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Activity Report 2015

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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Other Research Topics and Application Domains:

1.3. - Neuroscience and cognitive science
2.5. - Handicap and personal assistances
8.5. - Smart society
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9.7. - Knowledge dissemination

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Robin Gourdel [granted by SATT Nancy Grand-Est, from Sep 2015]
Jeremy Laviole [Inria, granted by Inria ADT Artik]

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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.

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 novice 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.

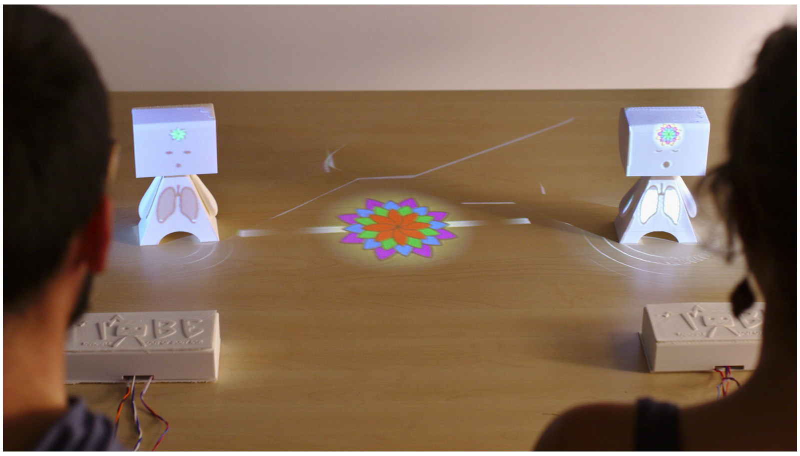

Figure 1. Tobe combines tangible interaction, spatial augmented reality, and physiological computing. It allows users to feel and explore their inner states.

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.

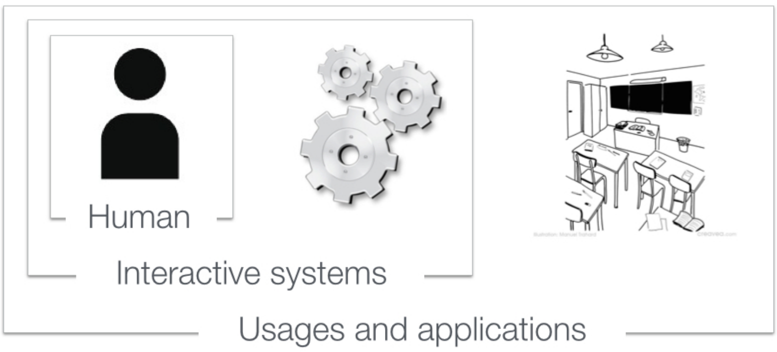

Figure 2. The three axes of the potioc team objectives.

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 contributions 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 little studied. 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 in the creation of tools that are accessible to non-expert users.

3.2.2. Evaluating 3DUIs 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 3DUI, 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.

3.3. 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 mouse/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.

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. Popularization of science

Popularization of science is at the core of the motivations of the Potioc group. 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.

3.4.2. Education

Education is also a key domain for Potioc. 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. In the future, we will continue exploring new interactive approaches dedicated to education, in various fields.

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 benefit to 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 beleive 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. Popularization of science, education, 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

- popularization of science
- education
- 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

- Fabien Lotte obtained the ANR project REBEL (JCJC, acceptance rate 9.7%). More details in Section 9.2
- We have conceived a new system that aims at teaching Optics in an innovative way (Patent pending). This system mixes spatial augmented reality and tangible interaction. It is currently evaluated based on a panel of more than one hundred students. This work is conducted in collaboration with experts in Optics and Electronics (Univ. Bordeaux), and Education Sciences (Univ. Lorraine). More details in Section 7.6.

5.1.1. Awards

IFRATH PhD Award, First Prize ex-aequo with J. Veytizou, Institut Fédératif de Recherche sur les Aides Techniques pour personnes Handicapées, June 2015 (Anke Brock)

BEST PAPERS AWARDS:

[39]
C. JEUNET. *Training Users' Spatial Abilities to Improve Brain-Computer Interface Performance: A Theoretical Approach*, in "Colloque des Jeunes Chercheurs en Sciences Cognitives", Compiègne, France, June 2015, https://hal.inria.fr/hal-01162411

[27]
J. FREY. *Heart Rate Monitoring as an Easy Way to Increase Engagement in Human-Agent Interaction*, in "PhyCS - International Conference on Physiological Computing Systems", Angers, France, SCITEPRESS, February 2015, https://hal.inria.fr/hal-01090544

6. New Software and Platforms

6.1. OpenVIBE

KEYWORDS: Neurosciences - Interaction - Virtual reality - Health - Real time - Neurofeedback - Brain-Computer Interface - EEG - 3D interaction

FUNCTIONAL DESCRIPTION

OpenViBE is a software platform for real-time neurosciences (that is, for real-time processing of brain signals). It can be used to acquire, filter, process, classify and visualize brain signals in real time from various signal sources. OpenViBE is free and open source software. It works on Windows and Linux operating systems.

- Participants: Yann Renard, Anatole Lécuyer, Fabien Lotte, Bruno Renier, Vincent Delannoy, Laurent Bonnet, Baptiste Payan, Jozef Legény, Jussi Tapio Lindgren, Alison Cellard, Loïc Mahé, Guillaume Serriere, Marsel Mano, Maureen Clerc Gallagher, Théodore Papadopoulo, Laurent Bougrain, Jérémy Frey, Nathanael Foy
- Partners: INSERM - CEA-List - GIPSA-Lab
- Contact: Anatole Lécuyer
- URL: http://openvibe.inria.fr

In 2015, the first stable version of the OpenViBE software, OpenViBE version 1.0.0, was released. OpenViBE 1.0.0 features lots of fixes for stability and usability. There has been a significant effort in cleanup and removal of unused components and dead code. This version introduces more tools for communicating with other software, added support for some new, emerging acquisition systems, such as OpenBCI and new signal processing algorithms such as Wavelet decomposition and artifact removal boxes. Link: http://openvibe.inria.fr/openvibe-1-0-0-has-been-released/

6.2. Platforms

6.2.1. AMI

Augmented Michelson Interferometer

SCIENTIFIC DESCRIPTION

We have developed a hybrid plateform that merges physical and virtual elements for teaching optics. This work is described in more details in Section 7.6

- Participants: David Furio, Martin Hachet, Patrick Reuter and Bruno Bousquet
- Partners: Université de Bordeaux - LaBRI
- Contact: Martin Hachet
- URL: https://team.inria.fr/potioc/fr/2015/06/30/hobit-hybrid-optical-bench-for-innovative-teaching

7. New Results

7.1. Pointing in Spatial Augmented Reality from 2D Pointing Devices

Participants: Renaud Gervais, Jérémy Frey, Martin Hachet.

Spatial Augmented Reality (SAR) opens interesting perspectives for new generations of mixed reality applications. Compared to traditional human-computer interaction contexts, there is little work that studies user performance in SAR. In this project, we present an experiment that compares pointing in SAR versus pointing in front of a screen, from standard pointing devices (mouse and graphics tablet). The results showed that the participants tend to interact in SAR in a way that is similar to the screen condition, without a big loss of performance [30] (See Figure 3).

Figure 3. A user reaches a target displayed on a spatially augmented object with an indirect input device

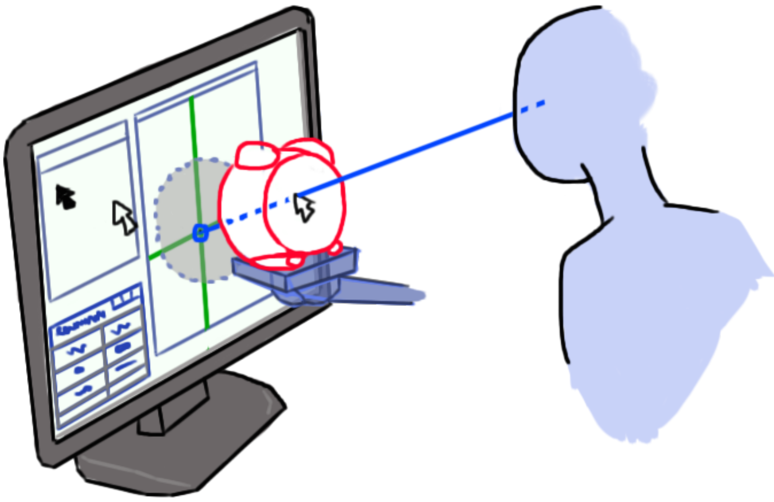

Figure 4. A user interacts with an object located in front of the screen as if the object was rendered on screen

7.2. Tangible Viewports

Participants: Renaud Gervais, Joan Sol Roo, Martin Hachet.

