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Activity Report 2017

Project-Team POTIOC

Popular interaction with 3d content

RESEARCH CENTER
Bordeaux - Sud-Ouest

THEME
Interaction and visualization

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Project-Team POTIOC

Creation of the Team: 2012 January 01, updated into Project-Team: 2014 January 01

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1. Personnel

Research Scientists

Martin Hachet [Team leader, Inria, Researcher, HDR]
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Fabien Lotte [Inria, Researcher, HDR]

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PhD Students

Aurélien Appriou [Inria, from Oct 2017]
Pierre-Antoine Cinquin [Univ de Bordeaux]
Damien Clergeaud [Inria, until Oct 2017]
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Philippe Giraudeau [Inria, from Oct 2017]
Jelena Mladenovic [Inria, until Sep 2017]
Lea Pillette [Inria]
Stephanie Rey [Berger Levrault, from Mar 2017 until Oct 2017]
Joan Sol Roo [Inria]

Technical staff

Jeremy Albouys-Perrois [Inria, from Aug 2017]
Pierre Camilli [AST, from Nov 2017]
Benoit Coulais [Inria, until Sep 2017]

Interns

Maxime Agor [Inria, from Apr 2017 until Aug 2017]
Jeremy Albouys-Perrois [Inria, from Feb 2017 until Jul 2017]
Jean Basset [Inria, from May 2017 until Jul 2017]
Fabien Coden [Inria, Feb 2017]
Philippe Giraudeau [Inria, until Jun 2017]
John James Kelway [Univ de Bordeaux, from Feb 2017 until Jul 2017]
Flavie Le Bars [Inria, Jun 2017]
Clementine Petit [Inria, from Apr 2017 until Aug 2017]
John Eric Sanchez Suarez [Inria, from Jun 2017 until Jul 2017]

Administrative Assistants

Cecile Boutros [Inria]
Catherine Cattaert Megrat [Inria]

2. Overall Objectives

2.1. Overall Objectives

The overall objective of Potioc is **to design, to develop, and to evaluate** new approaches that provide **rich interaction experiences between users and the digital world**. Thus, we aim at stimulating motivation, curiosity, engagement, or pleasure of use. In other words, we are interested in **popular interaction**, mainly targeted at the general public.

We believe that such popular interaction may enhance **learning, creation, entertainment or popularization of science** that are the main application areas targeted by our project-team. To this end, we explore input and output modalities that go beyond standard interaction approaches which are based on mice/keyboards and (touch)screens. Similarly, we are interested in 3D content that offers new opportunities compared to traditional 2D contexts. More precisely, Potioc explores interaction approaches that rely notably on interactive 3D graphics, augmented and virtual reality (AR/VR), tangible interaction, brain-computer interfaces (BCI) and physiological computing.

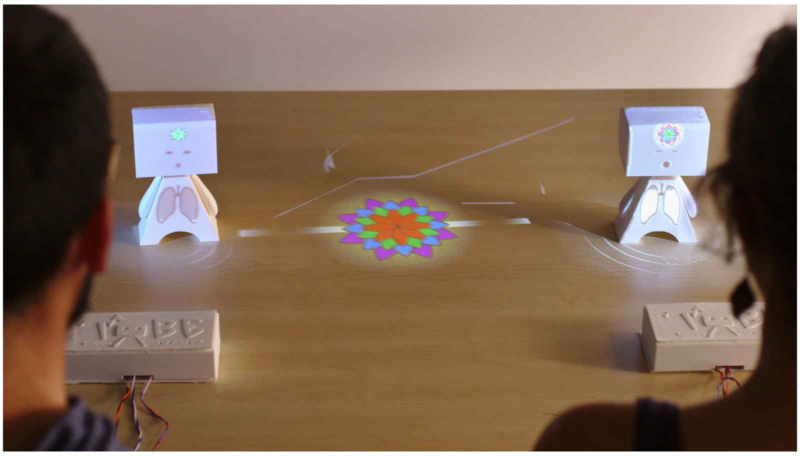

Figure 1. Tobe combines tangible interaction, spatial augmented reality, and physiological computing. It allows users to feel and explore their inner states.

Such approaches hold great promises in a number of fields. For example, interactive 3D graphics have become ubiquitous in the industry, where they have revolutionized usages, notably by improving work cycles for conception or simulation tasks. However, except for video games, we believe that such approaches are still far from being exploited to their full extent outside such industrial contexts despite having a huge potential for the masses in the areas targeted by our project.

In order to design interactive systems that can be beneficial to many people, and not only expert users, we propose to change the usual design approaches that are generally driven by criteria such as speed, efficiency or precision. Instead, we give more credit to the user experience, in particular criteria such as interface appeal and enjoyment arising from the interface use. Indeed, these criteria have been often neglected in academic research whereas we believe they are crucial for users who are novices with 3D interaction, multisensory spaces, or brain-computer interfaces. An interface with a strong appeal and enjoyment factor will motivate users to use and benefit from the system.

In the Potioc team, we follow a multidisciplinary approach in order to tackle the problem as a whole, from the most fundamental works on human sensori-motor and cognitive abilities and preferences, to the aspects that are linked to the usage and applications, passing through the technical aspects of the interaction, both at a hardware and software level.

3. Research Program

3.1. Introduction

The project of team potioc is oriented along three axes:

- Understanding humans interacting with the digital world
- Creating interactive systems
- Exploring new applications and usages

These axes are depicted in Figure 2.

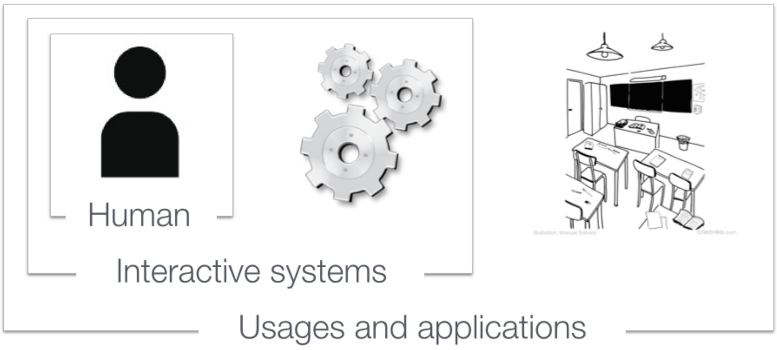

Figure 2. The three axes of the potioc team objectives.

Objective 1 is centered on the human sensori-motor and cognitive abilities, as well as user strategies and preferences, for completing interaction tasks. Our target contribution for this objective are a better understanding of humans interacting with interactive systems. The impact of this objective is mainly at a fundamental level.
In objective 2, our goal is to create interactive systems. This may include hardware parts where new input and output modalities are explored. This also includes software parts, that are strongly linked to the underlying hardware components. Our target contribution in objective 2 is to develop (hardware/software) interaction techniques allowing humans to perform interaction tasks.
Finally, in objective 3, we consider interaction at a higher level, taking into account factors that are linked to specific application domains and usages. Our target contribution in this area is the exploration and the emergence of new applications and usages that take benefit from the results of the project. With this objective, we target mainly a societal impact.
Of course, strong links exist between the three objectives of the project. For example, the results obtained in objective 1 guide the development of objective 2. Conversely, new systems developed in objective 2 may feed research questions of objective 1. There are similar links with objective 3.

3.2. Objective 1: Understanding humans interacting with the digital world

Our first objective is centered on the human side. Our finality is not to enhance the general knowledge about the human being as a research team in psychology would do. Instead, we focus on human skills and behaviors during interaction processes. To this end, we conduct experiments that allow us to better understand what users like, where and why they have difficulties. Thanks to these investigations, we are able to design interaction techniques and systems (described in Objective 2) that are well suited to the targeted users. We believe that this fundamental piece of work is the first step that is required for the design of usable popular interactions. We are particularly interested in 3D interaction tasks for which we design dedicated experiments. We also explore a new approach based on physiological and brain (ElectroEncephaloGraphy - EEG) signals for the evaluation of these interactions.

3.2.1. Interacting with physical and virtual environments

Interacting with digital content displayed on 2D screens has been extensively studied in HCI. On the other hand, less conventional contexts have been studied less. This is the case of 3D environments, immersive virtual environments, augmented reality, and tangible objects. With the final goal of making interaction in such contexts user-friendly, we conduct experiments to better understand user strategies and performance. This allows us to propose guidelines to help designers creating of tools that are accessible to non-expert users.

3.2.2. Evaluating (3D) interaction with physiological signals

Recently, physiological computing has been shown to be a promising complement to Human-Computer Interfaces (HCI) in general, and to 3D User Interfaces (3DUI) in particular, in several directions. Within this research area, we are interested in using various physiological signals, and notably EEG signals, as a new tool to assess objectively the ergonomic quality of a given (3D) UI, to identify where and when are the pros and cons of this interface, based on the user's mental state during interaction. For instance, estimating the user's mental workload during interaction can give insights about where and when the interface is cognitively difficult to use. This could be useful for 2D HCI in general, and even more for 3DUI. Indeed, in a 3DUI, the user perception of the 3D scene – part of which could potentially be measured in EEG - is essential. Moreover, the usual need for a mapping between the user inputs and the corresponding actions on 3D objects make 3DUI and interaction techniques more difficult to assess and to design.

3.2.3. Interacting with Brain-Computer Interfaces

Although very promising for numerous applications, BCIs mostly remain prototypes not used outside laboratories, due to their low reliability. Poor BCI performances are partly due to imperfect EEG signal processing algorithms but also to the user who may not be able to produce reliable EEG patterns. Indeed, BCI use is a skill, requiring the user to be properly trained to achieve BCI control. If he/she cannot perform the desired mental commands, no signal processing algorithm can identify them. Therefore, rather than improving EEG signal processing alone, an interesting research direction is to also guide users to learn BCI control mastery. We aim at addressing this objective. We are notably exploring theoretical models and guidelines from educational sciences to improve BCI training protocols. We also study which users' profiles (personality and cognitive profile) fail or succeed at learning BCI control. Finally, we explore new feedback types and new EEG visualization techniques in order to help users gain BCI control skills more efficiently. These new feedback and visualizations notably aim at providing BCI users with more information about their EEG patterns, in order to identify more easily relevant BCI control strategies, as well as motivating and engaging them in the learning task.

3.2.4. Interaction for people with special needs

Interaction capabilities and needs largely depend on the target user group. In the Potioc project-team, we work with people having special needs. As an example, we work with children in the context of education, which requires us to design interfaces that are usable, engaging and support learning for this target group. Furthermore, we work with people with cognitive or perceptive disabilities, which requires us to consider accessibility, while at the same time designing interfaces that are learnable and enjoyable to use. In order to meet the needs of the different target groups, we apply participative and user-centred design methods.

3.3. Objective 2: Creating interactive systems

Our objective here is to create interactive systems and design interaction techniques dedicated to the completion of interaction tasks. We divide our work into three main categories:

- Interaction techniques based on existing Input/Output (IO) devices.
- New IO and related techniques.
- BCI and physiological computing.

