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PEOPLE
MARIE CURIE ACTIONS

**Intra-European Fellowships (IEF)**
**Call: FP7-PEOPLE-2012-IEF**

PART B

"IXMI"

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# B1 Scientific and technological Quality

*B1.1 Research and technological quality, including any interdisciplinary and multidisciplinary aspects of the proposal*

**Improving the experience with digital musical instruments …**

Many digital musical instruments have been developed in the past thirty years, allowing for the creation of new sounds, new musical structures and even new musical genres. On the contrary to acoustic instruments which rely on vibrations initiated by musicians gestures, digital musical instruments do not provide a direct physical link between gestures and sound, i.e. between sensors that captures musicians gestures and parameters of a digital sound synthesis process. This disconnection is accentuated in multiprocess instruments where sound might be produced by autonomous sound synthesis processes instead of being directly generated by musicians. Most research in the music interaction field therefore investigates this link and try to recreate it by exploring layers of mappings in both directions, i.e. from musician to sound (control) and from sound to musician (feedback) [14] [26]. For example, the value of a potentiometer may be directly mapped to the volume of a synthesizer, but another mapping layer may also compute the variation speed of this input value and map this speed to the volume. Recent instruments make use of graphical interfaces as a mapping layer for both control and feedback, and especially for multiprocess instruments. These interfaces are highly interesting because of both their malleability and of their capacity to display much information [16]. However, chosen mappings between gestures and sounds vary greatly from one instrument to another, making these instruments less accessible for novices and for non-musicians, on the contrary to physical instrument which are ruled by physical properties that everyone is familiar with. This project investigates new approaches, based on recent research on graphical interfaces and mixed-reality, to improve the experience of musicians with different expertise levels and of spectators with digital musical instruments.

*Figure 1: Musician performing with laptop and control surface. The impact of the musician's gestures on the sound is hard to tell.*

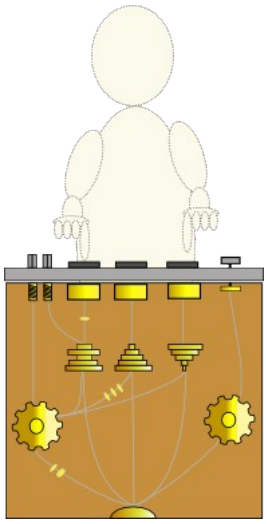


*Figure 2: A simplified representation of the instrument components is displayed on a screen below the control surface and shows the impact of each gesture.*

**... of spectators …**

While a lot of researchers aim at recreating the link between gestures and sound for musicians, very few investigate this link from the audience point of view. Even if the mapping is correct for the musician, the audience, when seeing a public performance, may not be able to understand the impact of musicians actions. This happens mostly because electronic musicians, even when playing with the same software instrument, may use very different mappings, which might event change during a single performance. The input/output complexity ratio of these mappings can also be very different from one instrument to another. For example one gesture by the musician such as rotating a knob may trigger several modifications of the sound at the same time.

Another example is pointed out by Cascone [12]: most spectators of electronic music concerts where the musician uses only a laptop cannot tell if he is reading his email or if his actions actually have an impact on the sound. This fact is obvious when looking at Figure 1, and even more prominent with orchestras of these new instruments. Even instruments with visual feedback are not adapted for the audience. Most of the time the interface is re-projected on a big screen apart from the actual instrument, which break the spatial consistency between the actual physical performance of the musician and the graphical interface. Finally, Marshall [20] of the Host Institute showed that the enjoyment of a digital musical instrument is correlated with its liveness, a dimension which relates to the perceived impact of musicians gestures and expressiveness.
This project will investigate dedicated 3D graphical representations and displays in order to provide a better understanding of the mechanisms of the instrument and a better experience for the audience. In collaboration with musicians, common hardware and software configurations of musical instruments will be investigated, classified and analysed to extract common components such as sensors and sound processes. As sketched on Figure 5, 3D representations of these components will be developed, spatially merged with real sensors to preserve the instrument consistency, and to show the mappings between gestures/sensors and the various components. To that extent, the project will rely on previous research done by Dr. Berthaut on representation of sound processes in 3D virtual environments in order to provide visually as much as information as possible. An example of these 3D reactive widgets [3][5] is shown on Figure 3. Different level of details for the 3D representations will be explored, to investigate if the more information is given, the better the understanding is. It will also rely on research done at the Host Institute on multi-user see-through displays [17]. In fact, these displays are essential as they will not only allow for the integration of physical and virtual elements as depicted on Figure 4, but they will also provide several views on the same 3D scene so that spectators placed at different locations will all have the perspective corresponding to their position, therefore preserving the consistency between the physical and virtual spaces. Finally, measurement of the impact of this system on spectators experience, i.e. understanding and enjoyment, will rely on work done on liveness by Marshall [20] of the Host Institute.