Spatial augmented reality and tangible interaction enrich the standard computer I/O space. Systems based on such modalities offer new user experiences and open up interesting perspectives in various fields. On the other hand, such systems tend to live outside the standard desktop paradigm and, as a consequence, they do not benefit from the richness and versatility of desktop environments. In this work, we propose to join together physical visualization and tangible interaction within a standard desktop environment. We introduce the concept of Tangible Viewport, an on-screen window that creates a dynamic link between augmented objects and computer screens, allowing a screen-based cursor to move onto the object in a seamless manner (Figure 4). We describe an implementation of this concept and explore the interaction space around it. A preliminary evaluation shows that the metaphor is transparent to the users while providing the benefits of tangibility [31].

7.3. Tobe

Participants: Renaud Gervais, Jérémy Frey, Alexis Gay, Fabien Lotte, Martin Hachet.

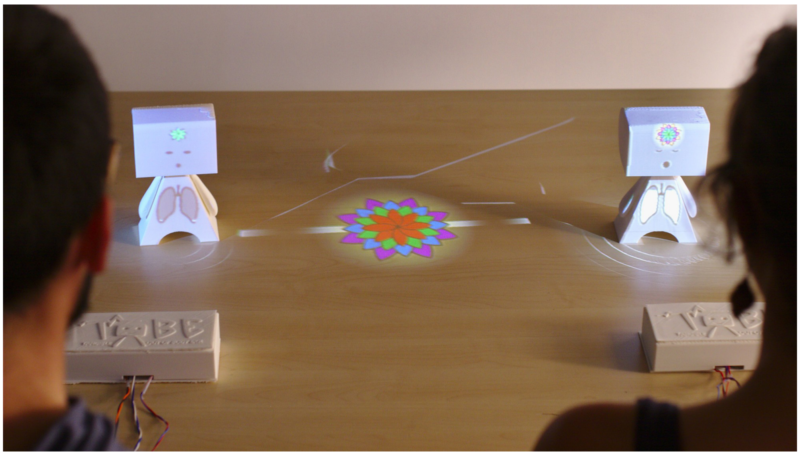

Figure 5. Two users are relaxing together using Tobe as a biofeedback for heartrate and breathing

We propose Tobe, a toolkit for creating Tangible Out-of-Body Experiences: exposing the inner states of users using physiological signals such as heart rate or brain activity. Tobe can take the form of a tangible avatar displaying live physiological readings to reflect on ourselves and others. Such a toolkit could be used by researchers and designers to create a multitude of potential tangible applications, including (but not limited to) educational tools about Science Technologies Engineering and Mathematics (STEM) and cognitive science, medical applications or entertainment and social experiences with one or several users or Tobes involved. Through a co-design approach, we investigated how everyday people picture their physiology and we validated the acceptability of Tobe in a scientific museum. We also give a practical example where two users relax together, with insights on how Tobe helped them to synchronize their signals and share a moment, as illustrated in Figure 5 [29].

7.4. Inner Garden

Participants: Joan Sol Roo, Renaud Gervais, Martin Hachet.

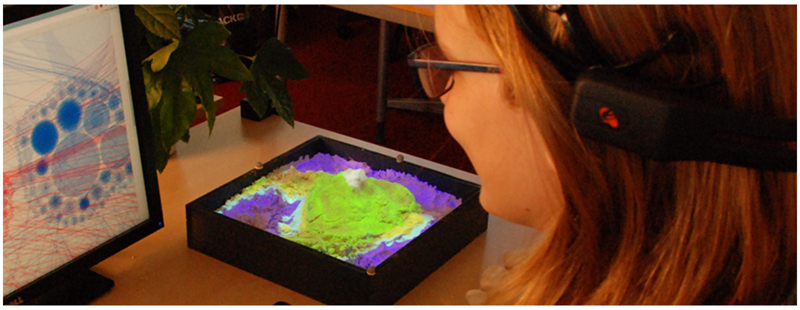

Figure 6. Inner garden is an augmented sandbox which depicts an evolving world reflecting the inner state of the user

We present a prototype of an augmented sandbox where the sand is used to create a miniature living world, designed as an ambient display for contemplation and self-reflection. The landscape can be reshaped at any time. Once the sand is left still for a moment, the world starts evolving – vegetation grows, water flows and creatures move around – according to the user's internal state. We use a consumer-grade EEG and breathing sensors to reflect on frustration and meditative states of users, which they can monitor by looking at the sandbox (Figure 6) [49].

7.5. Augmented geographic maps

Participants: Julia Chatain, Marie Demangeat, Anke Brock, Martin Hachet.

Figure 7. Interacting with an augmented geographic map using tangible, spatial and multitouch interaction

Interactive geographic maps are today widely available, but remain mostly limited to standard interaction contexts. We introduce SyMAPse [48], a spatial augmented reality map, based on the PapARt framework. In our prototype, we use augmented reality to display a virtual map on a physical piece of paper, thus keeping features of both media. Thanks to the digital map base, users can pan, zoom and even change the basemap. At the same time, the paper base allows users to manipulate the map physically and so to interact in a more “natural” way, as well as to draw on the paper using regular pens. In a preliminary study with visitors of the "Cap Sciences" science center, we compared interaction techniques based on touch, tangible and spatial modalities for these three common map functions: zooming, panning, and changing the basemap. Our results suggest that object-based and spatial interaction may be advantageous over touch in our augmented reality setup.

7.6. HOBIT - Hybrid Optical Bench for Innovative Teaching

Participants: David Furio, Benoit Coulais, Martin Hachet.

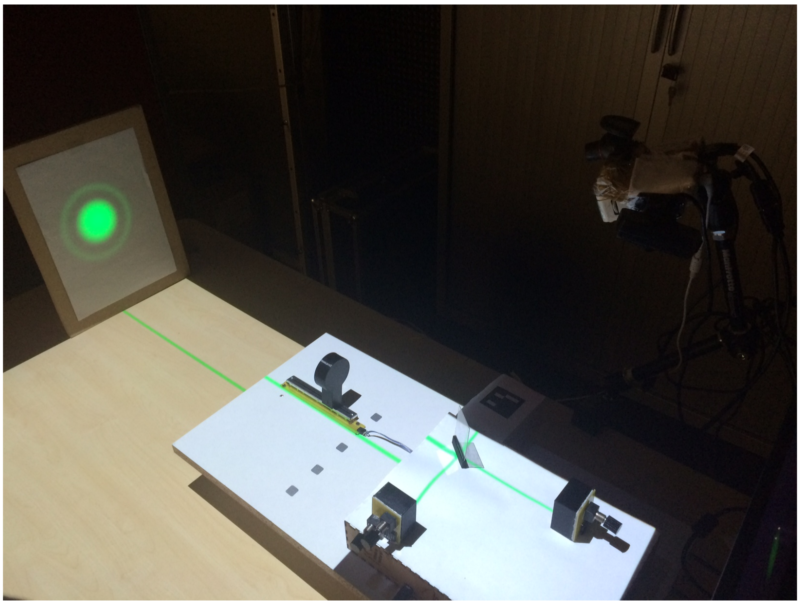

Figure 8. HOBIT mixes physical and virtual elements to teach optics.