3.3.1. Interaction techniques based on existing Input/Output (IO) devices

When using desktop IOs (i.e., based on mice/keyboards/monitors), a big challenge is to design interaction techniques that allow users to complete 3D interaction tasks. Indeed, the desktop IO space that is mainly dedicated to the completion of 2D interaction task is not well suited to 3D content and, consequently, 3D user interfaces need to be designed with a great care. In the past few years, we have been particularly interested in the problem of interaction when the 3D content is displayed on a touchscreen. Indeed, standard (2D) HCI has evolved from mouse to touch input, and numerous research projects have been conducted. On the contrary, in 3D, very little work has been proposed. We are contributing to moving desktop 3D UIs from the mouse to the touch paradigm; what we used to do with mice in front of a screen does not work well on touch devices anymore. In the future, we will continue designing new interaction techniques that are based on standard IOs (eg. pointing devices and webcams) and that target the main objectives of Potioc which are to enhance the interaction bandwidth for non expert users.

3.3.2. New IO and related techniques

Beyond standard IOs, we are interested in exploring new IO modalities that may make interaction easier, more engaging and motivating. In Potioc, we design new interactive systems that exploit unconventional IO modalities such as stereoscopy, 3D spatial input, augmented reality and so on. In particular, tangible interaction and spatial augmented reality are major subjects of interest for us. Indeed, we believe that manipulating directly physical objects for interacting with the digital world has a great potential, in particular when the general public is targeted. With such approaches, the computer disappears, and the user interacts with the digital content as he or she would do with physical content, which reduces the distance to the manipulated content. As an example, we recently designed Teegi, a new system based on a unique combination of spatial augmented reality, tangible interaction and real-time neurotechnologies. With Teegi, a user can visualize and analyze his or her own brain activity in real-time, on a tangible character that can be easily manipulated, and with which it is possible to interact. Such unconventionnal user interfaces that are based on rich sensing modalities hold great promises in the field of popular interaction.

We are also interested in designing systems that combine different sensory modalities, such as vision, touch and audition. Concrete examples include the design of tangible user interfaces or interfaces for visually impaired people. It has been shown that multimodality can provide rich interaction that can efficiently support learning, and it is also important in the context of accessibility.

3.3.3. BCI and physiological computing

Although Brain-Computer Interfaces (BCI) have demonstrated their tremendous potential in numerous applications, they are still mostly prototypes, not used outside laboratories. This is mainly due to the following limitations:

- Performances: the poor classification accuracies of BCIs make them inconvenient to use or simply useless compared to available alternatives
- Stability and robustness: the sensibility of ElectroEncephaloGraphic (EEG) signals to noise and their inherent non-stationarity make the already poor initial performances difficult to maintain over time
- Calibration time: the need to tune current BCIs to each user's EEG signals makes their calibration times too long.

As part of our research on EEG-based BCIs, we notably aim at addressing these limitations by designing robust EEG signal processing tools with minimal calibration times, in order to design practical BCI systems, usable and useful outside laboratories. To do so we explore the design of alternative features and robust spatial filtering algorithms to make BCIs more robust to noise and non-stationarities, as well as more accurate. We also explore artificial EEG data generation and user-to-user data transfer to reduce calibration times.

3.4. Objective 3: Exploring new applications and usages

Objective 3 is centered on the applications and usages. Beyond the human sensori-motor and cognitive skills (Objective 1), and the hardware and software components (Objective 2), Objectives 3 takes into account broader criteria for the emergence of new usages and applications in various areas, and in particular in the scope of education, art, popularization of science and entertainment. Our goal here is not to develop full-fledged end-user applications. Instead, our contribution is to stimulate the evolution of current applications with new engaging interactive systems.

3.4.1. Education

Education is at the core of the motivations of the Potioc group. Indeed, we are convinced that the approaches we investigate—which target motivation, curiosity, pleasure of use and high level of interactivity—may serve education purposes. To this end, we collaborate with experts in Educational Sciences and teachers for exploring new interactive systems that enhance learning processes. We are currently investigating the fields of astronomy, optics, and neurosciences. We are also working with special education centres for the blind on accessible augmented reality prototypes. In the future, we will continue exploring new interactive approaches dedicated to education, in various fields.

3.4.2. Popularization of science

Popularization of Science is also a key domain for Potioc. Focusing on this subject allows us to get inspiration for the development of new interactive approaches. In particular, we have built a strong partnership with Cap Sciences, which is a center dedicated to the popularization of science in Bordeaux that is visited by thousands of visitors every month. This was initiated with the ANR national project InSTInCT, whose goal was to study the benefits of 3D touch-based interaction in public exhibitions. This project has led to the creation of a Living Lab where several systems developed by Potioc have been tested and will be tested by the visitors. This provides us with very interesting observations that go beyond the feedback we can obtain in our controlled lab-experiments.

3.4.3. Art

Art, which is strongly linked with emotions and user experiences, is also a target area for Potioc. We believe that the work conducted in Potioc may be beneficial for creation from the artist point of view, and it may open new interactive experiences from the audience point of view. As an example, we are working with colleagues who are specialists in digital music, and with musicians. We are also working with jugglers and mockup builders with the goal of enhancing interactivity and user experience.

3.4.4. Entertainment

Similarly, entertainment is a domain where our work may have an impact. We notably explored BCI-based gaming and non-medical applications of BCI, as well as mobile Augmented Reality games. Once again, we believe that our approaches that merge the physical and the virtual world may enhance the user experience. Exploring such a domain will raise numerous scientific and technological questions.

4. Application Domains

4.1. Education, popularization of science, art, entertainment

Our project aims at providing rich interaction experiences between users and the digital world, in particular for non-expert users. The final goal is to stimulate understanding, learning, communication and creation. Our scope of applications encompasses

- education
- popularization of science
- art
- entertainment

See "Objective 3: Exploring new applications and usages" (3.4) for a detailed description.

5. Highlights of the Year

5.1. Highlights of the Year

- A Handbook of Brain-Computer Interfaces was co-edited by Potioc (F. Lotte), involving the international BCI community [41]

5.1.1. Awards

- Best paper - Honorable mention award (top 5% over 2400 submissions), ACM CHI 2017, HOBIT, D. Furio, S. Fleck, B. Bousquet, J.-P. Guillet, L. Canioni, M. Hachet
- Best paper - Honorable mention award (top 5% over 2400 submissions), ACM CHI 2017, Inner Garden, J. S. Roo, R. Gervais, J. Frey, M. Hachet
- Honorable mention award, MUM'17, Bespoke map customization, A. Brock, B. Hecht, B. Signer, J. Schöning
- Best technnote award, IEEE 3DUI 2017, Hybrid space, J. S. Roo, M. Hachet
- Best Demo award for Teegi, IHM 17, T. Lainé, J. Frey, M. Hachet
- PhD thesis award, International PhD award committee from Bordeaux University 2017, C. Jeunet
- PhD thesis award, IFRATH/KAELIS 2017, C. Jeunet
- PhD thesis award, SMC Grant Initiative 2017 for the "Best PhD Thesis in Human-Machine Systems", C. Jeunet
- 2 Publons top peer reviewer awards in 2017, for the top 1% most peer reviews in both Engineering in Neuroscience, F. Lotte

BEST PAPERS AWARDS:

[24]
D. FURIO, S. FLECK, B. BOUSQUET, J.-P. GUILLET, L. CANIONI, M. HACHET. *HOBIT: Hybrid Optical Bench for Innovative Teaching*, in "CHI'17 - Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems", Denver, United States, May 2017 [*DOI :* 10.1145/3025453.3025789], https://hal.inria.fr/hal-01455510

[32]
J. SOL ROO, R. GERVAIS, J. FREY, M. HACHET. *Inner Garden: Connecting Inner States to a Mixed Reality Sandbox for Mindfulness*, in "CHI '17 - International Conference of Human-Computer Interaction", Denver, United States, CHI '17, ACM, May 2017 [*DOI :* 10.1145/3025453.3025743], https://hal.archives-ouvertes.fr/hal-01455174

[17]
A. BROCK, B. HECHT, B. SIGNER, J. SCHÖNING. *Bespoke Map Customization Behavior and Its Implications for the Design of Multimedia Cartographic Tools*, in "MUM 2017 - 16th International Conference on Mobile and Ubiquitous Multimedia", Stuttgart, Germany, November 2017, pp. 1-11, Honorable Mention Award, https://hal-enac.archives-ouvertes.fr/hal-01649814

[30]
J. S. ROO, M. HACHET. *Towards a Hybrid Space Combining Spatial Augmented Reality and Virtual Reality*, in "3DUI - IEEE Symposium on 3D User Interfaces", Los Angeles, United States, 3DUI 17, IEEE, March 2017, https://hal.archives-ouvertes.fr/hal-01453385

6. New Software and Platforms

6.1. Aïana

KEYWORD: Multimedia player

FUNCTIONAL DESCRIPTION: This software aims to make accessible the playing of a MOOC composed of various information flows (boards, videos, subtitles ...). It is not intended to be "reserved" for people with disabilities but rather to be open to as many as possible by allowing each user to adapt the interface, and therefore the use, to its users own capabilities and needs.

- Authors: Marc Chambon, Julien Grynberg, Hélène Sauzéon, Pascal Guitton and Pierre-Antoine Cinquin
- Partner: Université de Bordeaux
- Contact: Pascal Guitton

6.2. HybridOptics : Hybrid Optical Platform

KEYWORDS: Augmented reality - Education - Tangible interface

FUNCTIONAL DESCRIPTION: The software platform - gets the values of the sensors - computes in real-time the result of the simulation - generates pedagogical supports that are directly linked to the simulation (projected on the work table) - allows the user to control several parameters from a dedicated application on a tablet

- Participants: Benoît Coulais, Lionel Canioni, Bruno Bousquet, Martin Hachet and Jean-Paul Guillet
- Contact: Martin Hachet
- URL : https://project.inria.fr/hobit/fr/

7. New Results

7.1. HOBIT

Participants: David Furio, Benoit Coulais, Martin Hachet

Practical work in optics learning allows supporting the construction of knowledge, in particular when the concept to be learned remains diffuse. To overcome the limitations of the current experimental setups, we have designed a hybrid system that combines physical interaction and numerical simulation. This system relies on 3D-printed replicas of optical elements, which are augmented with pedagogical information (see Figure 3). In a first step, we have focused on the well-known Michelson interferometer experiment, widely studied in under graduate programs of Science. A 3-months user study with 101 students and 6 teachers showed that, beyond the practical aspects offered by this system, such an approach enhances the technical and scientific learning compared to a standard Michelson interferometer experiment. This work has been published at CHI 2017 [24], and the paper obtained a Best Paper - Honorable Mention Award.

Currently, we are developping a second version of HOBIT. This new version will let us simulate and augment multiple experiments related with optics, like polarization or Young's interferometer.

7.2. Inner Garden

Participants: Joan Sol Roo, Renaud Gervais, Jeremy Frey, Martin Hachet

Digital technology has completely integrated our daily lives; we use it for entertainment, productivity and our social lives. However, the potential of leveraging technology to improve its users' overall happiness and life satisfaction is still largely untapped. Mindfulness, the act of paying a deliberate and non-judgmental attention to the present moment, has been shown to have a positive impact on a person's subjective well-being. With this in mind we created Inner Garden, an ambient mixed reality installation, inspired by a zen garden, comprised of an augmented sandbox along with a virtual reality modality to support mindful experiences (Figure 4. By shaping the sand, the user creates a living miniature world that is projected back onto the sand. Moreover, using a VR headset, she can take a moment to herself by actually going inside her own garden to meditate. The natural elements of the garden are connected to real-time physiological measurements, such as breathing, helping staying focused on the body. We evaluated the system through a first user study and consulted meditation teachers, who envisioned the use of the garden in their teaching, especially for novice practitioners. The reception of the system seems to indicate that technology can, when designed carefully, both engage the users and foster well-being.

