Fully funded Ph.D. position
in Brain-Computer Interfaces (Embedded systems/Neuroscience)
Application deadline: 15/11/2020

Where: Nancy/Metz and Rennes, France
When: December 2020 (3 years duration)
Who: Laurent Bougrain (Univ. Lorraine/LORIA) & Stéphanie Fleck (Univ. Lorraine/Perseus) & Anatole Lécuyer (Inria)

Keywords

Brain-Computer Interfaces, Human-computer interaction, user-centered design, Haptic feedback, Rehabilitation, Motor deficiencies, Electroencephalography, Stroke, Kinesthetic motor imagery.

Project description

The objective of this thesis is to co-design and evaluate a brain-computer interface integrating visual and haptic feedback. This interface should support the brain activity engaged during a motor imagination to improve the rehabilitation of a motor disorder in time and quality by more fully involving the sensorimotor loop engaged in the control of a movement.

Context

Stroke is the leading cause of acquired disability in adults. A stroke occurs every 4 minutes in France. Whether the artery bursts or is blocked, the blood, and therefore the oxygen it carries, no longer reaches the neurons. They quickly die and no longer perform their function. In 50% of cases, significant sequelae appear as language, vision or motor control disorders. In the latter case, it is possible to stimulate the neurons through exercises to develop new networks which will partly compensate for the handicap. To stimulate motor neurons, researchers are interested in Kinesthetic Motor Imagination (KMI), which is the ability to mentally perform movement without actually doing it. In a motor imagination, the power of oscillations in the alpha and beta frequency bands is modulated over time as in real movement. More specifically, within electroencephalographic (EEG) signals, it is possible to observe neuronal desynchronizations (ERD, Event-related desynchronization) during the motor act and neuronal synchronizations (ERS, Event-related synchronization) after it.
To answer the research questions and the technological challenges associated with the issues of post-stroke rehabilitation, researches in neurosciences, human-machine interactions (HMI) and instructional design (ID) constitute an innovative and important approach to the public health challenge of rehabilitating stroke victims. In this context, Brain-Computer Interfaces (BCI) make it possible to measure brain activity, for example, via electroencephalography (EEG) and to provide people, in particular with strong motor impairments, a neurofeedback of the quality of the brain activity. By extension, it becomes possible to learn to amplify it aim to improve motor rehabilitation.

This thesis is part of the French ANR GRASP-IT project that aims to support the rehabilitation of upper limb control by improving the generation of kinesthetic motor imagery (KMI) in brain-injured patients after stroke. This approach is based on a gamified rehabilitation program supported by a Brain-Computer Interface (BCI), providing its users with visual, tangible and haptic stimulation, and feedback in a unified environment. This innovative BCI's ultimate goal is based on motor imagination to integrate complementary modalities of interactions such as tangible and haptic interactions in a flexible 3D printable orthosis.

Method

To achieve these objectives within the ANR Grasp-IT project, the Ph.D. student will be involved in:
Step 1: Design a hapto-tangible interface that fits into an orthosis and can be coupled to the BCI, providing various visuo-haptic neurofeedbacks to be validated with patients;
Step 2: Assessment of the potential of the proposed solutions in terms of acceptability, usability and positive user experience, but also in terms of rehabilitation processes;
Step 3: validation of the proposed solution;
Step 4: Integration of the hapto-tangible solution into the multimodal BCI;
Step 5: Assessment of the final multimodal BCI in terms of usability (including efficacy for motor cortex stimulation), acceptability, and user experience in hemiplegic patients.

From design to development and evaluation of interaction techniques, this work integrates the specificities of patient-users in their diversity (age, type of motor, sensory, cognitive disability, etc.). This work is based on a first functional prototype already developed by the members of the consortium, and will be carried out in collaboration with the research teams, engineers and therapists involved in the ANR GRASP-IT project.

Expected result

In terms of technological products, the interface prototypes will be functional, acceptable and generating positive user experiences. The environments designed will meet the real needs of users in the context of use (i.e., brain-injured patients, their therapists).

In terms of scientific results, neurofeedback should support the rehabilitation of a motor disorder of the terminal upper limbs (e.g., catch, pinch, let go, etc.) and be meaningful to facilitate progress in the gamified rehabilitation program.

Partners

Partners of the GRASP-IT project are:
- U. Lorraine/LORIA-Inria/Neurorhythms (https://neurosys.loria.fr/research/);
- U. Lorraine/Perseus (https://perseus.univ-lorraine.fr/);
- Inria Hybrid (https://team.inria.fr/hybrid/);
- Inria Camin (https://team.inria.fr/camin/);
- Center of physical medicine and rehabilitation for adults of Lay Saint Christophe - Lorraine;
- University Hospital of Rennes;
- University Hospital of Toulouse;
- Alchimies/Open Edge compagny - Lorraine.

Candidate profile

The future Ph.D. candidate must have strong experience in both embedded systems and interactions.
In particular, the following qualities and skills will be highly valued, if not required:

* Solid bases in embedded systems and interactions (required);
* Knowledge of neuroscience/brain-computer interfaces and machine learning;
* Previous experience in experimental neuroscience/brain-computer interfaces or at least in data mining;
* Programming experience (Python or similar coding language);
* Good English reading/speaking skills and French speaking skills (to interact with patients).

How to apply

Please send your application (CV, letter of motivation, and the names and email addresses of one or two persons who can provide a recommendation letters) to
Dr. Laurent Bougrain (laurent.bougrain@loria.fr), Dr. Stéphanie Fleck (stephanie.fleck@univ-lorraine.fr) and Dr. Anatole Lécuyer (anatole.lecuyer@inria.fr) before the 30/11/2020.

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