Experiments in optics are essential for learning and understanding physical phenomena. The problem with these experiments is that they are generally time consuming for both their construction and their maintenance, potentially dangerous through the use of laser sources, and often expensive due to high technology optical components. We propose to simulate such experiments by using hybrid systems that exploit both spatial augmented reality and tangible interaction (See Figure 8). In particular, we focus on one of the most popular optical experiments: Michelson interferometer. In our approach, we target a highly interactive system where students are able to interact in real time with the Augmented Michelson Interferometer (AMI) to observe, test hypotheses and then to enhance their comprehension. Compared to a fully digital simulation, we are investigating an approach that benefits from both physical and virtual elements, and where the students experiment by manipulating 3D-printed physical replicas of optical components (e.g. lenses and mirrors). Our objective is twofold. First, we want to ensure that the students will learn with our simulator the same concepts and skills that they learn with traditional methods. Second, we hypothesis that such a system opens new opportunities to teach optics in a way that was not possible before, by manipulating concepts beyond the limits of observable physical phenomena. To reach this goal, we have built a complementary team composed of experts in the field of optics, human-computer interaction, computer graphics, sensors and actuators, and education science. HOBIT is a joint project between Inria and Université de Bordeaux (Idex CPU – LAPHIA), in collaboration with Université de Lorraine (team PErSEUs). [28]

7.7. Mixed Reality to improve children's interaction with astronomical concepts

Participant: Martin Hachet.

This project stands on a collaboration with Stéphanie Fleck from Université de Lorraine. To make astronomical learning more efficient for young pupils, we have designed an Augmented Inquiry-Based Learning Environment (AIBLE): HELIOS. Because manipulations in astronomy are intrinsically not possible, we propose to manipulate the underlying model. With HELIOS, virtual replicas of the sun, moon and earth are directly manipulated from tangible manipulations. This digital support combines the possibilities of Augmented Reality (AR) while maintaining intuitive interactions following the principles of didactic of sciences. Light properties are taken into account and shadows of Earth and Moon are directly produced by an omnidirectional light source associated to the virtual Sun. This AR environment provides users with experiences they would otherwise not be able to experiment in the physical world. Our main goal is that students can take active control of their learning, express and support their ideas, make predictions and hypotheses, and test them by conducting investigations. [24][23]

7.8. Combining and Revealing Spaces for Musical Performances

Participant: Martin Hachet.

In collaboration with University of Bristol (Florent Berthaut, Diego Martinez, and Sriram Subramanian) we have designed a mixed-reality environment for musical performances that allows for freely displaying virtual content on stage, such as 3D virtual musical interfaces or visual augmentations of instruments and performers. This environment, called Reflets, relies on spectators and performers revealing virtual objects by slicing through them with body parts or objects, and on planar slightly reflective transparent panels that combine the stage and audience spaces. It allows for placing virtual content anywhere on large stages, even overlapping with physical elements and provides a consistent rendering of this content for large numbers of spectators. It also preserves non-verbal communication between the audience and the performers, and is inherently engaging for the spectators. Reflets opens musical performance opportunities such as augmented interaction between musicians and novel techniques for 3D sound shapes manipulation [20].

7.9. Improving User-Training for Brain-Computer Interfaces

Participants: Martin Hachet, Emilie Jahanpour, Camille Jeunet, Fabien Lotte, Boris Masencal, Julia Schumacher.

While Mental Imagery based Brain-Computer Interfaces (MI-BCIs) are promising for many applications, ranging from assistive technologies for motor disabled patients to video games, their usability"out-of-the-lab" has been questioned due to their lack of reliability: literature reports that 15% to 30% of users cannot control such a technology, while most of the remaining users obtain only modest performances. As controlling an MI-BCI requires the acquisition of specific skills (i.e., producing stable and distinct brain-activity patterns), an adapted training is necessary. Thus, the main objective of our project is to improve the user training to facilitate the acquisition of MI-BCI related skills. In order to do so, we focused on two axes [18]: (1) the impact of the user-profile and (2) the impact of the protocol on MI-BCI performance.

Concerning the impact of the user-profile, our results ([40], [14]) suggested an important impact of some aspects of the personality (such as the tension and autonomy levels) as the spatial abilities (i.e., the ability to produce, interpret and transform mental imageries). On the one hand, we are working on learning companions, whose goal would be to provide the learners with a specific emotional support, based on their profile and on their cognitive state. On the other hand, we are currently implementing and testing a spatial ability training in order to test the hypothesis of a causal effect of the spatial abilities on MI-BCI performance [39]. In other words, we would like to know if increasing spatial abilities would result in better MI-BCI performance. One application of such a research is stroke rehabilitation. Indeed, motor after-effects are usual following a stroke. MI-BCI have been shown very useful to facilitate the rehabilitation process, which consists in enhancing brain plasticity through motor-imagery, as they enable to visualise the BCI activity while the patients perform MI-tasks. However, MI-tasks tend to increase the depressive state of the patients as they remind them they lost the ability to move their limb. Thus, as spatial ability exercises (e.g., mental rotation) activate the motor cortex, they could be used as more transparent rehabilitation exercises to trigger brain plasticity.

Second, concerning the impact of the protocol, we completed a study (see activity report 2014) in which we asked the participants to use the standard MI-BCI training protocol to learn to perform simple motor tasks: drawing circles and triangles on a graphic tablet. As it would have been the case for an MI-BCI experiment, they had to find the right strategy so that the system recognises the task they were performing. Seventeen percent of the participants (N=54) showed difficulties in performing these tasks. Also, when we selected the 10 best and 10 worst performers of this experiment and asked them to use an MI-BCI (by imagining left and right-han movements), it appeared that the ones who had difficulties in performing the simple motor tasks improved in terms of performance during the MI-BCI experiment, while the participants who performed well during the motor experiment did not progress during the second. Furthermore, we have shown that tactile feedback was more efficient than an equivalent visual feedback in a multitasking context [32]. Based on a literature review, this could be due to an increased sense of agency (i.e., the feeling to be in control). We are thus currently exploring the impact of the sense of agency on MI-BCI performance. Finally, still regarding the feedback, we explored what kind of information could help the user to perform better mental imagery tasks. As such, we look for physiological features that could predict whether a mental task will be correctly recognized by the BCI, and that could be understood by the user. Among the different features we explored, it appears that the user's relaxation (from a muscular point of view), as measured in EMG activity collected by EEG channels, is one of such features. We are currently building and exploring new BCI training protocols that provide additional information about the user's muscular relaxation as complementary feedback [34].

7.10. EEG Signal Processing

Participant: Fabien Lotte.

To make BCI practical and useful, we need to make them reliable, i.e., able to recognize the users' mental commands, despite noise and non-stationarities [42]. We also need to reduce their calibration time, as current systems needs many examples from each user to calibrate the system for this specific user. This year we addressed these two issues with two different studies.

In order to reduce BCI calibration times, we first surveyed existing approaches, these approaches being notably based on regularization, user-to-user transfer, semi-supervised learning and a-priori physiological information. We then proposed new tools to reduce BCI calibration time. In particular, we proposed to generate artificial EEG trials from the few EEG trials initially available, in order to augment the training set size. These artificial EEG trials are obtained by relevant combinations and distortions of the original trials available. We proposed 3 different methods to do so. We also proposed a new, fast and simple approach to perform user-to-user transfer for BCI. Finally, we studied and compared offline different approaches, both old and new ones, on the data of 50 users from 3 different BCI data sets. This enabled us to identify guidelines about how to reduce or suppress calibration time for BCI [16].

In order to increased BCI robustness, we performed an empirical comparison of covariance matrix averaging methods for EEG signal classification. Indeed, averaging EEG signal covariance matrices is a key step in designing brain-computer interfaces (BCI) based on the popular common spatial pattern (CSP) algorithm.

BCI paradigms are typically structured into trials and we argue that this structure should be taken into account. Moreover, the non-Euclidean structure of covariance matrices should be taken into consideration as well. We reviewed several approaches from the literature for averaging covariance matrices in CSP and compared them empirically on three publicly available data sets. Our results showed that using Riemannian geometry for averaging covariance matrices improves performances for small dimensional problems, but also the limits of this approach when the dimensionality increases [36].

7.11. ECoG-based analysis of Speech processes

Participant: Fabien Lotte.

