INVENTEURS DU MONDE NUMÉRIQUE

Proposition of PhD position:

COUPLING MODEL FOR HYBRID EEG-MRI IN BRAIN REHABILITATION

Deadline for application: June 30th, 2013

Research teams: PANAMA and VISAGES Teams, Inria Rennes (http://www.irisa.fr/)

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Keywords: Signal and Image Analysis, Sparse Representation, Machine Learning, Non linear estimation, Real-Time fMRI, Medical Imaging, Neuro-rehabilitation

Description:

The VISAGES and PANAMA teams at Inria Rennes are seeking a highly qualified Ph.D. candidate with background in applied mathematics, machine learning, and image processing for a Ph.D. research project in neuro-imaging.

The proposed position arises in the context of the HEMISFER project (see Environment below) which aims at making full use of the neurofeedback (NF) paradigm in the context of novel neuro-rehabilitation procedures. The major expected breakthrough of HEMISFER will come from the design and use of a coupling model associating real-time functional and metabolic information from Magnetic Resonance Imaging (rtfMRI) to Electro-encephalography (EEG) to "enhance" NF protocols.

The objective of the PhD will be to design a coupling model, to develop methods able to learn parameters of the coupling model given observations performed during simultaneous fMRI and EEG acquisitions, under some well designed stimulation paradigms, and to exploit the trained model when the stimulation paradigms are performed with EEG only in between two simultaneous real-time fMRI/EEG sessions. In such cases, the learned coupling model will "supplement" the EEG NF signals when recorded alone (typically through NF sessions in clinical services). More specifically, this PhD will address the issue of learning models at the signal level able to explain the coupling of EEG and fMRI signals under simple and more advanced brain stimuli (e.g. BOLD fMRI or functional ASL), or through basal brain activation (i.e. basal ASL or resting state fMRI). This learning will be based on single or successive simultaneous acquisitions.

We primarily envision to learn models that will combine a) a common high-resolution spatio-temporal model of brain activity, characterized by sparsity in an appropriate domain; b) models of the acquisition process in each of the considered modalities. Learning the models will therefore consist in learning both the domain in which brain activity is sparse (e.g., dictionary learning), and in adjusting a parametric model of the acquisition processes (this can be seen as a calibration process). Alternative methods based on machine learning with out-of-sampling strategies will also be considered.

We plan also to provide these models with some a priori brain structural information coming from morphological and diffusion MRI (the connectomics model). The individual brain connectome, learned on each patient, will give a priori information about the correlation between EEG and fMRI signals recorded in the brain.

Environment:

This work will be conducted at Inria under the HEMISFER project of the Labex “CominLabs” (https://iww.inria.fr/cominlabs-newsletter/april-2013-four-projects-selected/#hemisfer). It will form collaboration between the Unit/Project VISAGES U746 (INSERM/INRIA/CNRS/university of Rennes I), and the PANAMA Team at Inria Rennes, along with the ATHENA Team at Inria Sophia-Antipolis. This work will benefits from a new research 3T MRI systems provided by the NeurInfo in-vivo neuroimaging platform on which these new research protocols will be set up (http://www.neurinfo.org). The experimental part will be conducted in close collaborations with medical doctors and Prof. I. BONAN (Visages U746, Rennes Hospital CHU) and Prof. D. DRAPIER (EA 4712, Rennes psychiatric hospital CHGR).

The HEMISFER project: The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to “enhance” the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, …). This project will be conducted through a very complementary set of competences over the different teams involved in HEMISFER (Visages Inserm U746, HYBRID and PANAMA Teams from Inria/Irisa, EA 4712 team from University of Rennes I and ATHENA team from Inria Sophia-Antipolis).

Skills and applicant profile

This position requires background in applied mathematics, machine learning, numerical analysis, and statistics as well as in image processing. A good practice in programming, especially in Matlab and in object-oriented programming (C++) will be appreciated. The applicant should have obtained the MS degree in 2012 or after.

References:

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