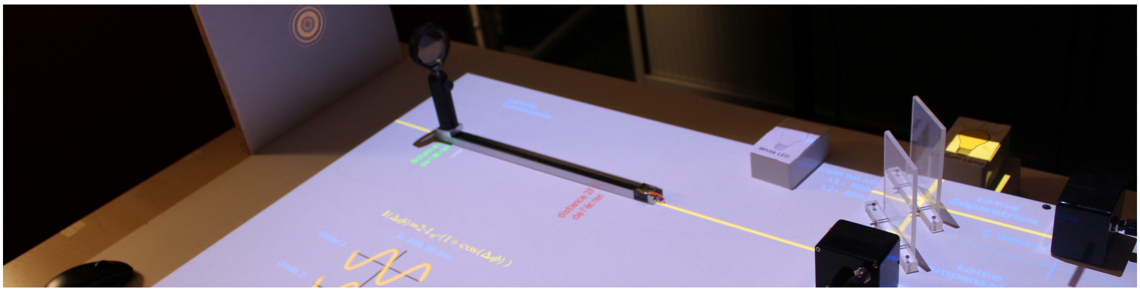

Figure 3. HOBIT: Hybrid Optical Bench for Innovative Teaching

This work has been published at CHI 2017 [32], and the paper obtained a Best Paper - Honorable Mention Award.

Figure 4. Inner Garden, an ambient mixed reality installation to support mindful experiences

7.3. Art and Science

Participants: Clémentine Petit, Maxime Agor, Martin Hachet

Potioc collaborates with artists for Art and Science projects. These projects are supported by a dedicated program at Idex - Université de Bordeaux.

The first one, Kilometre 2.0, is a joint project with Cécile Léna https://www.lenadazy.fr who is a visual artist and scenographer. We have augmented physical mockups with digital objects (see Figure 5). More concretely, our system detects train tickets being manipulated above a miniature scenery. Depending on their locations, dedicated movies are projected exactly on them, in the 3D space. Other sound and smoke effects are also generated. This artistic and interactive setup has been showed during the FACTS festival in November 18.

The second project is conducted in collaboration with Antoine Clée from Le Cirque Inachevé http://www.lecirqueinacheve.fr. Our objective is to explore new forms of juggling where the balls are not constrained by gravity anymore. More precisely, the balls are held by nano-quadcopters (drones) as illustrated in Figure 6. The juggler controls these drones by way of tracked gloves and associated interaction techniques. We presented

Figure 5. Spatial augmented reality in an artistic installation

this work as a poster presentation at IHM 2017 [16]. It has also been demonstrated during a live performance at OARA in Bordeaux on November 23rd, part of the FACTS festival.

Figure 6. A juggler interacting with flying balls

7.4. New version of Teegi and its pedagogical potential

Participants: Jeremy Frey, Fabien Lotte and Martin Hachet

Cerebral activity is an intangible physiological process that is difficult to apprehend, especially for children. To overcome this difficulty, Teegi was designed as a new type of educational support. This tangible interface enables children to discover the relationship between brain activity and the functions of the human body.

This year, we have designed a new version of Teegi (see Figure 7. It is 3D printed, and embeds a Raspberry Pi 3 and NiMh batteries (autonomy of approximately 2 hours). A python script on the Raspberry Pi handles the 402 LEDs (Adafruit Neopixel) covering the "head", which are connected to its GPIO pins. For a smoother display, the light of the LEDs is diffused by a 3mm thick cap made of acrylic glass. Two 8-by-8 white LEDs matrices picture the eyes. The script also commands the servomotors placed in the hands and feet, 4 Dynamixel XL320.

We used this new version of Teegi as a case of study for developing a multi-methods research approach to estimate the pedagogical potential of a tangible interface used in a real-life educational context. Using this methodology, we conducted a user study (N=29) that highlighted the strengths of this interface, both in terms of its usability and its impact on learning. Moreover, results revealed possible improvements to further increase pedagogical effectiveness. This type of interface, as well as the evaluation method that we propose, contribute to extending our knowledge concerning the pedagogical use of new interactive tools at school.

This work was published at IHM 2017 [22], and the accompanying demo won the best demo award. Teegi was also demonstrated at CHI 2017 [23].

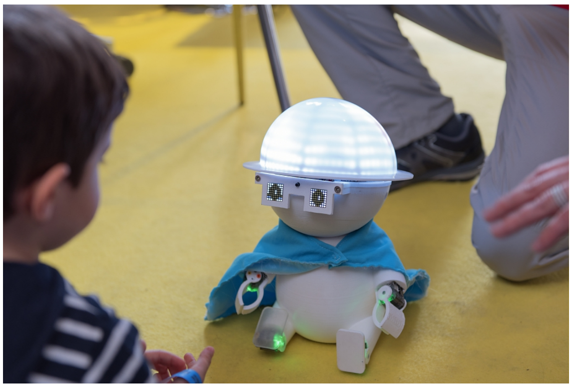

Figure 7. Teegi

7.5. One Reality

Participants: Joan Sol Roo and Martin Hachet

This project explores the combination of Physical and Virtual Reality through the usage of Mixed Reality. Early explorations involved the usage of Spatial Augmented Reality in combination with Virtual Reality, two technologies with complementary characteristics that evolved separately in the past. Spatial Augmented Reality (SAR) augments the environment using projectors or screens, without the need of user instrumentation. By keeping a single unified frame of reference, it supports social interaction and natural perception of the space, but the augmentation is limited by physical constraints (e.g., it requires a surface to display information). Immersive head mounted displays on the other hand are not limited by the physical properties of the environment, yet they isolate the user from their environment. We have proposed a unified frame of reference for both SAR and immersive displays, where the users can select the visualization that is best suited for a given task (Figure 8). This enables both asymmetric collaboration between users, and back-and-forths for a single user. These explorations were followed by the combination of additional modalities, in an incremental fashion. This way, one or more users can chose the desired modalities, and immerse themselves as much as the task requires. As a result, the virtual world can be framed in relationship with the physical one.

A preliminary version of this work was presented at 3DUI 2017 [30] where we obtained a best paper -honorable mention- award. An extended version of this work was then presented at UIST 2017 [33].

In order for such systems to succeed, it is required that users are able to create unified mental models out of heterogeneous representations. To better understand how humans perceive hybrid systems as the one described above, we conducted two studies. They focused on the users' performance on heterogeneous systems (using Spatial Augmented Reality and immersive Virtual Reality displays), and combining viewpoints (egocentric and exocentric). The results show robust estimation capabilities across conditions. This work has been (conditionally) accepted at CHI 18.

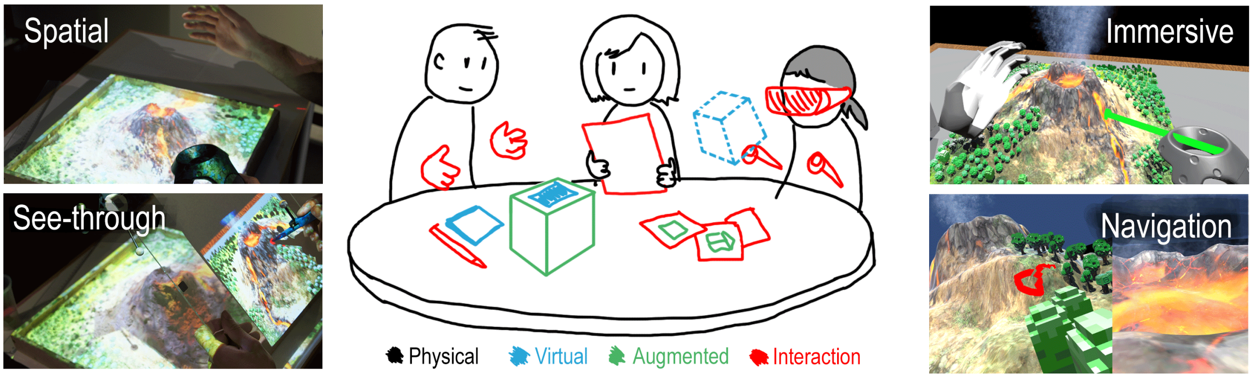

Figure 8. One Reality combines the real and virtual worlds

7.6. Collaboration in VR

Participants: Damien Clergeaud and Pascal Guitton

The aerospace industry is no longer composed of local and individual businesses. Due to the complexity of the products (their size, the number of components, the variety of systems and regulation constraints), the design of an aircraft or a launcher involves a considerable number of engineers with various fields of expertise. Furthermore, aerospace companies often have industrial facilities all over the world. In such a complex setting, it is necessary to build virtual experiments that can be shared between different remote sites. Specific problems then arise, particularly in terms of the perception of other immersed users and of interaction tasks involving several immersed users.

We work with Airbus Group in order to design efficient collaborative interaction methods. These collaborative sessions allow multiple sites to be connected within the same virtual experiment and enable experts from different fields to be immersed simultaneously. For instance, if a problem occurs during the final stages of a launcher assembly, it may be necessary to bring together experts on different sites who were involved in previous steps (initial design, manufacturing processes). IIn the context of this collaboration, we working on various projects:

- Design of basic communication tools for the aerospace context.
- Pano: a 360° visualization system that's facilitate the communication in the case of guiding someone else [19],
- Design of an Annotation System for taking notes in VR [18].

7.7. Tangible interaction and augmented reality for collaborative learning

Participants: Philippe Giraudeau and Martin Hachet

Part of the e-Fran project e-Tac, we explore approaches based on the hybridization of physical and digital content for mind-mapping activities at schools. Based on the literature in the fields of cognitive science and HCI, we have designed a mixed-reality (MR) interface called Reality-Map (Figure 10. We conducted a pilot study with 11 participants suggesting that learning and manipulating information about the brain and their cognitive functions could be improved by the use of such a MR interface compared to a traditional WIMP interface [45]. We are now extending this approach with the partners of the project to design and develop a new pedgogical tool that will be evaluated in classrooms.

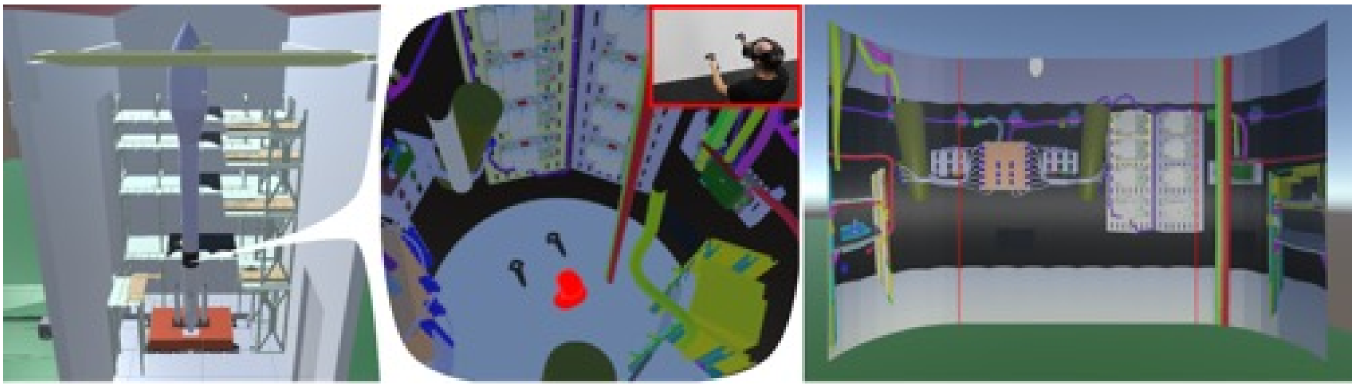

Figure 9. An immersed user has to perform a virtual task in a complex environment. In order to help the user to be fully aware of the VE, another immersed operator may guide him using a Through-The-Lens metaphor.