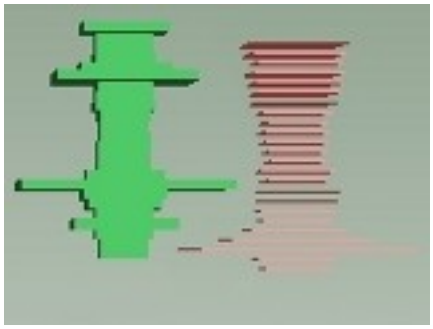


*Figure 3: 3D reactive widgets displaying multiple sound parameters for each sound process using shape, color, density, size, ...*

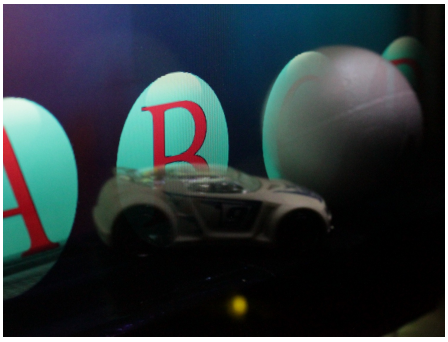


*Figure 4: Mustard see-through display allows for the integration of real and virtual elements*

**... and of musicians from novices to experts .**
The second issue relates to how the choice of mappings may affect the experience of musicians with various levels of expertise when playing a digital musical instrument. As explained by Jordà [15], if the mapping ratio between input complexity, i.e. complexity of musicians gestures, and output complexity, i.e. resulting musical complexity, is too low, the instrument is not challenging enough for expert musicians. On the other hand, if this ratio is too high, the instrument gives more musical parameters but is also very hard to master, and not accessible to novices. The choice of mappings therefore also has an impact on the learning process. For instance, less accessible instruments may prevent novices from wanting to practice them, but after a gain in expertise,, instruments not complex enough may have the same effect. This project aims at evaluating the use of separated but coherent views of an instrument to provide adaptive mappings between gestures and sound, in order to ensure a good experience for musicians with any level of expertise.

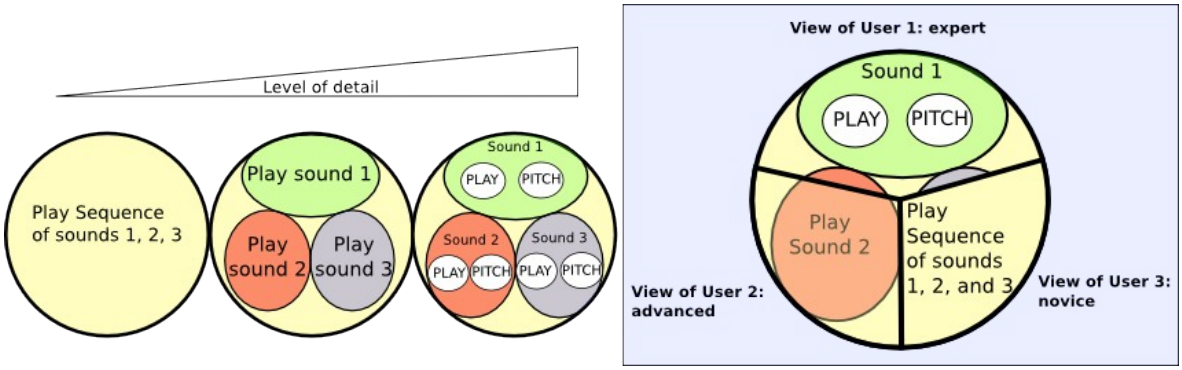



*Figure 5: Left: Three levels of detail for a 2D graphical musical interface. Right: Views for three users of the same graphical element with different levels of detail. The less detailed level (novice) only allows one to play a predefined sequence of three sounds. The advanced level gives direct access to the three sounds, allowing one to create his own sequences, but with predefined pitches. The more detailed level gives access to both triggering and pitch for each sounds, allowing one to create sequences with different rhythms and melodies.*