Acoustic speech output results from coordinated articulation of dozens of muscles, bones and cartilages of the vocal mechanism. While we commonly take the fluency and speed of our speech productions for granted, the neural mechanisms facilitating the requisite muscular control are not completely understood. Previous neuroimaging and electrophysiology studies of speech sensorimotor control has typically concentrated on speech sounds (i.e. phonemes, syllables and words) in isolation; sentence-length investigations have largely been used to inform coincident linguistic processing. In this study, we examined the neural representations of segmental features in the context of fluent, continuous speech production. We used recordings from the cortical surface (electrocorticography (ECoG)) to simultaneously evaluate the spatial topography and temporal dynamics of the neural correlates of speech articulation that may mediate the generation of hypothesized gestural or articulatory scores. We found some aspects of speech production (place of articulation) involved broad networks of brain regions during all phases of speech production: preparation, execution and monitoring. Other aspects (manner of articulation and voicing status) were dominated by auditory cortical responses after speech had been initiated. These results provide a new insight into the articulatory and auditory processes underlying speech production in terms of their motor requirements and acoustic correlates (see Figure 9, [15]).

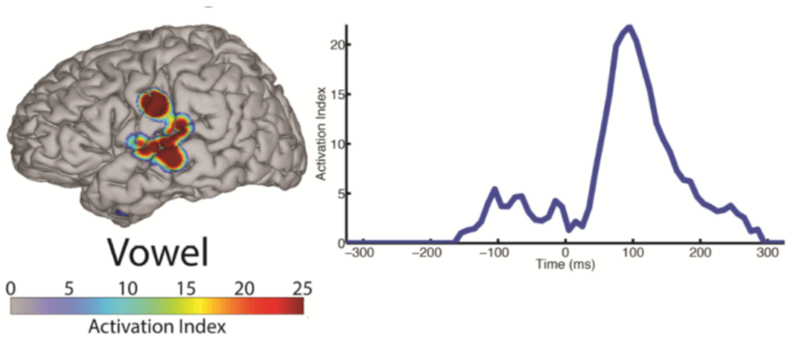

Figure 9. Exemple of the ECoG signature of vowel phonemes.

7.12. Toward a portable tangible EEG interface

Participants: Maxime Duluc, Thibault Laine, Jérémy Frey, Renaud Gervais, Fabien Lotte, Martin Hachet.

Last year we presented Teegi, the first interface that combines electroencephalographic (EEG) recordings and tangible interaction in order to let novices learn about how their brain works. By displaying EEG activity in real time on a support that is easy to manipulate and to comprehend, Teegi is a good tool for scientific outreach, that raises public interest.

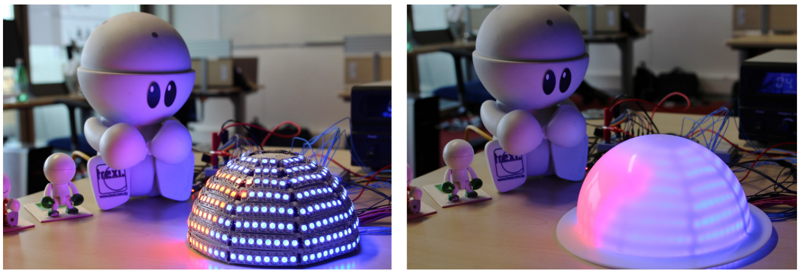

Figure 10. Development version of a portable version of Teegi, a Tangible EEG Interface. An array of LEDs and a diffuser replace the use of spatial augmented reality.

Yet, the gap between research projects and the field is not often bridged. While our past prototype used an external projector and a supplementary tracking device to display information onto the head of the puppet, over the course of the year we developed a semi-spherical display based on LEDs (see Figure 10). By embedding all the electronics into the puppet, Teegi will be easier to bring outside the laboratory. Thanks to these technological advances, real-life applications of the system are finally within reach.

7.13. Electroencephalography-based evaluation of user experience

Participants: Jérémy Frey, Maxime Daniel, Dennis Wobrock, Julien Castet, Martin Hachet, Fabien Lotte.

Designing user interfaces requires adequate evaluation tools to ensure good usability and user experience. While many evaluation tools are already available and widely used, existing approaches generally cannot provide continuous and objective measures of usability qualities during interaction without interrupting the user. On the other hand, the measure of brain activity by the mean of electroencephalography (EEG) is mature enough to assess mental states. Combined with existing methods, such tool can be used to strengthen the understanding of user experience.

In [35] we studied 3D object manipulation tasks. We showed how mental workload can be estimated from EEG, and then measured it on 8 participants during an actual 3D object manipulation task with an input device known as the CubTile (see figure 11). These first results suggested that we could continuously assess the 3DUI and/or interaction technique ease-of-use.

We pushed further these finding in a second study [26], where we have developed a set of methods to continuously estimate the user's mental workload, attention level and recognition of interaction errors during different interaction tasks. We validated these measures in a controlled virtual environment and showed how they can be used to compare different interaction techniques – for instance a keyboard and a touch-based interface (see Figure 12).

Thanks to such framework, EEG becomes a useful addition to the repertoire of available evaluation tools, enabling a finer grain assessment of the ergonomic qualities of computer systems.

7.14. Classifying EEG Signals during Stereoscopic Visualization to Estimate Visual Comfort

Participants: Jérémy Frey, Aurélien Appriou, Fabien Lotte, Martin Hachet.

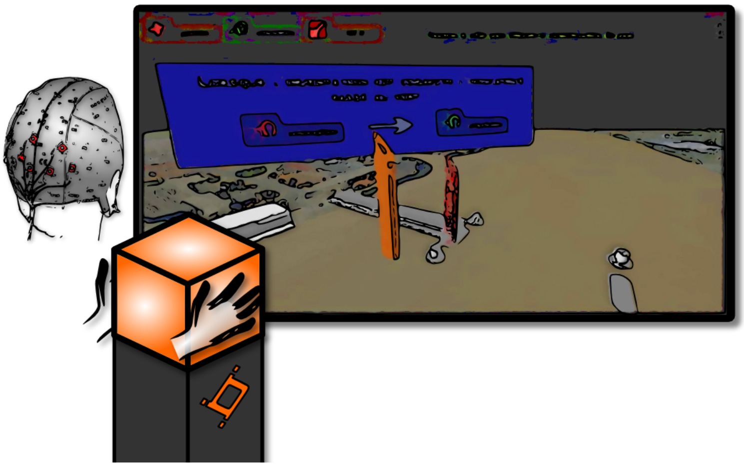

Figure 11. Schematic view of a user performing 3D manipulations tasks with the CubTile input device. His/her mental effort are monitored based on brain signals (electroencephalography).

Figure 12. A keyboard (left) can be compared with a touch interface (middle) using a continuous measure of mental workload through electroencephalography (right).

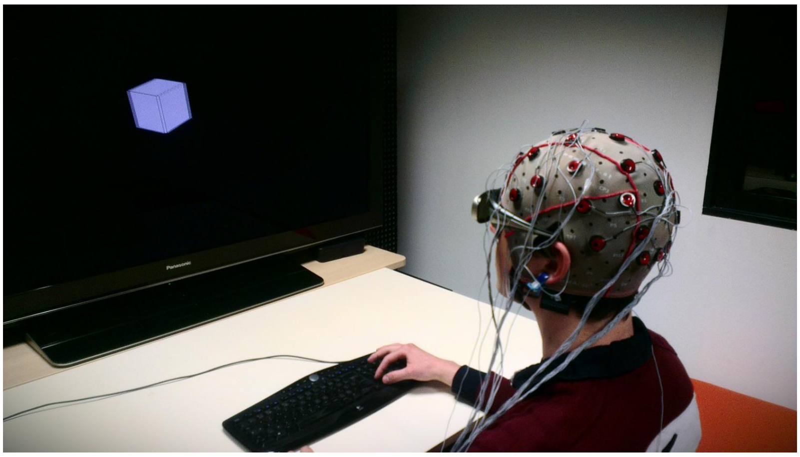

Figure 13. Setup of the experiment, with a subject being presented with stereoscopic images while his EEG signals are being recorded.