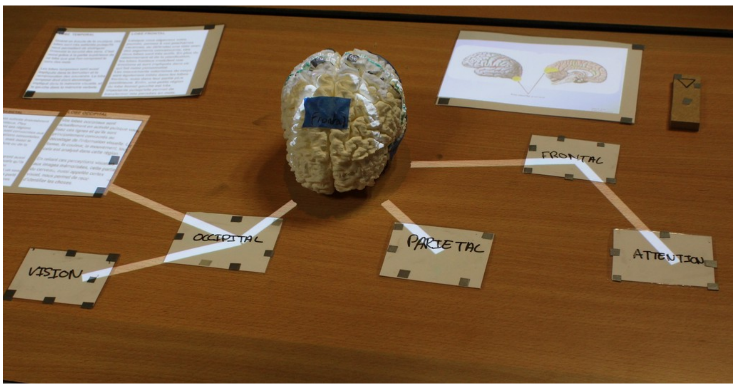

Figure 10. Digital and physical objects combined for collaborative learning

7.8. A model of Mental-Imagery BCI

Participants: Camille Jeunet and Fabien Lotte

Mental-Imagery based Brain-Computer Interfaces (MI-BCIs) enable users to control applications using their brain activity alone, by realising mental imagery tasks. Although promising, MI-BCIs remain barely used outside laboratories, notably due to the difficulties users encounter when attempting to control them. We claim that understanding and improving the user training process could greatly improve users' MI-BCI control abilities. Yet, to better understand the training process, we need a model of the factors impacting MI-BCI performance. In other words, we need to understand which traits and states impact MI-BCI performance, how these factors interact and how to influence them to improve this performance. Such a model would enable us to design adapted and adaptive training protocols, to guide europhysiological analyses or design informed classifiers, among others. In this paper we propose a theoretical model of MI-BCI tasks, which is the first step towards the design of this full cognitive and computational model. This work was published in the International BCI conference [46].

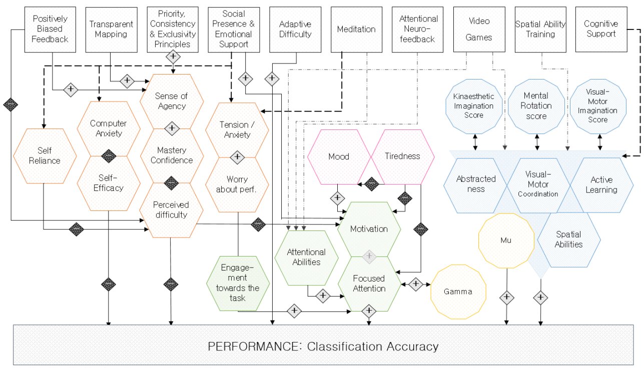

Figure 11. A conceptual model of Mental-Imagery BCI user training

7.9. PEANUT - Personalized Emotional Agent for Neurotechnology User Training

Participants: Léa Pillette, Camille Jeunet and Fabien Lotte

Mental-Imagery based Brain-Computer Interfaces (MI-BCI) are neurotechnologies enabling users to control applications using their brain activity alone. Although promising, they are barely used outside laboratories because they are poorly reliable, partly due to inappropriate training protocols. Indeed, it has been shown that tense and non-autonomous users, that is to say those who require the greatest social presence and emotional support, struggle to use MI-BCI. Yet, the importance of such support during MI-BCI training is neglected. Therefore we designed and tested PEANUT, the first Learning Companion providing social presence and emotional support dedicated to the improvement of MI-BCI user-training. PEANUT was designed based on the literature, data analyses and user-studies. Promising results revealed that participants accompanied by PEANUT found the MI-BCI system significantly more usable. This work was published in the International BCI conference [29].

7.10. The Impact of Flow on BCI user training

Participants: Jelena Mladenovic, Jérémy Frey, Manon Bonnet-Save, Fabien Lotte

Figure 12. The PEANUT learning companion for BCI user training

Major issues in Brain Computer Interfaces (BCIs) include low usability and poor user performance. This paper tackles them by ensuring the users to be in a state of immersion, control and motivation, called state of flow. Indeed, in various disciplines, being in the state of flow was shown to improve performances and learning. Hence, we intended to draw BCI users in a flow state to improve both their subjective experience and their performances. In a Motor Imagery BCI game, we manipulated flow in two ways: 1) by adapting the task difficulty and 2) by using background music. Results showed that the difficulty adaptation induced a higher flow state, however music had no effect. There was a positive correlation between subjective flow scores and offline performance, although the flow factors had no effect (adaptation) or negative effect (music) on online performance. Overall, favoring the flow state seems a promising approach for enhancing users' satisfaction, although its complexity requires more thorough investigations. This work was published at the international BCI conference [27]

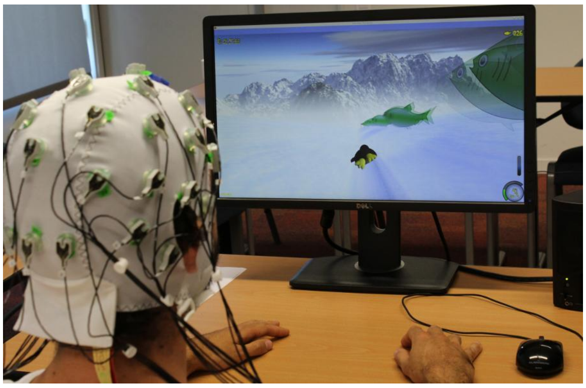

Figure 13. Adaptive BCI user training to maximize the flow state

7.11. New Performance metrics to study BCI user training

Participants: Fabien Lotte and Camille Jeunet

While promising for many applications, Electroencephalography (EEG)-based Brain-Computer Interfaces (BCIs) are still scarcely used outside laboratories, due to a poor reliability. It is thus necessary to study and fix this reliability issue. Doing so requires to use appropriate reliability metrics to quantify both signal processing and user learning performances. So far, Classification Accuracy (CA) is the typical metric used for both aspects. However, we argue in this paper that CA is a poor metric to study how well users are learning to use the BCI. Indeed CA is notably unspecific, discrete, training data and classifier dependent, and as such may not always reflect successful EEG pattern self-modulation by the user. We thus propose new performance metrics to specifically measure how distinct and stable the EEG patterns produced by the user are. By re-analyzing EEG data with these metrics, we indeed confirm that CA may hide some learning effects or hide the user inability to self-modulate a given EEG pattern. This was published at the international BCI Conference [25].

7.12. Joint EEG-fMRI Neurofeedback training

Participants: Fabien Lotte

Neurofeedback is a promising tool for brain rehabilitation and peak performance training. Neurofeedback approaches usually rely on a single brain imaging modality such as EEG or fMRI. Combining these modalities for neurofeedback training could allow to provide richer information to the subject and could thus enable him/her to achieve faster and more specific self-regulation. Yet unimodal and multimodal neurofeedback have never been compared before. In the present work, we introduce a simultaneous EEG-fMRI experimental protocol in which participants performed a motor-imagery task in unimodal and bimodal NF conditions. With this protocol we were able to compare for the first time the effects of unimodal EEG-neurofeedback and fMRI-neurofeedback versus bimodal EEG-fMRI-neurofeedback by looking both at EEG and fMRI activations. We also propose a new feedback metaphor for bimodal EEG-fMRI-neurofeedback that integrates both EEG and fMRI signal in a single bi-dimensional feedback (a ball moving in 2D). Such a feedback is intended to relieve the cognitive load of the subject by presenting the bimodal neurofeedback task as a single regulation task instead of two. Additionally, this integrated feedback metaphor gives flexibility on defining a bimodal neurofeedback target. Participants were able to regulate activity in their motor regions in all NF conditions. Moreover, motor activations as revealed by offline fMRI analysis were stronger during EEG-fMRI-neurofeedback than during EEG-neurofeedback. This result suggests that EEG-fMRI-neurofeedback could be more specific or more engaging than EEG-neurofeedback. Our results also suggest that during EEG-fMRI-neurofeedback, participants tended to regulate more the modality that was harder to control. Taken together our results shed first light on the specific mechanisms of bimodal EEG-fMRI-neurofeedback and on its added-value as compared to unimodal EEG-neurofeedback and fMRI-neurofeedback.

This work in collaboration with Inria teams Hybrid, Visage and Athena, was published in the journal Frontiers in Neuroscience [14].

7.13. Robust EEG spatial filters for single trial regression

Participants: Fabien Lotte

In the field of Brain-Computer Interfaces (BCI), robust methods for the decoding of continuous brain states are of great interest as new application fields are arising. When capturing brain activity by an electroencephalogram (EEG), the Source Power Comodulation (SPoC) algorithm allows to compute spatial filters for the decoding of a continuous variable. However, dealing with high-dimensional EEG data that suffer from low signal-to-noise ratio, the method reveals instabilities for small training data sets and is prone to overfitting. In this paper, we introduce a framework for applying Tikhonov regularization to the SPoC approach in order to restrict the solution space of filters. Our findings show that an additional trace normalization of the included covariance matrices is a necessary prerequisite to tune the sensitivity of the resulting algorithm. In an offline analysis with data from N=18 subjects, the introduced trace normalized and Tihonov regularized SPoC variant (NTR-SPoC) outperforms the standard SPoC method for the majority of individuals. With this proof-of-concept study, a generalizable regularization framework for SPoC has been established which allows to implement a variety of different regularization strategies in the future. This work in collaboration with Freiburg University, Germany, was published at the international BCI Conference [26].

7.14. Optimal motor tasks for Sensorimotor BCI calibration

Participants: Fabien Lotte

SensoriMotor Rhythm (SMR)-based Brain-Computer Interfaces (BCI) are among the most used ElectroEncephaloGraphy (EEG) BCI systems. However, such systems have low performance and many of their users are "non-responders". There is thus a need to understand the limitations of current SMR-BCI and to improve them. Many of them use machine learning. They are typically calibrated on EEG signals collected while the users are performing Motor Imagery (MI), i.e., imagining limb movements. Once calibrated, they also use MI as control strategy. However, for many first time users of SMR-BCI, performing MI is new and difficult, and they may be unable to perform clear MI. Thus, using MI for calibration may result in suboptimal EEG features and corresponding real-time feedback. Therefore, we aim at elucidating whether MI tasks are the best motor tasks to use for calibration and control in SMR-BCI. To do so, we collected EEG signals from subjects instructed to perform four different motor tasks and a rest task, for multiple trials. In particular, subjects have to 1) execute real feet movements; 2) imagine feet movements (walking); 3) observe feet movements (walking), in a first person view and 4) observe feet movements while imagining them at the same time. Preliminary results revealed that for some subjects, calibrating EEG spatial filters on real motor movements can lead to better performances with an MI-BCI than calibrating them on MI tasks. This thus warrant further investigation into the calibartion tasks in SMR-BCI. This preliminary work, in collaboration with RIKEN Brain Science Institute in Japan, was presented as a poster at RTFIN 2017 [48].