This project will rely on the concept of level of detail, which is often used in 3D graphics for performance reasons, in order to provide several views of graphical control objects (widgets) corresponding to different mapping ratios, as depicted for a 2D case on Figure 5. It will be combined with ideas from the Fellow's previous research such as the hierarchical live-looping technique [4], in which musicians build and manipulate musical trees with a growing musical complexity from the leaves to the root. In other words, these trees give access to different musical levels of detail, and different mapping ratios. For instance, root nodes represent complex musical sequences which produce enjoyable musical results when triggered, while leaves represent raw sound processes which will only produce single sounds and therefore require musicians to be able to play the rhythms and melodies themselves. Drile [4], depicted on Figure 6, is an immersive virtual musical instrument (IVMI) developed by Dr. Berthaut which implements this technique and which will be used for prototyping this part of the project. In particular, it allows musicians, immersed in a 3D virtual environment by means of head-tracking and stereoscopic rendering, to manipulate nodes of these musical trees thanks to adapted interaction devices, techniques and metaphors. This 3D interface, combined with the multi-user display technologies developed by the Host Institute [17] and depicted on Figure 7, will provide a distinct view for each level of detail while preserving the consistency between these views and the musicians gestures. Impact of the use of adaptive mappings compared to fixed mappings will be evaluated with regard to both the experience of users and the learning curve of the instrument. The evaluation will consists in measurement of subject emotions and in evaluation of performance in musical tasks.

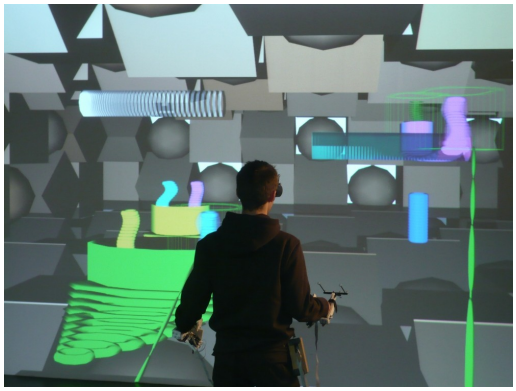


*Figure 6: Drile allows musicians to manipulate 3D musical trees*

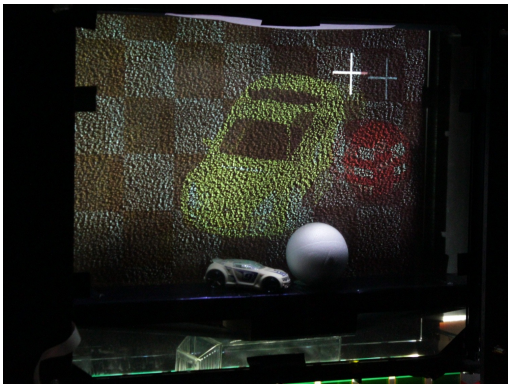


*Figure 7: Mustard display allows for multiple views of a single 3D scene*

These two phases of the project eventually both amount to improving the “accessibility” and “enjoyability" of digital musical instruments by using 3D interfaces with multiple coherent views.

In both parts, this project is a perfect combination of previous research by the Fellow and the Host Institute: hierarchical live-looping / Drile with multi-user displays and 3D reactive widgets / scenography with multi-user see-through displays / study of liveness.

**Multidisciplinary aspect**
This project is highly multidisciplinary. On a very high-level, it tackles both scientific and artistic issues, with both development of new technologies and investigation of musical practice and perception. On the scientific side this project spreads among various fields such as computer science, cognitive science, engineering. Finally within the computer science field, this project combines human-computer interaction, information visualization, virtual and mixed reality and music computing. In particular, research in mixed-reality explore technologies and software applications that combine the physical and virtual worlds, so that they form a consistent world with which users can interact. Outside the music computing field, this project has significant implications for human-computer interaction regarding the process of learning new interfaces and the understanding of these new interfaces.

### *B1.2 Appropriateness of research methodology and approach*

The two phases of this projects are both composed of two parts with specific research methodologies.

