

Proposition of PhD position:

NEUROFEEDBACK USING VIRTUAL REALITY AND
COMBINING EEG-MRI FOR BRAIN REHABILITATION

Deadline for application: June 30th, 2013

Research teams: HYBRID and VISAGES Teams, Inria Rennes (<http://www.inria.fr/>)
ATHENA Team, Inria Sophia-Antipolis

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Keywords: Neurofeedback, Clinical Neurosciences, Virtual Reality, Real-Time MRI,
Medical Imaging, Neuro-rehabilitation

Topic:

This PhD is conducted in the context of the HEMISFER collaborative research project, which aims at designing novel concepts of « NeuroFeedback » in the context of rehabilitation related to motor deficiencies or psychiatric disorders. Main objective will be the design of new therapeutic tools based on innovative technologies of Virtual Reality and Neurofeedback.

Neurofeedback consists in presenting to the patient a feedback related to his/her brain activity, in order for him/her to progressively learn how to control it. This progressive improvement in controlling such brain activities is expected to improve the rehabilitation and treatment of pathologies, which are known to be associated with them. Neurofeedback thus combines: 1) real-time brain activity acquisition systems such as EEG (electroencephalography) and 2) display systems for providing feedback to the subjects such as with monitor screens and visual gauges.

In this PhD program we will search for innovative paths on both sides, i.e., 1) the exploitation of a novel combination of several cerebral recording devices (real-time EEG *plus* fMRI devices), and 2) the exploitation of novel feedback strategies based on multi-sensory feedback and virtual reality technologies.

More specifically, this PhD will study the design of novel paradigms of Neurofeedback under visual or auditory stimuli that can be conducted with fMRI coupled with simultaneous EEG recordings. The targeted pathologies are related to functional rehabilitation (stroke and ADHD) and psychiatric disorders (depressions). Evaluations 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).

This PhD will address the definition of novel experimental paradigms of immersive stimulations for Neurofeedback based on fMRI and EEG. It will study the design of novel sensory feedbacks and novel immersive visualization techniques to display cerebral activity coming from fMRI and EEG. Stereoscopic visual feedback (3D), but also auditory feedback will be proposed to enhance the immersion and motivation of the patient, and the perception of the evolution of his/her brain activity

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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 HYBRID Team at Inria Rennes, along with the ATHENA Team at Inria Sophia-Antipolis. This work will benefit 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 HEMISFER project: The major breakthrough of HEMISFER will stem from a coupling scheme mixing the functional information and metabolic information provided by fMRI and the high temporal resolution given by EEG, in order to enhance and improve the Neurofeedback. Thus, we propose to combine advanced measurements systems (EEG and fMRI) together with novel paradigms of Human-Computer Interaction (exploiting Virtual Reality and Serious Games) and new computational models (blind source separation, sparsity and machine learning) to deliver new paradigms of therapy and neuro-reeducation for various pathologies (stroke, attention deficits, depressions, etc). HEMISFER involves a very complementary and pluridisciplinary consortium (Visages Inserm U746, Inria teams HYBRID, ATHENA and PANAMA, EA 4712 team from University of Rennes I). More specifically, this PhD will study the design of novel paradigms of Neurofeedback and brain stimulation, which can be conducted with fMRI, coupled with simultaneous EEG recordings. The targeted pathologies are related to functional reeducation (stroke and ADHD) and psychiatric pathologies (depressions). Evaluations will be conducted in close collaborations with medical doctors and Prof. I. BONAN (Visages U746, Rennes Hospital CHU) et Prof. D. DRAPIER (EA 4712, Rennes psychiatric hospital CHGR).

Skills:

- Master of Science (or equivalent) in Computer Science (Computer Science, Visualization, Virtual Reality, Computer Graphics)
- Excellent programming skills: C/C++
- Motivation for Neurosciences and Cognitive Sciences.

References:

1. J. F. Lubar, M. O. Swartwood, J. N. Swartwood, and P. H. O'Donnell, "Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance," *Biofeedback Self Regul*, vol. 20, pp. 83-99, Mar 1995.
2. Lecuyer, F. Lotte, R. B. Reilly, R. Leeb, M. Hirose, and M. Slater, "Brain-Computer Interfaces, Virtual Reality, and Videogames," *Computer*, vol. 41, pp. 66-72, 2008.
3. R. Leeb, D. Friedman, G. R. Muller-Putz, R. Scherer, M. Slater, and G. Pfurtscheller, "Self-paced (asynchronous) BCI control of a wheelchair in virtual environments: a case study with a tetraplegic," *Comput Intell Neurosci*, p. 79642, 2007.
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