Proposition of PhD position:

MULTIMODAL NEUROFEEDBACK USING REAL-TIME EEG-MRI FOR BRAIN REHABILITATION

Deadline for application: June 30th, 2017

Research teams:

VISAGES Team, Inserm U1228/Inria/IRISA-CNRS, Rennes (http://www.irisa.fr/visages)
HYBRID Team, Inria/IRISA-CNRS, Rennes (http://www.irisa.fr/hybrid)

Associate Supervisors:

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Keywords: Brain-Computer Interfaces, Neurofeedback, Virtual Reality, Clinical Neurosciences, Medical Imaging, Real-time Processing, Statistical Analysis

Topic:

Neurofeedback (NF) is neuro-adaptive technology that provides an individual with real-time biofeedback about his or her brain activity in the form of sensory feedback. It enables individuals to learn to better control brain activity [3], which can be measured in real time using various non-invasive sensors as described above. Although EEG is currently the only modality used by NF clinical practitioners, it lacks specificity due to its low spatial resolution. In addition, NF can appear impenetrable due to the abundance of unreliable information. Research has therefore recently turned to other modalities that target the activity of different regions of the brain more precisely. Since the turn of the millennium, dynamic research into fMRI-NF holds promise for treating depression [5], chronic pain and stroke [4] since it offers real-time imagery of activity in deep brain structures with high spatial resolution. Nevertheless, the low temporal resolution and high cost of fMRI-NF has hampered the development of many applications. Though promising, current NF technologies still suffer from the antagonism between high (fMRI) and low (EEG) burden solutions. The future of brain rehabilitation belongs to hybrid answers that combine the best of both approaches. Combining these modalities for neurofeedback training will allow to provide richer information to the subject and could thus enable him/her to achieve faster and more specific self-regulation. We have developed, in the lab and on the experimental platform NEURINFO, a unique real-time computational environment that makes now possible to perform NF training under both EEG and fMRI. Based on this computational platform, we have conducted two complementary simultaneous EEG-fMRI experimental protocols in which participants have performed motor-imagery tasks in either unimodal and bimodal NF conditions.

The goal of this PhD position will be to develop new NF paradigms that use simultaneous multimodal sensing relevant to focus and stimulate specific brain regions. These NF methods will involve sensory stimuli such as those generated by computer (e.g. through ball games parametrized by hybrid features, self-mind mirror metaphors, anthropomorphic gauges parametrized by spatiotemporal mixtures of features, real-word morphing of images rendering sadness/happiness, calm/stress or familiar/unfamiliar metaphors, etc.). In turn, this will generate endogenous brain stimulation tailored to the regions associated with the disease. The conceptual research will provide new frontiers of BCI for exploring high resolution real-time multimodal sensing of the brain, hybrid feedback and non-Euclidian metrics controlling NF on a manifold.

Research environment

This technological framework will be implemented and evaluated on normal controls and on pathological populations from two different and complementary applications: Rehabilitation of Stroke patients suffering from upper-limb disabilities and in psychiatry for treatment of depressive disorders. This work will be closely conducted with prof. I. BONAN (Visages U1228, head of rehabilitation Dept. University

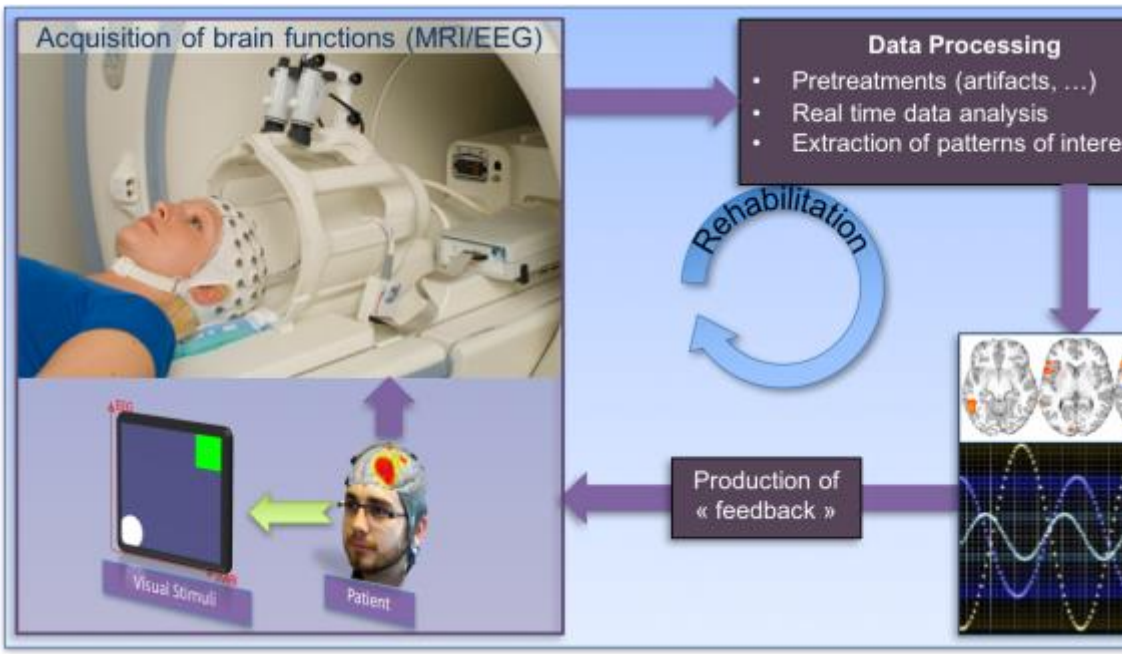
Hospital of Rennes)) and D. DRAPIER (EA 4712, head of Psychiatry unit at the Psychiatry Hospital of Rennes. Resident and medical doctors from these disciplines will also be interacting with this project.

Skills and applicant profile and package

This position requires background in computer sciences, numerical analysis, and statistics as well as in image processing. Knowledge in neuroscience and/or virtual reality would be appreciated. A good practice on computer sciences, especially in Matlab and in object-oriented programming (C++) will be appreciated.

Applicants should send their complete application package by including:

- Complete CV
- Motivation letter
- At least two recommendation letters or names and contact of the mentors
- **Incomplete applications will not be processed.**



General principal of the Neurofeedback rehabilitation scenario proposed in this PhD program

References

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