**Design and prototyping with user feedback**
This first part involves prototyping software applications and hardware solutions.
For the first phase of the project, this first part will involve investigating configurations used by different electronic musicians in order to develop a prototype application that can adapt to many different hardware (control surfaces) and software (virtual musical instruments) configurations. This prototype will be based on both the 3D reactive widgets designed by Dr. Berthaut and the multi-user see-through screens developed at the host institute. After a first version of the hardware prototype is developed (1 month), a first workshop will be organized in Bristol with local musicians, contacted using connexions of the host institute and by investigating local music labels, in order to gather their instrument configurations. Additional informations will result from questionnaires sent to other musicians groups known by Dr Berthaut, such as the Scrime, Octet and the Electronoon Addicts in Bordeaux, France, and the San Francisco electronic musicians meetup group. After this first workshop, prototyping will continue and later workshops (every month) will help musicians integrate the system with their instrument and comment on it. Finally, 5 instruments will be chosen for the study.
For the second phase of the project investigating expertise and learning, this step will rely on the Drile instrument, developed by Dr. Berthaut. The hardware part will again be based on the multi-user see-through display Mustard developed by the host of this project, Dr. Subramanian, in order to provide different graphical representations for users with different levels of expertise. To be more specific, instead of using different angles only for giving the correct perspective on a 3D scene, they will also be used to depict different graphical and musical level of details. The size of the display will have to be increased in order to support multiple users interacting with Drile from these different angles. Also stereoscopy will need to be added to support the interaction techniques used in Drile. Drile will be modified in order to display different level-of-details on the same tree on separate views. The prototype will be evaluated iteratively with researchers of the host institute.
This approach is appropriate for several reasons. First, early prototyping while designing will allow the researchers to detect theoretical solutions which seem interesting but which cannot be implemented. Also, having a first implementation will help during the workshops as a support to discussions. With the workshops, free exchanges of ideas will be favoured over formal presentation by researchers. After the first prototype, the design process will undergo several iterations, each time with evaluations. This approach has proven to be successful for software development, for example with the AGILE method which is used by many companies for many types of applications, but also more specifically in “user-centered interface design“.

**Evaluation of the proposed solutions with short and long term user studies involving performance and emotion measurements.**
This second part involves common human-computer interaction (HCI) user studies, with design of experiments, experiments conducting and data analysis. In the first phase it will aim at evaluating the impact of visualization on the experience of spectators. In the second phase, the study will aim at evaluating the use of adaptive mappings in both learning and collaboratively playing a 3D graphical musical instrument.

For the first phase of the project, a within-subject evaluation will be conducted on 20-30 subjects and the 5 selected instruments. Studied variables will be the collocation or separation of musicians and represented sound processes, the presence or absence of visual links between musicians gestures/actions and components of the sound processes, and the complexity of the visual representation of these sound processes. Subjects will watch short performances for each condition, and will then be asked to describe how they think the instrument works and how they think the musician controls it. These answers will be rated by comparing them to the ground truth. Subjects will also be asked to rate the enjoyability of each condition. Levels of understanding and enjoyability will then be analysed in order to see how the added representation impacts them. In addition to experiments conducted within a controlled room and with a live performance, videos of the performances will be recorded and made accessible with a questionnaire on a web page in order to get results from a larger audience.
For the second phase of the project, the evaluation step will consist in two between-groups combined studies, one long term and one short term, involving 20-30 subjects. During the short-term study, two groups of subjects will be defined. One will manipulate the prototype only with the highest level of detail, while the other group will use different levels sequentially from lowest to highest. Subjects of both groups will be asked to rate their enjoyment of the instrument, once again using questionnaires with emotion ratings scales and other questions rated with a Likert Scale. For the long-term study, two groups of subjects will be formed. Each subject of both groups will be given the opportunity to practice the instrument once per week during three months. Subjects of the first group will be given access directly to the highest level of detail during the three months, while subject of the second group will be given access to increasing levels of detail each month (lowest the first month, intermediate the second month, highest the third month). During this process, questionnaires will be filled by subjects after each session, in order to evaluate their experience. At the end of the three months, all subjects will undergo an experiment involving musical tasks such as reproducing a pre-defined musical sequence, in order to measure their expertise with the instrument and therefore the impact of the adaptive mappings on the learning process.
An important aspect of our experiments will be pilot testing. For instance, early experimental designs will be tested on few groups of subjects in order to overcome potential biases which may invalidate the results, such as a learning effect, and to make sure all relevant data is recorded. Another essential aspect is the selection of subjects. In order to correctly validate the proposed solutions, subjects with different experience of electronic music, i.e. ranging from people who do not listen to electronic music to electronic musicians, will be asked to participate, so that we can take their experience into account when analysing the enjoyability and understanding parameters. Subjective measurements with questionnaires will be supported by the expertise of the Host Institute. Many guidelines exist in the literature, especially in social sciences, on how to construct questionnaires in order to get statistically valid results. An important aspect will be the measurement of subjects emotions [24] as this will give strong indications on the experience of both musicians and spectators. Finally, by coupling the experiment for the first phase with an online questionnaire, data will potentially be gathered on populations different from the ones undertaking the live experiment. In particular, people not interested in electronic music might be more inclined participate to a shorter online experiment. However the associated results will have to be handled with more caution, because of the lack of control.