With stereoscopic displays a sensation of depth that is too strong can impede visual comfort and may result in fatigue or pain. We used Electroencephalography (EEG) to develop a novel brain-computer interface that monitors users' states in order to reduce visual strain. We present the first system that discriminates comfortable conditions from uncomfortable ones during stereoscopic vision of still images using EEG [13], [25] – see Figure 13). In particular, we show that changes in event-related potentials' (ERPs) amplitudes following stereoscopic objects presentation can be used to estimate visual comfort. Our system reacts within 1 second to depth variations, achieving 63% accuracy on average (up to 76%) and 74% on average when 7 consecutive variations are measured (up to 93%). Performances are stable (≈62.5%) when a simplified signal processing is used to simulate online analyses or when the number of EEG channels is lessened. This study could lead to adaptive systems that automatically suit stereoscopic displays to users and viewing conditions. For example, it could be possible to match the stereoscopic effect with users' state by modifying the overlap of left and rAight images according to the classifier output

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
- The Airbus company regularly uses virtual reality for design, manufacturing and maintenance (see Figure 14). 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.

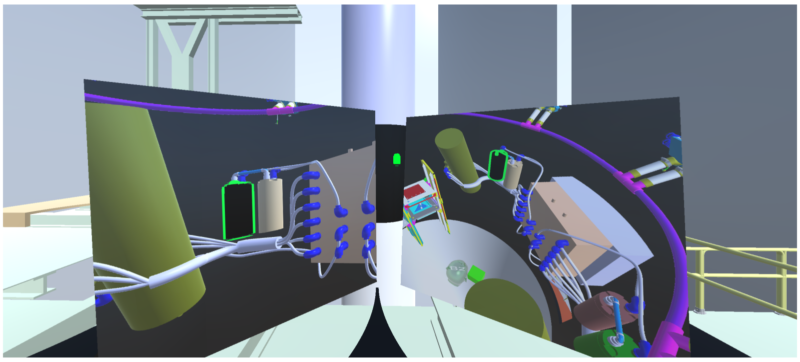

Figure 14. Example of a tool which allows to be aware of a remote place in a virtual reality application (Airbus collaboration)

9. Partnerships and Cooperations

9.1. Regional Initiatives

Inria ADT Artik:

- duration: 2014-2016
- coordinator: Jérémy Laviole & Martin Hachet
- The Artik projet is focused on the development of Papart (Paper Augmented Reality Toolkit). Papart is a toolkit that enables projector/cameras (ProCam) and depth camera to work together to create interactive surfaces. It works with comsumer-available hardware and enables tabletop interactions, although high-end cameras and projectors are also well supported. Here are the major advances of the developments of 2015: The hardware is now managed with a dedicated application, each Papart application is now hardware agnostic. Extrinsic calibration of projector / color and depth cameras can be done with any application running, the calibration processing is now below 2 minutes. The touch detection can be tweaked to fit any suface: it has been tested on a table, wall, and floor with respectively finger, hand, and foot interaction. This project relies on open source software, we also maintain the support of Maven distribution for the Processing project.
- website: https://team.inria.fr/potioc/scientific-subjects/papart/

Cap Sciences:

- Potioc has strong relationships with the Cap Sciences museum (http://www.cap-sciences.net/), especially through its Living Lab. In 2015, we have co-supervised a Master thesis on augmented interactive maps that was partly done at Cap Sciences and Inria-Potioc. We are currently investigating how this map prototype can be used in a smart city project with Cap Sciences.

Immersion:

- Potioc has strong relationships with Immersion. In 2015, Immersion and Potioc notably co-supervised a Master student (Maxime Daniel) on the topic "Évaluation de la charge de travail, de l’attention, et de la reconnaissance d’erreur dans un environnement interactif par analyse EEG".

9.2. National Initiatives

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.

HOBIT: Hybrid Optical Bench for Innovative Teaching:

- duration: 2015-2017
- funding: Idex CPU & LAPHIA, and Inria ADT
- partners: Université de Bordeaux (IUT mesures physiques) & Université de Lorraine
- The goal of the Hobit project (Hybrid Optical Bench for Innovative Teaching) is to design a hybrid optical bench that benefits from both the physical and the virtual worlds to enhance teaching and training in the field of optics and photonics.

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 (e.g. a ball on the figure). It opens new perspectives for exciting tomorrow's applications, beyond traditional screen-based applications.
- website: https://team.inria.fr/potioc/scientific-subjects/papart/

Inria ADT OpenViBE-X:

- duration: 2014-2016
- partners: Inria teams Hybrid and Athena
- coordinator: Maureen Clerc (Inria Sophia Antipolis)
- This is the follow-up project of OpenViBE-NT
- website: http://openvibe.inria.fr

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)
- Project around BCI in the evaluation process, first meeting with all the partners was in October 2013
- 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/

Helios:

- duration: 2014-2015
- partners: Université de Lorraine
- funding: SATT Nancy Grand Est
- coordinator: Stéphanie Fleck (Université de Lorraine)
- The Helios project aims to provide a methodology and innovative media for the improvement of learning of basic astronomical phenomena for school groups (8-11 years). As part of this project, Potioc will focus on the development of the final application for augmented reality based and 3D manipulation, for providing a high-fidelity prototype.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, except FP7 & H2020

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

- duration: 2014-2018
- partners: Ulster University (UK)
- funding: DGA-DSTL project
- 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.

9.3.2. Collaborations with Major European Organizations

Collaboration with the University of Sussex, Brighton, Interact Lab, UK (Head: Pr. Sriram Subramanian)

- We have strong relationships with Sriram Subramanian. This has led to joint paper publications, numerous visits and a co-supervision of a PhD thesis (Camille Jeunet).

Bordeaux Idex project "Conception de Système d'interfaces cerveau-ordinateur prenant en compte les facteurs humains afin d'optimiser l'apprentissage de l'utilisateur" for international PhD project

- partners: Bordeaux Segalen University (Handicap & Système nerveux team), Bristol University (BIG team)
- duration: October 2013 - September 2016

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Pr. Roger N'KAMBOU, department of Computer Sciences at the UQAM (Université du Québec à Montréal) who is a specialist of Intelligent Tutoring Systems (ITS). We are collaborating with him to develop such a system in order to optimise human learning in Brain-Computer Interfaces (BCI), and thus improve the performances with such systems.
- We are collaborating with Dr. Cuntai Guan (I2R, Singapore), Pr. Jonathan Bromberg (Kansas University, USA) and Pr. Gerwin Schalk (Wadsworth center, USA) on ElectroCorticoGraphic (ECoG) signal analysis.
- We are collaborating with Prof. Johannes Schoening (Univ. Hasselt, Belgium), Prof. Beat Signer (Vrije Universiteit Brussel, Belgium) and Dr. Brent Hecht (University of Minnesota, USA) on customization of geographic maps.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Pr. Pierre Dillenbourg, EPFL, visited team Potioc in April, 2015
- Dr. Thorsten Zander, group leader at TU Berlin, Germany, visited team Potioc from November to December 2015 with two of his students (Lena M. Andreessen and Laurens R. Krol)
- Pr. Sriram Subramanian, University of Sussex, visited team Potioc in December 2015

9.5.2. Visits to International Teams

9.5.2.1. Research stays abroad

- Jérémy Frey was working at the INRS in Montreal, Canada, in the MuSAE (Multimedia/Multimodal Signal Analysis and Enhancemen) laboratory of Prof. Tiago H. Falk, from October to November 2015
- Camille Jeunet was working at the University of Sussex, Brighton, UK, in the Interact Lab of Pr. Sriram Subramanian, from November 2015 to January 2016.
- Fabien Lotte was working at the Sugiyama Laboratory, The University of Tokyo, Japan, from July to August 2015