7.15. A review of Rapid Serial Visualization Protocol-based BCI

Participants: Fabien Lotte

Rapid serial visual presentation (RSVP) combined with the detection of event related brain responses facilitates the selection of relevant information contained in a stream of images presented rapidly to a human. Event related potentials (ERPs), measured non-invasively with electroencephalography (EEG), can be associated with infrequent target stimuli(images) in groups of images, potentially providing an interface for human-machine symbiosis, where humans can interact and interface with a computer without moving and which may offer faster image sorting than scenarios where humans are expected to physically react when a target image is detected. Certain features of the human visual system impact on the success of the RSVP paradigm. Pre-attentive processing supports the identification of target information 100ms following information presentation. This paper presents a comprehensive review and evaluation of research in the broad field of RSVP-based brain-computer interfaces (BCIs). Applications that use RSVP-based BCIs are classified based on the operation mode whilst protocol design considerations are critiqued. Guidelines for using the RSVP-based BCI paradigms are defined and discussed, with a view to further standardization of methods and experimental evidence gathering to support the use of RSVP-based BCIs in practice. This review in collaboration with Ulster University, UK, was published in Journal of Neural Engineering [13].

7.16. Active Inference-based design of adaptive P300-Speller BCIs

Participants: Jelena Mladenovic, Fabien Lotte

Recent developments in computational neuroscience gave rise to an efficient generic framework to implement both optimal perceptual (Bayesian) inference and choice behaviour. This framework named Active Inference rests on minimizing free energy or surprise [3]. We suggest it could be used to implement efficient adaptive Brain-Computer Interfaces (BCIs). We briefly illustrate it on a simulated P300-speller task. This work in collaboration with Inserm Lyon, was published in the first Neuro Adaptive Technology conference [28].

7.17. BCI Handbook

Participants: Fabien Lotte

Together with Chang S Nam (USA) and Anton Nijholt (Netherlands/Malaysia), we edited an Handbook of BCI technologies [41]. This handbook is a valuable resource to anyone involved with improvement of people's lives by replacing, restoring, supplementing and improving motor action, and understanding the neural bases of such functions. While there are several other resources available, there is no handbook such as this one. This handbook addresses the recent and rapid changes in the field of braincomputer interfaces (BCIs). Due to these changes interest in BCI has grown enormously, including interest from computer science researchers with a background in computational intelligence, human-computer interaction, and researchers in entertainment technology.

7.18. Augmented Reality Maps for Visually Impaired People

Participants: Anke Brock

VISTE builds on the previous development of the GEOTHNK platform (Kavouras et al., 2016). The VISTE framework and associated resources and tools focus on collaborative learning of spatial concepts and skills for sighted and VI students to foster inclusion within mainstream education. VISTE will empower students with VI to acquire spatial skills through specially designed learning activities as well as through an augmented reality prototype. At Inria Bordeaux, we have designed and implemented an augmented reality prototype that can be used as spatial thinking training tool in special education schools. It makes use of the PapARt technology, an OpenSource augmented reality framework [1]. Current low-tech Orientation & Mobility (O&M) tools for visually impaired people, e.g. tactile maps, possess limitations. Interactive accessible maps have been developed to overcome these [2]. However, most of them are limited to exploration of existing maps, and have remained in laboratories. Using a participatory design approach, we have worked closely with 15 visually impaired students and 3 O&M instructors over 6 months. We iteratively designed and developed an augmented reality map destined at use in O&M classes in special education centers. This prototype combines projection, audio output and use of tactile tokens, and thus allows both map exploration and construction by low vision and blind people. Our user study demonstrated that all students were able to successfull$f$y use the prototype, and showed a high user satisfaction. A second phase with 22 international special education teachers allowed us to gain more qualitative insights. This work shows that augmented reality has potential for improving the access to education for visually impaired people. A publication about this map prototype and the user study has been (conditionally) accepted at CHI'18 [3] Learn more about VISTE project : http://visteproject.eu/ https://team.inria.fr/potioc/viste-empowering-spatial-thinking-of-students-with-visual-impairment/

7.19. Accessibility of e-learning systems

Participants: Pierre-Antoine Cinquin and Pascal Guitton

New digital teaching systems such as MOOCs are taking an increasingly important place in current teaching practices. Unfortunately, accessibility for people with disabilities is often forgotten, which excludes them, particularly those with cognitive impairments for whom accessibility standards are fare from being established. This is truly unfortunate as the interest of using these specialized practices for this audience is scientifically proven.

To overcome these limitations, we propose new design principles based on knowledge in the areas of accessibility (Ability-based Design and Universal Design), digital pedagogy (Instruction Design with functionalities that reduce the cognitive load : navigation by concept, slowing of the flow. . .), specialized pedagogy (Universal Design for Learning, eg, automatic note-taking, and Self Determination Theory, e.g., configuration of the interface according to users needs and preferences) and psychoducational interventions (eg, support the joint teacher-learner attention), but also through a participatory design approach involving students with disabilities

[1] Laviole & Hachet, 2012
[2] Ducasse et al., 2018
[3] Jeremy Albouys-Perrois, Jeremy Laviole, Carine Briant, and Anke Brock. Towards a Multisensory Augmented Reality Map for Blind and Low Vision People: a Participatory Design Approach. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, USA

and experts in the field of disability. From these framework, we have designed interaction features which have been implemented in a specific MOOC player called Aïana. Moreover, we have produced a MOOC on digital accessibility which is published on the national MOOC platform (FUN) using Aïana (2 sessions in 2016 and 2017) https://mooc-francophone.com/cours/mooc-accessibilite-numerique/.

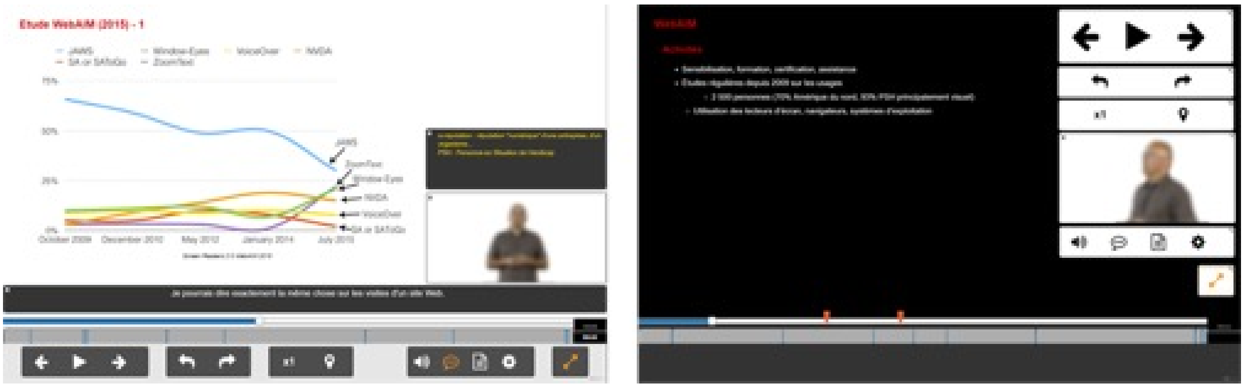

Figure 14. The Aïana MOOC player.

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

Interactive Collaboration in Virtual Reality for Aerospace Scenarii:

Duration: 2014-2017

PhD Thesis of Damien Clergeaud

Partners: Airbus Group

Local coordinator: Pascal Guitton

The Airbus company regularly uses virtual reality for design, manufacturing and maintenance. We work with them on collaborative interaction in order to enable an efficient collaboration between operators immersed in the virtual environment from remote locations and with heterogeneous equipment. More precisely, we have developped tools to point and manipulate objects, to remotely visualize the virtual environment, to be aware of remote manipulations and to describe tools and components trajectories

9. Partnerships and Cooperations

9.1. Regional Initiatives

Introspectibles - Collaborative research project :

Funding: Région Aquitaine

Duration: 2017-2018

Local coordinator: Martin Hachet

Partners: ULLO,

Following our work with the Introspectibles (Teegi, TOBE, Inner Garden), we are currently working with the ULLO company to bring these new interfaces to healthcare centers.

HOBIT - Maturation project :

Funding: Aquitaine Science Transfer

Duration: 2017-2018

Local coordinator: Martin Hachet

Partners: Université de Bordeaux

We are currently moving our platform HOBIT from his lab state to a commercial product.

Km 2.0 - Arts an Sciences program :

Funding: Idex Université Bordeaux

Duration: 2017-2018

Local coordinator: Martin Hachet

Partners: Léna D'Azy

We work with Cécile Léna for creating artistic installations based on interactive projection. See http://www.facts-bordeaux.fr/RESIDENCES/KM-2.0

Telekinetik juggling - Arts an Sciences program :

Funding: Idex Université Bordeaux

Duration: 2017-2018

Local coordinator: Martin Hachet

Partners: Le Cirque Inachevé

We work with Antoine Cléé from Cirque Inachevé for the design of an interactive environment where the artist will be able to juggle with zero gravity objects. The artist wear gloves, and interact with mini-drones supporting balls. See http://www.facts-bordeaux.fr/RESIDENCES/Jonglerie-telekinetique

Neuroperf :

Funding: Idex Université Bordeaux

Duration: 2017-2019

Coordinator: Jean-Arthur Micoulaud Franci

Local coordinator: Fabien Lotte

Partners: SANPSY - Potioc

This project aims at studying EEG-based Neurofeedback to reduce fatigue symptoms in sleep-deprived individuals. See http://brain.labex.u-bordeaux.fr/Actualites/Selection-projets-recherche-Clinique-2017-i5064.html

9.2. National Initiatives

eTAC: Tangible and Augmented Interfaces for Collaborative Learning:

Funding: EFRAN

Duration: 2017-2021

Coordinator: Université de Lorraine

Local coordinator: Martin Hachet

Partners: Université de Lorraine, Inria, ESPE, Canopé, OpenEdge,

the e-TAC project proposes to investigate the potential of technologies "beyond the mouse" in order to promote collaborative learning in a school context. In particular, we will explore augmented reality and tangible interfaces, which supports active learning and favors social interaction.

ANR Rebel:

Duration: 2016-2019

Coordinator: Fabien Lotte

Funding: ANR Jeune Chercheur Jeune Chercheuse Project

Partners: Disabilities and Nervous Systems Laboratory Bordeaux

Brain-Computer Interfaces (BCI) are communication systems that enable their users to send commands to computers through brain activity only. While BCI are very promising for assistive technologies or human-computer interaction (HCI), they are barely used outside laboratories, due to a poor reliability. Designing a BCI requires 1) its user to learn to produce distinct brain activity patterns and 2) the machine to recognize these patterns using signal processing. Most research efforts focused on signal processing. However, BCI user training is as essential but is only scarcely studied and based on heuristics that do not satisfy human learning principles. Thus, currently poor BCI reliability is probably due to suboptimal user training. Thus, we propose to create a new generation of BCI that apply human learning principles in their design to ensure the users can learn high quality control skills, hence making BCI reliable. This could change HCI as BCI have promised but failed to do so far.

