, Canada, Jul. 2020.
- R Fablet, L Drumetz, F Rousseau. Joint learning of variational representations and solvers for inverse problems with partially-observed data. Arxiv 2020.