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific events organisation

10.1.1.1. Member of the organizing committees

- Workshop organizer Interco3D (workshop on 3D Interaction & Cognition), ACM IHM conference, Toulouse, October 2015 (Anke Brock & Fabien Lotte)
- Doctoral Consortium, ACM IHM conference, Toulouse, October 2015 (Anke Brock)
- Panel Chair, ACM womENcourage conference, Uppsala, Sweden, September 2015 (Anke Brock)
- Workshop Organizer "Accessible Interaction for Visually Impaired People", MUC'15, Stuttgart, Germany, September 2015 (Anke Brock)
- Workshop co-organizer "Affective Brain-Computer Interface", ACII 2015, Xi'an, China (Fabien Lotte)
- Special session on "Robust EEG signal processing towards practical BCI design" at EUSIPCO 2015, Nice, France (Fabien Lotte)
- Special session on "user training" in the BCI workshop at the SMC2015 conference, Hong Kong, October 2015 (Fabien Lotte & Camille Jeunet)
- 4th Sino-French Workshop on Virtual Reality Co-organizer, Xi'an, August 2015 (Pascal Guitton)

10.1.2. Scientific events selection

10.1.2.1. Member of the conference program committees

- ACII 2015: Program Committee Member (Fabien Lotte)
- Assets'15: Poster Committee Member (Anke Brock)
- Augmented Humans 2016: Program Committee Member (Fabien Lotte)
- CAA 2015: Program Committee Member (Pascal Guitton)
- CHI 2015: Program Committee Member (Martin Hachet)
- EUSIPCO 2015: Program Committee Member (Fabien Lotte)
- IEEE 3DUI: Best paper award Committee (Martin Hachet)
- IEEE SMC 2015: Program Committee Member (Fabien Lotte, Camille Jeunet)
- International Winter Conference on Brain-Computer Interfaces: Program Committee Member (Fabien Lotte)
- ITS'15: Program Committee Member (Anke Brock)
- Journées scientifiques Inria 2015 : Program Commitee Member (Pascal Guitton)

10.1.2.2. Reviewer

- ACII 2015 (Fabien Lotte)
- Augmented Humans 2016 (Fabien Lotte)
- CHI'15 (Anke Brock, Camille Jeunet, Fabien Lotte)
- CHI'16 (Jérémy Frey, Fabien Lotte, Anke Brock, Camille Jeunet)
- EUSIPCO 2015 (Fabien Lotte)
- ICASSP 2015 (Fabien Lotte)
- IHM'15 (Anke Brock)
- Interact'15 (Anke Brock, Fabien Lotte)
- Jetsan'15 (Anke Brock)

- MobileHCI'15 (Anke Brock)
- NIPS 2015 (Fabien Lotte)
- PRNI 2015 (Fabien Lotte)
- SMC2015 (Camille Jeunet, Fabien Lotte)
- UIST'15 (Anke Brock, Martin Hachet)
- womENcourage'15 (Anke Brock)

10.1.3. Journal

10.1.3.1. Member of the editorial boards

- Review Editor for Frontiers in Robotics and AI (Martin Hachet)
- Review Editor for Frontiers in Neuroprosthetics (Fabien Lotte)
- Review Editor for Frontiers in Human-Media Interaction (Fabien Lotte)

10.1.3.2. Reviewer - Reviewing activities

- ACM Journal on Computing and Cultural Heritage (Anke Brock)
- Frontiers in Human Media Interaction (Fabien Lotte)
- Frontiers in Neurosciences (Fabien Lotte)
- IEEE Journal on Selected Topics in Signal Processing (Fabien Lotte)
- IEEE Transactions on Affective Computing (Fabien Lotte)
- IEEE Transactions on Biomedical Engineering (Fabien Lotte)
- IEEE Transactions on Haptics (Anke Brock)
- IEEE Transactions on Human-Machine Systems (Fabien Lotte, Camille Jeunet)
- IEEE Transactions on Neural Systems and Rehabilitation Engineering (Fabien Lotte)
- International Journal of Psychophysiology (Camille Jeunet)
- Journal of Medical Imaging and Health Informatics (Fabien Lotte)
- Journal of Neural Engineering (Fabien Lotte)
- Journal of Visualized Experiments (Camille Jeunet)
- NeuroImage (Fabien Lotte)
- Proceedings of the IEEE (Fabien Lotte)
- T&F Behavior & Information Technology (Anke Brock)

10.1.4. Invited talks

- "Towards Improved BCI based on Human Learning Principles", 3rd International Winter Conference on Brain-Computer Interfaces, South Korea, January 2015 (Fabien Lotte)
- "Human Learning-based Brain-Computer Interface Design", University of Freiburg, Brain Links/Brain Tools excellence cluster, Germany, January 2015 (Fabien Lotte)
- “Interactions tangibles et réalités augmentées au service de l'éducation", Journées scientifiques Inria, Nancy, June 2015 (Martin Hachet)
- "Brain-Computer Interaction research at Potioc team », “Handicap & Système Nerveux” laboratory, The University of Bordeaux, Bordeaux, France, June 2015 (Fabien Lotte, Camille Jeunet, Jérémy Frey)
- “Towards practical BCI Technologies”, RIKEN BSI, Japan, July 2015 (Fabien Lotte)
- “Robust EEG signals classification towards practical Brain-Computer Interface technologies”, Sugiyama Laboratory, the University of Tokyo, Tokyo, Japan, July 2015 (Fabien Lotte)
- “Towards practical BCI Technologies”, Cinet, Osaka, Japan, July 2015 (Fabien Lotte)

- “Popular Interaction” and "Interacting with spatial information", EPFL, Lausanne, Switzerland, August 2015 (Martin Hachet & Anke Brock)
- “Popular Interaction”, Dassault Systèmes, Campus 3DS - Paris, September 2015 (Martin Hachet)
- “Towards practical EEG-based Brain-Computer Interface Technologies”, South China University of Technology, Guangzhou, China, October 2015 (Fabien Lotte)
- "Interacting with spatial information", DFKI Saarbruecken, Germany, November 2015 (Anke Brock)
- "Improving BCI-user training: Towards a new generation of reliable, efficient and accessible brain-computer interfaces", Donders Discussions, Netherlands, November 2015 (Camille Jeunet)

10.1.5. Leadership within the scientific community

- IEEE 3DUI Steering Committee - leader (Martin Hachet)

10.1.6. Scientific expertise

- Review for "Crédit Impot Recheche" (Martin Hachet)
- Review of two research projects for the Research Foundation Flanders (Anke Brock)
- Review of one research project for HES-SO (Switzerland) (Pascal Guitton)
- Review of an ANR project (Fabien Lotte)

10.1.7. Research administration

- Member of Inria Ethical Committee (COERLE) (Pascal Guitton)
- Member of Inria Comité Parité et Egalité (Pascal Guitton)
- Member of Comité de Pilotage de Software Heritage (Pascal Guitton)
- Member of Commission de recrutement des Inspecteurs Généraux de l’Education Nationale (IGEN) (Pascal Guitton)
- Member of Committee for technological development at Inria Bordeaux Sud Ouest (CDT) (Fabien Lotte)

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Licence

- Licence : Julia Chatain, Algorithms and programmation, TP, 32h eqtd, First year (L1), IUT de Bordeaux, France
- Licence : Jérémy Frey, Programming, CM-TD, 30h eqtd, L1 Computer Science, University of Bordeaux, France
- Licence : Damien Clergeaud, Functional and Symbolic Programming, TP, 32h eqtd, L3 Computer Science, University of Bordeaux, France

Master

- Master : Jérémy Frey, Programming projects, TD, 32h eqtd, M1 Computer Science, University of 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 : Anke Brock, Virtual Reality and 3D Interaction, CM, 7,5h 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 : Fabien Lotte, Virtual Reality and 3D Interaction, CM, 4h eqtd, M2 Cognitive Science, University of Bordeaux, France
- Master : Anke Brock, Handicap, Autonomy & Technology, TP, 4h eqtd, M2 Cognitive Science, University of Bordeaux, France
- Master : Anke Brock, Video Games and Interaction, CM-TD, 12h eqtd, 3rd year (M2), Enseirb, Bordeaux, France
- Master : Martin Hachet, Video Games and Interaction, CM-TD, 8h eqtd, 3rd year (M2), Enseirb, Bordeaux, France
- Master: Fabien Lotte, Virtual Reality, Accesibility and Brain-Computer Interfaces, 4h eqtd, 3rd year (M2), ENSSAT, Lannion, France
- Master: Fabien Lotte, Brain Computer Interfaces, 6h eqtd, 3rd year (M2), ESIEA, Laval, France
- Master : Anke Brock, Human-Computer Interaction, CM-TD, 12h eqtd, M2 Intelligent Systems and Robotics (M2SIR), University Toulouse, France