ANR Project ISAR:

Duration: 2014-2017

Coordinator: Martin Hachet

Partners: LIG-CNRS (Grenoble), Diotasoft (Paris)

Acronym: Interaction en Réalité Augmentée Spatiale / Interacting with Spatial Augmented Reality

The ISAR project (Interaction with Spatial Augmented Reality) focuses on the design, implementation, and evaluation of new paradigms to improve interaction with the digital world when digital content is directly projected onto physical objects. It opens new perspectives for exciting tomorrow's applications, beyond traditional screen-based applications.

website: https://team.inria.fr/potioc/scientific-subjects/papart/

Inria Project Lab BCI-LIFT:

Duration: 2015-2018

Partners: Inria team Athena (Inria Sophia-Antipolis), Inria team Hybrid (Inria Rennes), Inria team Neurosys (Inria Nancy), LITIS (Université de Rouen), Inria team DEMAR (Inria Sophia-Antipolis), Inria team MINT (Inria Lille), DyCOG (INSERM Lyon)

Coordinator: Maureen Clerc (Inria Sophia Antipolis)

Local coordinator: Fabien Lotte

The aim is to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. With this concern of usability as our driving objective, we will build non-invasive systems that benefit from advanced signal processing and machine learning methods, from smart interface design, and where the user immediately receives supportive feedback. What drives this project is the concern that a substantial proportion of human participants is currently categorized "BCI-illiterate" because of their apparent inability to communicate through BCI. Through this project we aim at making it easier for people to learn to use the BCI, by implementing appropriate machine learning methods and developping user training scenarios.

website: http://bci-lift.inria.fr/

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: ERC Starting Grant

Project acronym: BrainConquest

Project title: Boosting Brain-Computer Communication with High Quality User Training

Duration: 07/2017-06/2022

Coordinator: Fabien Lotte

Abstract: Brain-Computer Interfaces (BCIs) are communication systems that enable users to send commands to computers through brain signals only, by measuring and processing these signals. Making computer control possible without any physical activity, BCIs have promised to revolutionize many application areas, notably assistive technologies, e.g., for wheelchair control, and man-machine interaction. Despite this promising potential, BCIs are still barely used outside laboratories, due to their current poor reliability. For instance, BCIs only using two imagined hand movements as mental commands decode, on average, less than 80% of these commands correctly, while 10 to 30% of users cannot control a BCI at all. A BCI should be considered a co-adaptive communication system: its users learn to encode commands in their brain signals (with mental imagery) that the machine learns to decode using signal processing. Most research efforts so far have been dedicated to decoding the commands. However, BCI control is a skill that users have to learn too. Unfortunately how BCI users learn to encode the commands is essential but is barely studied, i.e., fundamental knowledge about how users learn BCI control is lacking. Moreover standard training approaches are only based on heuristics, without satisfying human learning principles. Thus, poor BCI reliability is probably largely due to highly suboptimal user training. In order to obtain a truly reliable BCI we need to completely redefine user training approaches. To do so, I propose to study and statistically model how users learn to encode BCI commands. Then, based on human learning principles and this model, I propose to create a new generation of BCIs which ensure that users learn how to successfully encode commands with high signal-to-noise ratio in their brain signals, hence making BCIs dramatically more reliable. Such a reliable BCI could positively change man-machine interaction as BCIs have promised but failed to do so far.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

- Program: DGA-DSTL Project

  Project title: Assessing and Optimising Human-Machine Symbiosis through Neural signals for Big Data Analytics

  Duration: 2014-2018

  Coordinator: Damien Coyle and Fabien Lotte

  Partners: Ulster University, UK, Potioc, France

  Abstract: This project objective is to design new tools for Big Data analysis, and in particular visual analytics tools that tap onto human cognitive skills as well as on Brain-Computer Interfaces. The goal is to enable the user to identify and select relevant information much faster than what can be achieved by using automatic tools or traditional human-computer interfaces. More specifically, this project will aim at identifying in a passive way various mental states (e.g., different kinds of attention, mental workload, relevant stimulus perception, etc.) in order to optimize the display, the arrangement of the selection of relevant information.

- Program: ERASMUS+

  Project acronym: VISTE

  Project title: Empowering spatial thinking of students with visual impairment

Duration: 2016-2019

Coordinator: National Technical University of Athens (Greece)

Local coordinator: Anke Brock

Other partners: Intrasoft International SA (Greece), Casa Corpolui Didatic Cluj (Romania), Liceul Special pentru Deficienti de Vedere Cluj-Napoca (Romania), Eidiko Dimotiko Sxolio Tiflon Kallitheas (Greece)

Abstract: VISTE addresses inclusion and diversity through an innovative, integrated approach for enhancing spatial thinking focusing on the unique needs of students with blindness or visual impairment. However, since spatial thinking is a critical competence for all students, the VISTE framework and associated resources and tools will focus on cultivating this competence through collaborative learning of spatial concepts and skills both for sighted and visually impaired students to foster inclusion within mainstream education. The VISTE project will introduce innovative educational practices for empowering students with blindness or visual impairment with spatial skills through specially designed educational scenarios and learning activities as well as through a spatial augmented reality prototype to support collaborative learning of spatial skills both for sighted and visually impaired students.

9.3.3. Collaborations with Major European Organizations

Partner 1: Univ. Freiburg, Brain State Decoding Laboratory (M. Tangermann), Germany

Topic 1: robust EEG spatial filters for single trial regression

Partner 2: TU Graz, Neural Engineering lab (R. Scherer), Austria

Topic 2: BCI pitfalls, negative results in BCI, guidelines for BCI design

Partner 3: EPFL, Defitech Foundation Chair in Brain-machine Interface (R. Chavarriaga), Switzerland

Topic 3: BCI pitfalls, negative results in BCI

Partner 4: Oldenbourg University, Neuropsychology department (S. Debener, C. Zich), Germany

Topic 4: guidelines for BCI design

Partner: Twente University (A. Nijholt), Enschede, The Netherlands

Topic: Handbook of Brain-Computer Interfaces

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Other IIL projects

Presentation of Potioc research activities during the annual Inria-EPFL Workshop (Session MOOCS & e-learning)

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

Partner: Université du Québec à Montréal, Institut des Sciences Cognitives (R. N'Kambou), Montreal, Canada

Topic: Learning companions for Brain-Computer Interfaces

Partner: North Carolina State University (Chang S. Nam), USA

Topic: Handbook of Brain-Computer Interfaces

9.4.3. Participation in Other International Programs

Partner: Flowers & Potioc teams, Inria Bordeaux, University of Waterloo, Canada

Funding: Univ. Bordeaux/Univ Waterloo joint grant call for project

Date: 2017-2018

Topic: Designing for Curiosity in Physical Spaces

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

3 Members of team Potioc spend several months at the RIKEN Brain Science Institute (BSI), Cichocki's advanced brain signal processing laboratory, Wakoshi, Japan.

- Fabien Lotte: 10 months in total, with the JSPS (Japan Society for the Promotion of Science) Invitation fellowship program
- Léa Pillette: 6 months in total, funded by the RIKEN BSI
- Aurélien Appriou: 3 months in total, funded by the RIKEN BSI

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. Member of the Organizing Committees

- EduIHM, Workshop at IHM 2017, Martin Hachet
- "Kick-off conference of CORTICO, the French BCI association", Paris, France, January 2017, Fabien Lotte
- "2nd National congress onNeurofeedback: NeXT Steps", Paris, France, January 2017, Fabien Lotte

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

- Program Chair IHM 2017, Martin Hachet

10.1.2.2. Member of the Conference Program Committees

- ACM CHI Conference, 2018, Anke Brock
- ACM ASSETS Conference, 2017, Anke Brock
- Late Breaking Work Committee ACM CHI Conference, 2017, Anke Brock
- Augmented Human Conference (AH), 2018, Fabien Lotte
- Eurographics STA,R 2017, Martin Hachet
- IEEE VR, 2017, Martin Hachet
- 7th International Brain-Computer Interface Conference, 2017, Fabien Lotte
- Neuroadaptive Technology conference (NAT), 2017, Fabien Lotte
- Symbiotic, 2017, Fabien Lotte

10.1.2.3. Reviewer

- ACM CHI 2018, Pascal Guitton, Fabien Lotte, Joan Sol Roo
- ACM ISS 2017, Joan Sol Roo
- ACM CHI-Play 2017, Joan Sol Roo

- ACM UIST 2017, Fabien Lotte
- Augmented Human Conference (AH), 2018, Fabien Lotte, Jelena Mladenovic
- Haptics Symposium 2018, Anke Brock
- ICASSP 2018, Fabien Lotte
- IEEE VR 2018, Joan Sol Roo
- 7th International Brain-Computer Interface Conference, 2017, Fabien Lotte
- JJ-ICON 2017, Fabien Lotte
- MobileHCI 2017, Anke Brock
- Symbiotic 2017, Fabien Lotte

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- Special Issue Chair TACCESS ACM ASSETS Conference, 2017, Anke Brock
- Member of the Editorial board of Journal of Neural Engineering, Fabien Lotte
- Member of the Editorial Board (Associate Editor) of the Brain-Computer Interface journal, Fabien Lotte
- Review Editor for the Frontiers in Human-Media Interaction journal, Fabien Lotte
- Review Editor for the Frontiers in Neuroprosthetics journal, Fabien Lotte
- Guest Editor, Frontiers in Neurosciences on "Detection and Estimation of Working Memory States and Cognitive Functions Based on Neurophysiological Measures", 2017, Fabien Lotte

10.1.3.2. Reviewer - Reviewing Activities

- ACM Transactions on Computer-Humans Interactions (TOCHI), Fabien Lotte
- BioMed Research International, Fabien Lotte
- Frontiers in Human Neurosciences, Fabien Lotte
- IEEE Access, Fabien Lotte
- IEEE Transactions on Biomedical Engineering, Fabien Lotte
- IEEE Transactions on Human-Machine Systems, Fabien Lotte
- International Journal of Human-Computer Studies, Fabien Lotte
- Journal of Accessibility and Design for All (JACCESS), Anke Brock
- Journal of Neural Engineering, Fabien Lotte
- Nature Scientific Reports, Fabien Lotte
- PLOS One, Fabien Lotte
- Transactions on Haptics, Anke Brock

10.1.4. Invited Talks

- Which feedback should be given to maximize Brain-Computer Interface training, 2nd National Day about Neurofeedback at ESPCI school in Paris, France, Jan. 2017, Léa Pillette
- The impact of flow on BCI neurofeedback training, 2nd National Day about Neurofeedback at ESPCI school in Paris, France, Jan. 2017, Jelena Mladenovic
- Engagement des publics et genre, Séminaire Projet RRI-Practice, CEA Saclay, Feb. 2017, Pascal Guitton
- Comment apprendre à contrôler un ordinateur avec son activité cérébrale ? Le projet BrainConquest, Journée 10 ans ERC - 50 ans Inria, Paris, March 2017, Fabien Lotte
- Art and Sciences at Potioc, Ministry of Culture, Paris, March 2017, Martin Hachet

- Multisensory Maps for Visually Impaired People, Robotics, Brain and Cognitive Sciences dept, Italian Institute of Technology, Genova, Italy, APril 2017, Anke Brock
- Designing for Accessibility, University Bordeaux, OpenCare Project Meeting (H2020), June 2017, Anke Brock
- L'éthique en Sciences du numérique, Ecole du Management Inria, Paris, June 2017, Pascal Guitton
- Creating, learning, and meditating; a trip in tangible hybrid spaces, ETIS, Luxembourg, June 2017, Martin Hachet
- Augmented reality & tangible interaction for accessibility, University Stuttgart, HCI Lab, July 2017, Anke Brock
- Understanding and improving BCI user training to boost brain-computer communications, International Graz Brain-Computer Interfaces Conference, opening Keynote, Graz, Austria, Sep. 2017, Fabien Lotte
- Brain-Computer Interfaces technologies for the benefit of all: Neuroergonomics and Neuroeducation, Tokyo University of Agriculture and Technology (TUAT), Tokyo, Japan, Oct. 2017, Fabien Lotte
- Brain-Computer Interfaces: design, user training and new applications, Japanese French Laboratory for Informatics (JFLI), Tokyo University, Tokyo, Japan, Oct. 2017, Fabien Lotte
- L'accessibilité des systèmes numériques d'enseignement, GT Handicap, FCS Paris-Saclay, Nov. 2017, Pascal Guitton
- Interactive projection and 3D gestures for Artistic performances, OARA, Bordeaux, Nov. 2017, Martin Hachet
- Combining machine learning and psychology to design usable Brain-Computer Interfaces, RIKEN Advanced Intelligence Project, Tokyo, Japan, Dec. 2017, Fabien Lotte

