Post-Doctoral Position

Electromagnetic tissue-equivalent phantoms for functional brain imaging

Research fields: electromagnetic modeling, low-frequency tissue-equivalent models, brain imaging, electromagnetic dosimetry, biomedical engineering

Research laboratory: IETR / CNRS (www.ietr.fr), Rennes and IMT Atlantique (www.imt-atlantique.fr), Brest, France

Offer type: Post-doctoral position (12 months)

Hiring institution: CNRS (www.cnrs.fr)

Expected starting date: October - December 2023

Post-doctoral research project

Context

Accurate imaging of the brain anatomy and electrophysiological activity is crucial for numerous applications including electromagnetic dosimetry, neurostimulation, brain computer interfaces, as well as diagnosis of diseases such as cancer, epilepsy, and Parkinson's. Conventional brain imaging approaches can be divided in two categories: (1) structural imaging that targets the brain structures and material properties and (2) functional imaging that focuses on the functional brain's electrochemical activity.

In the frame of the CYCLE research project supported by Labex CominLabs, IMT Atlantique together with IETR are exploring a novel approach aiming to improve the image quality by coupling the structural with functional approaches. This novel approach may be game-changing since plethora of functional and anatomical imaging techniques and their applications could substantially benefit from enhancement of the imaging quality.

Objective

This post-doctoral research project deals with design and implementation of novel electromagnetic tissue-equivalent phantoms at frequencies of functional brain imaging (from several Hz up to kHz range).

Work description

The research program is divided into three steps:

1) *Design of realistic heterogeneous and anisotropic electromagnetic brain phantoms reproducing behavior of the brain medium up to several kHz*. The phantoms are expected to be capable of generating plausible electrophysiologic signals compatible with those that occur during specific functional imaging sessions. Several phantoms and bio-signal generation schemes will be investigated and compared.

2) *Experimental validation of designed realistic head phantoms*. The realistic bio-signals will be produced in the phantoms and imaged using the new hybrid imaging modality. The imaging accuracy attained using the new imaging scheme developed by IMT Atlantique will be compared with the accuracy obtained using state-of-the-art approaches. Uncertainty and reproducibility analyses will be performed.

3) *Extension of the proposed models for dosimetry and exposure assessment*. Finally, the phantoms will be extended and optimized for electromagnetic dosimetry at frequencies upcoming for emerging wireless communications (WPT, IoT, etc.). This will rely on the expertise of IETR in design of bio-inspired tissue-equivalent models.

References

[1] M. Y. Monin, L. Rahmouni, A. Merlini and F. P. Andriulli, "A Hybrid Volume-Surface-Wire Integral Equation for the Anisotropic Forward Problem in Electroencephalography," IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology, vol. 4, no. 4, pp. 286-293, 2020.

[2] J. Lee, J. Bang, and J. Choi, "Realistic Head Phantom for Evaluation of Brain Stroke Localization Methods Using 3D Printer," Journal of electromagnetic engineering and science, vol. 16, no. 4, pp. 254–258, 2016.

[3] Madhuvanthi A Kandadai, Jason L Raymond, and George J Shaw. "Comparison of electrical conductivities of various brain phantom gels: Developing a 'brain gel model'". Materials Science and Engineering: C 32.8, pp. 2664–2667, 2012.

Research environment

The Post-doctoral researcher will join the Electromagnetic Waves in Complex Media (eWAVES, www.ietr.fr/eWAVES) research team of the IETR and will work in close collaboration with IMT Atlantique. eWaves research activities in biomedical electromagnetics cover a wide spectrum of fundamental and applied research spreading from multi-physics and multi-scale modeling to advanced technologies for body-centric wireless communications. The team was at the origin of several pioneering innovations in biomedical electromagnetics, including the first mmWave tissue-equivalent phantoms, novel reflectivity-based surface phantom concept, new broadband multi-physics characterization technique for Debye-type materials, innovative mmWave textile antennas for smart clothing, and the first mmWave reverberation chamber. We have a broad network of EU and international collaborators. The project will benefit from the advanced numerical facilities and state-of-the-art equipment / measurement facilities of the IETR (high-resolution 3D printing, multi-physics dosimetry, near-field characterization, etc.). IMT Atlantique has expertise in low frequency head phantom design. It will contribute with the bio-electromagnetic models and fast solver technology as the first technological stack to be validated using the new phantoms.

Candidate

We seek for engaged and motivated candidates with a PhD or equivalent degree in electromagnetics, electrical engineering or electronics. The required skills and qualifications are:

- Strong background in electromagnetics, analytical/numerical modeling, and electromagnetic engineering.
- Knowledge of numerical modeling and experience with commercial or open-source numerical solvers (e.g. COMSOL, CST, SIM4LIFE), programming skills (e.g. MATLAB).
- Knowledge about brain imaging, electromagnetic tissue-equivalent phantoms and dosimetry will be appreciated. Knowledge in biomedical engineering is welcome but not mandatory.
- Fluency in English: the candidate should be conversant and articulate in English and must have strong writing skills. Knowledge of French is not required.

How to apply

To apply please send your CV, transcripts, motivation letter, and reference letters (optional) to:

⇒ Dr. Maxim ZHADOBOV, IETR / CNRS (maxim.zhadobov@univ-rennes.fr)