10.2.2. Supervision

PhD

- PhD : Jérémy Frey, Leveraging human-computer interactions and social presence with physiological computing, Université de Bordeaux,defended 8/12/2015, (Martin Hachet & Fabien Lotte)
- PhD : Renaud Gervais, Interaction and Introspection with Tangible Augmented Objects, Université de Bordeaux, defended 9/12/2015, (Martin Hachet)

PhD in progress

- Julia Chatain (PhD Student in Computer Science, University of Bordeaux), "Design and evaluation of augmented geographic maps", since September 2015 (Anke Brock & Martin Hachet)
- Damien Clergeaud (PhD Student in Computer Science, University of Bordeaux), "Collaborative interaction for aerospace scenarios", since November 2014 (Pascal Guitton)
- Camille Jeunet (PhD Student in Cognitive Science, University of Bordeaux), "“Improving User training approaches for Brain-Computer Interface", since October 2013 (Martin Hachet, Fabien Lotte, co-supervision with Bernard N'Kaoua, University of Bordeaux and Sriram Subramanian, University of Sussex)
- Stephanie Lees (PhD student in Computer Science, Ulster University, UK): “Assessing and Optimising Human-Machine Symbiosis through Neural signals for Big Data Analytics”, since February 2014 (Fabien Lotte, co-supervision with Damien Coyle, Paul McCullagh and Liam Maguire, Ulster University)
- Lorraine Perronnet (PhD student in Computer Science, Rennes University): “Neurofeedback and Brain Rehabilitation based on EEG and fMRI”, since January 2014 (Fabien Lotte, co-supervision with Anatole Lécuyer, Christian Barillot, Inria Rennes and Maureen Clerc, Inria Sophia Antipolis)
- Joan Sol Roo (PhD Student in Computer Science, University of Bordeaux), "Interaction with Spatial Augmented Reality", since December 2014 (Martin Hachet)

Internships

- Julia Chatain (Master Student in Computer Science, Polytechnique France & EPFL Switzerland), "SyMAPse: Augmented Interactive Maps for Subjective Expression", February to July 2015, (Anke Brock & Martin Hachet, co-supervised by D. Laval at Cap Sciences)
- Pierre-Antoine Cinquin (M2 Cognitive Sciences, University of Bordeaux), "Digital accessibility for e-learning" (Pascal Guitton)
- Maxime Daniel (M2 Computer Science, University of Bordeaux), "Create a virtual environment that could validate the use of electroencephalography as an evaluation tool for 3D interactions", January to June 2015 (Jérémy Frey, Fabien Lotte, co-supervision with Julien Castet at Immersion)
- Adrien Dax (M2IHM, University Toulouse), "Design of Tangible Objects and InteractionTechniques for Visually Impaired Students", March to August 2015 (Anke Brock, co-supervision with C. Jouffrais, M. Macé & J. Ducasse at Irit Toulouse)
- Marie Demangeat (M1 Cognitive Science, University Bordeaux), "Design and evaluation of interactive devices forthe museum", April to May 2015, (Anke Brock, Julia Chatain & Martin Hachet)
- Maxime Duluc (last year in engineering school "Institut d'Optique Graduate School"), "Create an instrumented version of the tangible interface of electroencephalographic signals' visualization Teegi", January to June 2015 (Jérémy Frey)
- Alexis Gay (M2 Design, University of Bordeaux Montaigne), "Design of Tobe, a tangible out-of-body experience", April to June 2015 (Jérémy Frey and Renaud Gervais)
- Emilie Jahanpour (M1 Cognitive Sciences, University of Bordeaux), "Is it possible to predict BCI performance from the performance obtained at simple motor tasks? (Camille Jeunet, Fabien Lotte, co-supervision with Bernard N'Kaoua)
- Houda Lamqaddam (M2IHM, University Toulouse), "Design of Innovative Interaction Techniques forInteractive Maps", March to August 2015 (Anke Brock, co-supervision with E. Dubois & M. Serrano at Irit Toulouse)

Other Supervision

- Charles Coeurderoy & Violaine Sudret (M2 Enseirb, Bordeaux), "GPS Narratif", Student Project, November 2015 to January 2016 (Julia Chatain & Anke Brock)
- Paul Ecoffet, Florian Gouet, Elias Rhouzlane, Mathieu Seurin, "Detecting frustration during a training from physiological and neurophysiological markers" (Camille Jeunet & Fabien Lotte)
- Ilias Ainseba, Théo Geral, Charles Gouverneur, "Les Interfaces Cerveau-Ordinateur : La technologie peut-elle compenser les défaillances du corps humain ? ", TPE 1ère S, 2015 (Camille Jeunet)

10.2.3. Juries

- PhD (rapporteur): William Delamarre, Nov. 2015, Grenoble (Martin Hachet)
- PhD (rapporteur): Jonhatan Mercier, Oct. 2015, Rennes (Martin Hachet)
- PhD (rapporteur): Jean-Claude Morgère, April 2015, Lorient (Pascal Guitton)
- PhD (examinateur): Paul-Antoine Arras, Feb. 2015, Bordeaux (Pascal Guitton)
- PhD (examinateur): Remy Brouet, March 2015, Grenoble (Martin Hachet)
- PhD (examinateur): Gautier Durantin, ISAE, Toulouse (Fabien Lotte)
- HdR (examinateur): Julien Pettré, June 2015, Rennes (Pascal Guitton)
- PhD (examinateur): Raphaëlle N. Roy, CEA, Grenoble (Fabien Lotte)
- PhD qualification examen ("mi-thèse"): Tracy Brandmeyer, Toulouse (Fabien Lotte)

10.3. Popularization

10.3.1. Job Fairs

- Salon Aquitec (Regional Career Fair), Bordeaux, January 2015 (Anke Brock & Camille Jeunet)

10.3.2. Science Festivals

- Fête de la Science, Talence, September 2015 (Julia Chatain)
- TechFest 2015, Mumbai, India. January. (Jérémy Frey, Jérémy Laviole)

10.3.3. Popularization Talks

- "Ma Thèse en 180s", Public Prize of the University of Bordeaux Final and regional final, April 2015 (Camille Jeunet)
- "Rencontres Numériques", Cultures scientifiques et techniques, Créteil, October 2015 (Martin Hachet)
- “Peut-on tout contrôler par la pensée”, DocForum, Lyon, Lavoir Public, November 2015 (Fabien Lotte, with Jérémie Mattout and Emmanuel Maby, Inserm Lyon)

10.3.4. Popularization Articles

- "Publication : du papier au numérique", Blog Binaire - Le Monde (Pascal Guitton) [45]
- "Publication : le temps des dérives", Blog Binaire - Le Monde (Pascal Guitton), [46]

10.3.5. Demonstrations

- Augmented Michelson Interferometer, ETOP, June 2015 (David Furio, Martin Hachet).
- Fête du centre: virtual reality demo (Inria), June 2015

10.3.6. Women In Science

- Printemps de la Mixité (Event for High-School Students with the aim to increase the interest in science, specifically in girls), Université de Bordeaux, Mai 2015 (Anke Brock: Organisation for Inria and Panel Talk & Potioc team: Demos)
- Panelist "Témoignages de femmes dans des professions scientifiques des secteurs public et privé et à différents niveaux de carrière" at the Colloque femmes & sciences (women in science annual meeting), Toulouse, November 2015 (Anke Brock)
- Panelist at the "Journées Femmes et Informatique" (women in computing conference) of the Société Informatique de France (French association on computing), Orléans, February 2015 (Anke Brock)
- Panelist “Out of the ordinary jobs in Computer Science” at the ACM womENcourage conference, Uppsala, Sweden, September 2015 (Anke Brock)
- Django Girls, Bordeaux, November 2015 (Julia Chatain)