10.1.5. Scientific Expertise

- Reviewer for the Millennium Science Initiative 2017, Chile, Fabien Lotte
- Membre du comité ANR CE33 (Interaction, Robotics) 2017, Fabien Lotte
- Member of Inria Cellule de veille et de prospective, Pascal Guitton
- Reviews of projects : ANR, DFG, Crédit Impot Recherche ()Ministère de la recherche), Anke Brock, Martin Hachet
- Member of COSAE, scientific board of SCRIME, Martin Hachet
- Member of the scientific board of ULLO, Martin Hachet, Fabien Lotte

10.1.6. Research Administration

- Representative of Inria at NEM (New European Media), Fabien Lotte
- Member of Commission de recrutement des Inspecteurs Généraux de l'Education Nationale (IGEN), Pascal Guitton
- Member of Comité de Pilotage de Software Heritage, Pascal Guitton
- Femmes & Sciences Deputy Board Member, Anke Brock
- Member of Inria Ethical Committee (COERLE), Pascal Guitton
- Member of Inria Comité Parité et Egalité, Anke Brock & Pascal Guitton
- Responsable of Inria RA2020 Committee (new annual Activity Report), Pascal Guitton
- Member of Inria International Chairs Committee, Pascal Guitton
- Member of Comité de sélection Professeur d'informatique, Université de Rennes, Pascal Guitton
- Jury member for the competitive selection - Young graduate scientist (Chargé de Recherche 2) at Inria Bordeaux (2017), Anke Brock

- Jury member for an Assistant Professorship ()MCF section CNU 63, “Photonics and digital sciences”) at Institut Optique / Université Paris-Sud, Anke Brock
- Jury member for the competitive selection Research scientist (CR 2) at Inria Bordeaux, Anke Brock
- Member of Bureau du comité des projets, Inria Bordeaux Sud-Ouest, Martin Hachet
- Member of Comité de Dévelopement Technologique (CDT), Inria Bordeaux Sud-Ouest, Fabien Lotte
- Member of Comité Jeunes Chercheurs at Inria Bordeaux Sud-Ouest, Anke Brock
- Member of Comité de Pilotage Responsabilité Sociétale de l’Université, Université de Bordeaux, Pascal Guitton

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Licence Pierre-Antoine Cinquin, Assistive technologies for cognition, CM, 3h, 2nd year Institut de formation en ergothérapie, Bordeaux, France

Master: Pascal Guitton, Virtual and Augmented Realities, CM, 36h eqtd, M2 Computer Science, University of Bordeaux, France

Master: Pascal Guitton, Digital accessibility, CM, 12h eqtd, M1 Cognitive Science, University of Bordeaux, France

Master: Pascal Guitton, Assistive technologies, CM, 30h eqtd, M2 Cognitive Science, University of Bordeaux, France

Master: Martin Hachet, Virtual Reality and 3D Interaction, CM, 12h eqtd, M2 Cognitive Science, University of Bordeaux, France

Master: Martin Hachet, Interaction and Ergonomics, CM-TD, 8h eqtd, 3rd year (M2), Enseirb, Bordeaux, France

Master: Fabien Lotte, Brain-Computer Interfaces, CM, 2h, M2 Neuroergonomics & Human Factors International Master, ISAE, Toulouse, France

Master: Léa Pillette, Virtual Reality and 3D Interaction, CM, 5h eqtd, M2 Cognitive Science, University of Bordeaux, France

Master: Léa Pillette, Knowledge and Representations, TD, 54h, 1ère année, Ecole Nationale Supérieure de Cognitique, INP, Bordeaux, France

E-learning

MOOC : Pascal Guitton & Hélène Sauzéon, Accessibilité numérique, 5 semaines, Plateforme France Université Numérique (FUN), Inria, 2ème session (1900 inscrits)

10.2.2. Supervision

PhD: Lorraine Perronnet, Combining EEG and fMRI for Neurofeedback, Université de Rennes, Sep. 2017, Anatole Lécuyer, Christian Barillot, Maureen Clerc & Fabien Lotte

PhD: Damien Clergeaud, Collaborative interaction for aerospace scenarios, Oct. 2017, Pascal Guitton

PhD: Joan Sol Roo, One Reaity, Augmenting the Human Experience through the Combination of Physical and Digital Worlds, Dec. 2017, Martin Hachet

PhD in progress: Stephanie Lees, Ulster University, UK, Assessing and Optimising Human-Machine Symbiosis through Neural signals for Big Data Analytics, since Feb. 2014, Damien Coyle, Fabien Lotte, Paul McCullagh and Liam Maguire

PhD in progress: Jelena Mladenovic, BCI user modelling for adaptive BCI training and operation, since Jan. 2016, Fabien Lotte & with Jérémie Mattout

PhD in progress: Pierre-Antoine Cinquin, Design and Experimental Validation of Accessible E-learning systems for people with cognitive disabilities, since Sept. 2016, Pascal Guitton & Hélène Sauzéon

PhD in progress: Léa Pillette, Redefining Formative Feedback in Brain-Computer Interface User Training, since Oct. 2016, Fabien Lotte & Bernard N'Kaoua

PhD in progress: Aurélien Appriou, Estimating learning-related mental states from EEG signals, since Oct. 2017, Fabien Lotte

PhD in progress: Philippe Giraudeau, One Reality, Augmented Reality and Tangible Interaction to support Collaborative Learning, since Oct. 2017, Martin Hachet

PhD in progress: Stephanie Rey, Design and evaluation of a tool for personalized museum visits, Bourse CIFRE with Berger-Levrault, joint supervision by Anke Brock & Nadine Couture

PhD in progress: Rajkumar Darbar, Actuated Tangible User Interfaces, since Dec. 2017, Martin Hachet

10.2.3. Juries

- PhD (Reviewer): Paul Issartel, Université Paris Sud, Saclay, 2017 April 3rd, Martin Hachet
- PhD (Reviewer): Mariacarla Memeo, University of Genova and Italian Institute of Technology, April 2017, Anke Brock
- PhD (Reviewer): Jean-Baptiste Barreau, INSA Rennes, 2017 July 10th, Pascal Guitton
- PhD (Reviewer): Kireth Dhindsa, McMaster University, Canada, 2017 Aug., Fabien Lotte
- PhD (Reviewer): Lonni Besançon, Université Paris Sud, Saclay, 2017 Dec. 14th, Martin Hachet
- PhD (Jury member): Cecilia Lindig-Leon, University of Lorraine, France, Jan. 2017, Fabien Lotte
- PhD (Jury member): Philippe Roussille, Université Toulouse 3 ()IRIT), Jan. 2017, Anke Brock
- PhD (Jury member): Sarah Buchanan, University of Central Florida, USA, April 7th, Martin Hachet
- PhD (comité de suivi): Fanny Grosselin,UPMC / ICM / MyBrain technologies, France, 2017, Fabien Lotte

10.3. Popularization

Duties

- Member of the Editorial board of Blog Binaire - Le Monde, Pascal Guitton

Teaching and Education

- Participation à la création du MOOC Informatique et Création Numérique, Plate-forme FUN, Anke Brock & Pascal Guitton, https://www.fun-mooc.fr/courses/inria/41014/session01/about

Talks and Hands-on

- Collaborer avec la réalité virtuelle, Pint of Sciences, Bordeaux, May 14th, Damien Clergeaud
- Demonstration of VISTE project at Colloque Robotique et Éducation 2017, Bordeaux, July 2017, Anke Brock & Jérémy Albouys
- Demonstration and presentation of VISTE project at Fête de la science, Oct 2017, Jérémy Albouys
- Demonstration and presentation of VISTE project at Nuits des chercheurs at Cap Sciences, Oct. 2017, Jérémy Albouys
- Collaborative Interaction in Virtual Reality, Airbus PhD's Days, Saint Médard en Jalles, Nov. 8th, Damien Clergeaud
- La Table de Shanghai, Open Lab FACTS Festival, Nov. 14-25th
- Organization of an Hackathon on Cognitive Science and Artificial Intelligence at Bordeaux, Dec 9-10th, Philippe Giraudeau
- Interview, Martin Hachet, Inriality, https://www.inriality.fr/culture-loisirs/se-divertir-en-2067/
- Interview, Martin Hachet, RFI - autour de la question, http://www.rfi.fr/emission/20171113-comment-imaginer-notre-futur
- Interview, Martin Hachet, Libération, http://next.liberation.fr/musique/2017/01/27/un-nouveau-chant-de-vision_1544507

Popularizing inside Inria

- Comment favoriser l'accessibilité numérique, Unithé ou Café, Bordeaux, April 6th, Pascal Guitton
- Teegi, 50th anniversary Inria, Nov 7-8, Paris, Philippe Giraudeau, Martin Hachet

Written, Oral or Video Content

- "Fabien Lotte about his goal to improve BCI usability", g.tec medical engineering blog, http://blog.gtec.at/interview-fabien-lotte/, 2017
- Interview about VISTE project for LUDOVIAMAGAZINE : https://www.youtube.com/watch?v=Hdw5O0myifY, Anke Brock

11. Bibliography

Major publications by the team in recent years

[1] J. Frey, M. Daniel, J. Castet, M. Hachet, F. Lotte. *Framework for Electroencephalography-based Evaluation of User Experience*, in "CHI '16 - SIGCHI Conference on Human Factors in Computing System", San Jose, United States, ACM (editor), May 2016 [*DOI :* 10.1145/2858036.2858525], https://hal.inria.fr/hal-01251014

[2] J. Frey, R. Gervais, S. Fleck, F. Lotte, M. Hachet. *Teegi: Tangible EEG Interface*, in "UIST-ACM User Interface Software and Technology Symposium", Honolulu, United States, ACM, October 2014, https://hal.inria.fr/hal-01025621

[3] D. Furio, S. Fleck, B. Bousquet, J.-P. Guillet, L. Canioni, M. Hachet. *HOBIT: Hybrid Optical Bench for Innovative Teaching*, in "CHI'17 - Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems", Denver, United States, May 2017 [*DOI :* 10.1145/3025453.3025789], https://hal.inria.fr/hal-01455510

[4] M. Hachet, J.-B. De La Rivière, J. Laviole, A. Cohé, S. Cursan. *Touch-Based Interfaces for Interacting with 3D Content in Public Exhibitions*, in "IEEE Computer Graphics and Applications", March 2013, vol. 33, n^{o} 2, pp. 80-85 [*DOI :* 10.1109/MCG.2013.34], http://hal.inria.fr/hal-00789500

[5] J. Jankowski, M. Hachet. *A Survey of Interaction Techniques for Interactive 3D Environments*, in "Eurographics 2013 - STAR", Girona, Spain, May 2013, https://hal.inria.fr/hal-00789413

