Skills required:

- Be able to successfully predict performances and learning at any time
- Develop models (models of performance, of feedback processing, of performance variability across runs and trials, etc.) both for the healthy user population, but also for the BCI end users population, in particular for stroke patients (based on data from such users).
- Design and run MI-BCI experiments to acquire additional data to refine the initial models

Main activities:

- Validate models (models of performance, of feedback processing, of performance variability across runs and trials, etc) both for the healthy user population, but also for the BCI end users population, in particular for stroke patients (based on data from such users).

About Inria

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world’s top universities, Inria’s 2,500 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

About the research centre or Inria department

The Potioc project-team explores new approaches “beyond the mouse” in the field of Human-Computer Interaction. More specifically, we are interested in approaches that favor rich interactions, both regarding interaction possibilities and perceptual feedback. Our objective is to increase immersion and engagement of users with regard to the interaction tasks. Final goals are the stimulation of creativity, improvement of learning or contribution to the well-being of people. For achieving these goals, we focus on the design, development and evaluation of new methods for “popular interaction” targeted at a large variety of users.

Context

Brain computer interfaces (BCI) are communication and control tools that enable their users to interact with computers using brain activity alone. A prominent type of BCI is Mental Imagery (MI) BCI, that translates change in brain activity due to mental imagery tasks performed by the user (e.g., imagination of movements or mental calculation) into control commands for a computer.

Using a MI-BCI requires dedicated training, and the more the user practice the better he/she will get at it, i.e. the user’s mental commands will be more often correctly recognised by the system. Current BCI are rather unreliable, and one current hypothesis to explain this could be inappropriate user training.

We are thus currently conducting researches to understand this user training to then improve it and make it suitable.

Such researches are conducted as part of ERC starting grant project BrainConQuest (https://team.inria.fr/potioc/brainconquest – Principal Investigator: Fabien Lotte) at Inria Bordeaux Sud-Ouest, France, in team Potioc (https://team.inria.fr/potioc/).

Assignment

As part of this research, the goal of this PhD thesis would be to contribute to the understanding of BCI user training by trying to model its various components computationally.

The idea would be to create computational models of BCI user training that could predict the learning rate and the performances of various BCI users, over training time, based on their traits, states and skills over time, and based on the feedback they receive and on the training tasks they perform. Different models will be created to account for different aspects and time scale of learning, e.g., to predict the overall performances, but also the performances variability between sessions/runs, as well as to predict whether a given trial is going to be successful or not. Understanding and modeling how the BCI users exploit and learn from the feedback they receive is also of high interest.

More particularly, we are interested in identifying how different properties of the feedback affect BCI learning and performances. Such properties could include the feedback visual characteristics (update rate, bias, the fact of being positive/neutral or positive only, its modality, etc. By combining these various models (models of performance, of feedback processing, of performance variability across runs and trials, etc), we hope to be able to successfully predict performances and learning at any time. This would enable us to identify the factors to consider in order to improve user training, and how to manipulate them to optimize such training.

The goal would be to develop these models both for the healthy user population, but also for the BCI end users population, in particular for stroke patients (based on data from such users). Such models could be statistical/probabilistic model. They could be based on regression, hidden markov model, Bayesian networks, control theory or other generative machine learning/statistical tools. They could also be based on computational implementation of theoretical models of BCI performances or models of learning in general, from the psychology literature.

We already have data from multiple BCI users who trained over multiple days with MI-BCI, and for which we measured the traits using psychological questionnaires. We also have data sets from MI-BCI users who trained with different feedback characteristics such as visual or tactile feedback, positive only feedback, and various feedback biases. These data sets will be the basis for creating testing and validating different initial models.

The PhD thesis could also include designing and running MI-BCI experiments to acquire additional data to refine the initial models (e.g., to include missing factors), to validate them on different MI-BCI training tasks.

Main activities:

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Skills

Skills required:
• Modelling, statistical analysis and tools, and/or machine learning
• Python / Matlab programming
• Able to speak, write and work in an English speaking environment
• Skills in neurosciences, psychology, cognitive science appreciated
• Experience with ElectroEncephaloGraphy (EEG) and/or BCI experiments appreciated

Related literature:

BCI performance from personality, cognitive profile and neurophysiological patterns. PloS one, 10(12),
e0143962.

metric to study mental imagery-based BCI user learning: an experimental demonstration and new
metrics. In 7th International BCI Conference.
Learning.
C. Jeunet, F. Lotte, JM. Batail, P. Philip, JA. Micoulaud-Franchi, "Using recent BCI literature to deepen
our understanding of clinical neurofeedback: A short review", Neuroscience, 2018

Benefits package
• Subsidised catering service
• Partially-reimbursed public transport

Remuneration
1982€ / month (before taxs) during the first 2 years, 2085€ / month (before taxs) during the third
year.