10.3.7. Inria Media Channels

- Inside Inria Video https://www.youtube.com/watch?v=8bNS6JHmCwo (Anke Brock + the whole Potioc team)
- Podcast "Comment améliorer l’accès aux cartographies pour les déficients visuels ?" for Interstices, April 2015 https://interstices.info/jcms/ni_78646/comment-ameliorer-lacces-aux-cartographies-pour-les-deficients-visuels (Anke Brock)

11. Bibliography

Major publications by the team in recent years

[1] A. Brock, P. Truillet, B. Oriola, D. Picard, C. Jouffrais. *Interactivity Improves Usability of Geographic Maps for Visually Impaired People*, in "Human-Computer Interaction", 2015, vol. 30, n^{o} 2, pp. 156-194 [*DOI :* 10.1080/07370024.2014.924412], https://hal.archives-ouvertes.fr/hal-01077434

[2] 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

[3] 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

[4] R. GERVAIS, J. FREY, A. GAY, F. LOTTE, M. HACHET. *TOBE: Tangible Out-of-Body Experience*, in "TEI '16 - Tangible, Embedded and Embodied Interaction.", Eindhoven, Netherlands, ACM, February 2016 [*DOI :* 10.1145/2839462.2839486], https://hal.archives-ouvertes.fr/hal-01215499

[5] R. GERVAIS, J. SOL ROO, M. HACHET. *Tangible Viewports: Getting Out of Flatland in Desktop Environments*, in "Tangible, Embedded and Embodied Interaction (TEI)", Eindhoven, Netherlands, February 2016, https://hal.archives-ouvertes.fr/hal-01215502

[6] 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

[7] 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

[8] C. JEUNET, B. N'KAOUA, S. SUBRAMANIAN, M. HACHET, F. LOTTE. *Predicting Mental Imagery-Based BCI Performance from Personality, Cognitive Profile and Neurophysiological Patterns*, in "PLoS ONE", July 2015, 20 p. , https://hal.inria.fr/hal-01177685

[9] F. LOTTE. *Signal processing approaches to minimize or suppress calibration time in oscillatory activity-based Brain-Computer Interfaces*, in "Proceedings of the IEEE", 2015, vol. 103, n^{o} 6, pp. 871-890, https://hal.inria.fr/hal-01159171

[10] 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

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Articles in International Peer-Reviewed Journals

[11] A. BROCK, C. JOUFFRAIS. *Interactive audio-tactile maps for visually impaired people*, in "ACM SIGACCESS Accessibility and Computing (ACM Digital Library)", October 2015, n^{o} 113, pp. 3-12 [*DOI :* 10.1145/2850440.2850441], https://hal.inria.fr/hal-01237319

[12] A. BROCK, P. TRUILLET, B. ORIOLA, D. PICARD, C. JOUFFRAIS. *Interactivity Improves Usability of Geographic Maps for Visually Impaired People*, in "Human-Computer Interaction", 2015, vol. 30, n^{o} 2, pp. 156-194 [*DOI :* 10.1080/07370024.2014.924412], https://hal.archives-ouvertes.fr/hal-01077434

[13] J. FREY, A. APPRIOU, F. LOTTE, M. HACHET. *Classifying EEG Signals during Stereoscopic Visualization to Estimate Visual Comfort*, in "Computational Intelligence and Neuroscience", 2016, vol. 2016 [*DOI :* 10.1155/2016/2758103], https://hal.inria.fr/hal-01222045

[14] C. JEUNET, B. N'KAOUA, S. SUBRAMANIAN, M. HACHET, F. LOTTE. *Predicting Mental Imagery-Based BCI Performance from Personality, Cognitive Profile and Neurophysiological Patterns*, in "PLoS ONE", December 2015, vol. 10, n^{o} 12, 23 p. [*DOI :* 10.1371/JOURNAL.PONE.0143962], https://hal.inria.fr/hal-01177685

[15] F. LOTTE, J. BRUMBERG, P. BRUNNER, A. GUNDUZ, A. L. RITACCIO, C. GUAN, G. SCHALK. *Electrocorticographic Representations of Segmental Features in Continuous Speech*, in "Frontiers in Human Neuroscience", February 2015, vol. 9, n^{o} 97, 27 p. [*DOI :* 10.3389/FNHUM.2015.00097], https://hal.inria.fr/hal-01159163

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[17] H. SAUZÉON, B. N'KAOUA, P. ARVIND PALA, M. TAILLADE, P. GUITTON. *Age and active navigation effects on episodic memory: A virtual reality study*, in "British Journal of Psychology", 2015, 23 p. [*DOI :* 10.1111/BJOP.12123], https://hal.inria.fr/hal-01157833

Invited Conferences

[18] F. LOTTE, C. JEUNET. *Towards Improved BCI based on Human Learning Principles*, in "3rd International Winter Conference on Brain-Computer Interfaces", High1 Resort, South Korea, January 2015, https://hal.inria.fr/hal-01111843

International Conferences with Proceedings

[19] E. BALDISSER, J.-M. CIEUTAT, P. GUITTON. *Augmented Reality using Point Clouds for Survey and Design in Outdoor Public Construction*, in "EuroVR", Milan, Italy, October 2015, https://hal.inria.fr/hal-01238236

[20] F. BERTHAUT, D. MARTINEZ PLASENCIA, M. HACHET, S. SUBRAMANIAN. *Reflets: Combining and Revealing Spaces for Musical Performances*, in "New Interfaces for Musical Expression (NIME)", Baton Rouge, United States, May 2015, forthcoming, https://hal.inria.fr/hal-01136857

[21] E. BRULÉ, G. BAILLY, A. M. BROCK, F. VALENTIN, G. DENIS, C. JOUFFRAIS. *MapSense: Multi-Sensory Interactive Maps for Children Living with Visual Impairments*, in "ACM CHI 2016 - chi4good", San José, United States, Proceedings of the Annual ACM Conference on Human Factors in Computing Systems, ACM, May 2016, https://hal.inria.fr/hal-01263056

[22] J. CHATAIN, M. DEMANGEAT, A. BROCK, D. LAVAL, M. HACHET. *Exploring input modalities for interacting with augmented paper maps*, in "IHM'15 - 27ème conférence francophone sur l'Interaction Homme-Machine", Toulouse, France, ACM, October 2015, w01 [*DOI :* 10.1145/2820619.2825002], https://hal.archives-ouvertes.fr/hal-01219065

[23] S. FLECK, M. HACHET, C. BASTIEN. *Marker-based augmented reality: Instructional-design to improve children interactions with astronomical concepts*, in "Interaction Design and Children", Boston, United States, ACM SIGCHI, June 2015, forthcoming, https://hal.inria.fr/hal-01136835

[24] S. FLECK, M. HACHET. *Helios: a tangible and augmented environment to learn optical phenomena inastronomy*, in "ETOP - Education and Training in Optics & Photonics", Bordeaux, France, June 2015, https://hal.inria.fr/hal-01121923

[25] J. FREY, A. APPRIOU, F. LOTTE, M. HACHET. *Estimating Visual Comfort in Stereoscopic Displays Using Electroencephalography: A Proof-of-Concept*, in "INTERACT", Bamberg, Germany, September 2015, https://hal.inria.fr/hal-01157890

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[27] *Best Paper*
J. FREY. *Heart Rate Monitoring as an Easy Way to Increase Engagement in Human-Agent Interaction*, in "PhyCS - International Conference on Physiological Computing Systems", Angers, France, SCITEPRESS, February 2015, https://hal.inria.fr/hal-01090544.

[28] D. FURIO, M. HACHET, J.-P. GUILLET, B. BOUSQUET, S. FLECK, P. REUTER, L. CANIONI. *AMI : Augmented Michelson Interferometer*, in "ETOP - Education and Training in Optics & Photonics", Bordeaux, France, SPIE (editor), June 2015, https://hal.inria.fr/hal-01121917

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[39] *Best Paper*
C. Jeunet. *Training Users' Spatial Abilities to Improve Brain-Computer Interface Performance: A Theoretical Approach*, in "Colloque des Jeunes Chercheurs en Sciences Cognitives", Compiègne, France, June 2015, https://hal.inria.fr/hal-01162411.

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