[6] C. Jeunet, B. N'Kaoua, F. Lotte. *Advances in User-Training for Mental-Imagery Based BCI Control: Psychological and Cognitive Factors and their Neural Correlates*, in "Progress in brain research", February 2016, https://hal.inria.fr/hal-01302138

[7] F. Lotte, F. Larrue, C. Mühl. *Flaws in current human training protocols for spontaneous Brain-Computer Interfaces: lessons learned from instructional design*, in "Frontiers in Human Neurosciences", September 2013, vol. 7, n^{o} 568 [*DOI :* 10.3389/FNHUM.2013.00568], http://hal.inria.fr/hal-00862716

[8] J. Sol Roo, R. Gervais, J. Frey, M. Hachet. *Inner Garden: Connecting Inner States to a Mixed Reality Sandbox for Mindfulness*, in "CHI '17 - International Conference of Human-Computer Interaction", Denver, United States, CHI '17, ACM, May 2017 [*DOI :* 10.1145/3025453.3025743], https://hal.archives-ouvertes.fr/hal-01455174

[9] J. SOL ROO, M. HACHET. *One Reality: Augmenting How the Physical World is Experienced by combining Multiple Mixed Reality Modalities*, in "UIST 2017 - 30th ACM Symposium on User Interface Software and Technology", Quebec City, Canada, ACM, October 2017 [*DOI :* 10.1145/3126594.3126638], https://hal.archives-ouvertes.fr/hal-01572490

Publications of the year

Articles in International Peer-Reviewed Journals

[10] T. FOVET, J.-A. MICOULAUD-FRANCHI, F.-B. VIALATTE, F. LOTTE, C. DAUDET, J.-M. BATAIL, J. MATTOUT, G. WOOD, R. JARDRI, S. ENRIQUEZ-GEPPERT, T. ROS. *On assessing neurofeedback effects: should double-blind replace neurophysiological mechanisms?*, in "Brain - A Journal of Neurology ", 2017, vol. 140, n^{o} 10, e63 p. , Issue Section: Letters to the Editor [*DOI :* 10.1093/BRAIN/AWX211], https://hal.inria.fr/hal-01658935

[11] S. M. GIRAUD, A. BROCK, M. J.-M. MACÉ, C. JOUFFRAIS. *Map Learning with a 3D Printed Interactive Small-Scale Model: Improvement of Space and Text Memorization in Visually Impaired Students*, in "Frontiers in Psychology", June 2017, vol. 8, n^{o} 930, 10 p. [*DOI :* 10.3389/FPSYG.2017.00930], https://hal.inria.fr/hal-01537596

[12] P. GUITTON, P. NAIN, F. X. SILLION. *Inria: From Cold War Computing to Digital Sciences*, in "IEEE Computer Society", August 2017, vol. 50, n^{o} 8, pp. 8-12 [*DOI :* 10.1109/MC.2017.3001238], https://hal.inria.fr/hal-01614162

[13] S. LEES, N. DAYAN, H. CECOTTI, P. MCCULLAGH, L. MAGUIRE, F. LOTTE, D. COYLE. *A Review of Rapid Serial Visual Presentation-based Brain-Computer Interfaces*, in "Journal of Neural Engineering", 2017, pp. 1-39 [*DOI :* 10.1088/1741-2552/AA9817], https://hal.inria.fr/hal-01657643

[14] L. PERRONNET, A. LÉCUYER, M. MANO, E. BANNIER, F. LOTTE, M. CLERC, C. BARILLOT. *Unimodal Versus Bimodal EEG-fMRI Neurofeedback of a Motor Imagery Task*, in "Frontiers in Human Neuroscience", April 2017, vol. 11 [*DOI :* 10.3389/FNHUM.2017.00193], https://hal.inria.fr/hal-01519755

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International Conferences with Proceedings

[16] M. AGOR, A. CLÉE, D. CLERGEAUD, M. HACHET. *Human-Drones Interaction for Gravity-Free Juggling*, in "29ème conférence francophone sur l'Interaction Homme-Machine", Poitiers, France, AFIHM (editor), AFIHM, August 2017, 6 p. , TEC - Travaux en Cours [*DOI :* 10.1145/3132129.3132163], https://hal.archives-ouvertes.fr/hal-01578341

[17] *Best Paper*
A. BROCK, B. HECHT, B. SIGNER, J. SCHÖNING. *Bespoke Map Customization Behavior and Its Implications for the Design of Multimedia Cartographic Tools*, in "MUM 2017 - 16th International Conference on Mobile and Ubiquitous Multimedia", Stuttgart, Germany, November 2017, pp. 1-11, Honorable Mention Award, https://hal-enac.archives-ouvertes.fr/hal-01649814.

[18] D. CLERGEAUD, P. GUITTON. *Design of an annotation system for taking notes in virtual reality*, in "3DTV-CON 2017 : 3DTV Conference 2017: Research and Applications in Future 3D Media", Copenhague, Denmark, June 2017, 4 p. , https://hal.archives-ouvertes.fr/hal-01536680

[19] D. CLERGEAUD, P. GUITTON. *Pano: Design and Evaluation of a 360° Through-the-Lens Technique*, in "2017 IEEE Symposium on 3D User Interfaces (3DUI)", Los Angeles, United States, March 2017, pp. 2 - 11 [*DOI :* 10.1109/3DUI.2017.7893311], https://hal.archives-ouvertes.fr/hal-01505260

[20] D. CLERGEAUD, J. SOL ROO, M. HACHET, P. GUITTON. *Towards Seamless Interaction between Physical and Virtual Locations for Asymmetric Collaboration*, in "VRST 2017 - 23rd ACM Symposium on Virtual Reality Software and Technology", Gothemburg, Sweden, November 2017, pp. 1-5 [*DOI :* 10.1145/3139131.3139165], https://hal.archives-ouvertes.fr/hal-01649262

[21] T. CRESPEL, B. RIDEL, C. RIGAUD, A. BROCK, P. REUTER. *Code the Globe: Interactive Content for Spherical Displays with simple Webpages*, in "PerDis'17 - The 6th ACM International Symposium on Pervasive Displays", Lugano, Switzerland, ACM, June 2017, https://hal.inria.fr/hal-01523744

[22] S. FLECK, C. BARAUDON, J. FREY, T. LAINÉ, M. HACHET. *"Teegi, He's so cute" : Example of pedagogical potential testing of an interactive tangible interface for children at school*, in "29ème conférence francophone sur l'Interaction Homme-Machine", Poitiers, France, AFIHM (editor), ACM, August 2017, 12 p. [*DOI :* 10.1145/3132129.3132143], https://hal.archives-ouvertes.fr/hal-01578637

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[24] *Best Paper*
D. FURIO, S. FLECK, B. BOUSQUET, J.-P. GUILLET, L. CANIONI, M. HACHET. *HOBIT: Hybrid Optical Bench for Innovative Teaching*, in "CHI'17 - Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems", Denver, United States, May 2017 [*DOI :* 10.1145/3025453.3025789], https://hal.inria.fr/hal-01455510.

[25] F. LOTTE, C. JEUNET. *Online classification accuracy is a poor metric to study mental imagery-based bci user learning: an experimental demonstration and new metrics* , in "7th International BCI Conference", Graz, Austria, September 2017, https://hal.archives-ouvertes.fr/hal-01519478

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[27] J. MLADENOVIĆ, J. FREY, M. BONNET-SAVE, J. MATTOUT, F. LOTTE. *The Impact of Flow in an EEG-based Brain Computer Interface*, in "7th International BCI Conference", Graz, Austria, September 2017, https://arxiv.org/abs/1706.01728 , https://hal.inria.fr/hal-01527748

[28] J. MLADENOVIĆ, M. JOFFILY, J. FREY, F. LOTTE, J. MATTOUT. *Endowing the Machine with Active Inference: A Generic Framework to Implement Adaptive BCI*, in "NeuroAdaptive Technology Conference '17", Berlin, Germany, July 2017, https://hal.inria.fr/hal-01527752

[29] L. PILLETTE, C. JEUNET, B. MANSENCAL, R. N 'KAMBOU, B. N 'KAOUA, F. LOTTE. *PEANUT: Personalised Emotional Agent for Neurotechnology User-Training*, in "7th International BCI Conference", Graz, Austria, September 2017, https://hal.archives-ouvertes.fr/hal-01519480

[30] *Best Paper*
J. S. ROO, M. HACHET. *Towards a Hybrid Space Combining Spatial Augmented Reality and Virtual Reality*, in "3DUI - IEEE Symposium on 3D User Interfaces", Los Angeles, United States, 3DUI 17, IEEE, March 2017, https://hal.archives-ouvertes.fr/hal-01453385.

[31] S. REY. *Museomix: lessons learned from an open creative hackathon in museums*, in "European Tangible Interaction Studio (ETIS 2017)", Esch/Alzette, Luxembourg, D. ANASTASIOU, V. MAQUIL (editors), CEUR Workshop Proceedings - Proceedings of the 3rd European Tangible Interaction Studio (ETIS 2017), Dimitra Anastasiou and Valérie Maquil, June 2017, vol. 1861, 5 p. , https://hal.inria.fr/hal-01550565

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J. SOL ROO, R. GERVAIS, J. FREY, M. HACHET. *Inner Garden: Connecting Inner States to a Mixed Reality Sandbox for Mindfulness*, in "CHI '17 - International Conference of Human-Computer Interaction", Denver, United States, CHI '17, ACM, May 2017 [*DOI :* 10.1145/3025453.3025743], https://hal.archives-ouvertes.fr/hal-01455174.

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[35] A. BROCK, M. HACHET. *Teaching spatial thinking to visually impaired students using augmented reality: Introducing the VISTE project*, in "GET'17 - Journées Multimédia, Géomatique, Enseignement & Apprentissage", Toulouse, France, January 2017, https://hal.inria.fr/hal-01449886

[36] D. CLERGEAUD, P. GUITTON. *Conception d'un système d'annotation pour prendre des notes en réalité virtuelle*, in "Journées de l'AFRV", Rennes, France, October 2017, https://hal.archives-ouvertes.fr/hal-01627007

Scientific Books (or Scientific Book chapters)

[37] J. DUCASSE, A. BROCK, C. JOUFFRAIS. *Accessible Interactive Maps for Visually Impaired Users*, in "Mobility in Visually Impaired People - Fundamentals and ICT Assistive Technologies", E. PISSALOUX, R. VELAZQUEZ (editors), Springer, 2018, https://hal.inria.fr/hal-01515347

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Theoretical Advances", C. S. NAM, A. NIJHOLT, F. LOTTE (editors), CRC Press , 2018, forthcoming, https://hal.inria.fr/hal-01620186

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[40] J. MLADENOVIĆ, J. MATTOUT, F. LOTTE. *A generic framework for adaptive EEG-based BCI training and operation*, in "Brain-Computer Interfaces Handbook: Technological and Theoretical Advances", C. S. NAM, A. NIJHOLT, F. LOTTE (editors), Brain-Computer Interfaces Handbook: Technological and Theoretical Advances, CRC Press: Taylor & Francis Group, June 2017, vol. 1, https://hal.inria.fr/hal-01542504

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[45] P. GIRAUDEAU, M. HACHET. *Towards a Mixed-Reality Interface for Mind-Mapping*, October 2017, pp. 1-6, ACM ISS 2017 - Interactive Surfaces and Spaces, Poster [*DOI :* 10.1145/3132272.3132275], https://hal.inria.fr/hal-01649725

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