### *B1.3 Originality and innovative nature of the project, and relationship to the 'state of the art' of research in the field*

This project is original and innovative with regard to research done in both fields of music computing and mixed-reality.

**Improving audience experience**
Research has already been done on audience experience for example by Bongers [10], Cascone [12], and even Marshall [20] of the host institute. However, this previous work mostly attempts to define frameworks and to classify audience perception. On the contrary, this project aims at concretely improving the experience and understanding of new musical instruments by the audience with the use of dedicated displays and graphical representations. Related issues will also be investigated such as the impact of the collocation of the instrument and the visualization and of the level-of-detail of the visualization, and the relation between understanding and enjoyment.

**Classification of digital musical instruments**
Another original aspect of this project lies in a different approach to organology of digital musical instruments,

i.e. in their analysis and classification. Previous research has been done on this subject. For instance, Bonardi [9] investigates mathematical and logical descriptions of instruments, in order to classify and model them so that they can be preserved from software/hardware evolutions. Other research by for example Birnbaum et al. [8] organize digital musical instruments according to several dimensions such as the complexity of musical gestures, the complexity of musical output, the collaborative aspect of the instrument, and so on. In the first phase of this project, focus will be put on the definition of classes of usual components of digital musical instruments in order to define a consistent set of representations that will be easy to comprehend by spectators who potentially know nothing about how digital instruments work. For example, in musical performances, while some musicians manipulate sets of musical loops, i.e. infinitely repeated sequences of sounds, which are often represented as circles either rotating or with a moving cursor, other musicians use playlists, i.e. complete compositions on which they apply digital audio effects, which would be more correctly represented as a scrolling horizontal element, as they are usually in music software.

**Adaptive gesture-sounds mappings**
Current research on new instruments focuses on trying to find the correct fixed mappings with a ratio between input gestures complexity and output musical complexity that will give a good experience for both novices and experts users. Instruments are then classified using scales such as the one defined by Birnbaum et al. [8] or by Malloch et al. [20]. On the contrary, this project will investigate the use of adaptive mappings by relying on graphical interfaces and visual/musical level-of-detail in order to provide adapted mapping ratios for different levels of expertise.

**Long-term user study of learning process**
New instruments are usually evaluated with short term studies, which do not allow for the study of the learning process. This project will consists in long term studies that will investigate the learning curve of instruments, in order to measure the benefit of adaptive mappings over fixed ones.

**Audience experience evaluation**
In the same manner, research in the field of mixed-reality and more generally human-computer interaction consists in short-term user studies and is usually more focused on users of the interfaces although recently studies investigate public display/installations and audience perception. In particular, Benford [2] classifies public interfaces according to the ratio of what is hidden / shown from the interaction process, but he does not directly evaluate audience experience.

**New displays for musical interaction**
Many new display solutions have also been developed which tackle the issue of handling several users and can be interesting for both parts of this project. In particular, Kitamura et al. [18], Agrawala et al. [1] and Karmik of the Host Institute [17] have all developed multi-user displays with different technologies. However, these solutions have not been used in the context of music performance, which induces specific constraints such as the consistency between musicians gestures and graphical representations.

Overall, this project contributes significantly to knowledge on audience experience, musical practice and design of new instruments, but also more generally on the impact of graphical representations on users experience with new interfaces.

### *B1.4 Timeliness and relevance of the project*

This project is relevant with regard to both the current state of music performance and the location of the research institute.

**New instruments, Live performance, Bristol music scene and European software companies**
It will start at a period when more and more new instruments come out of laboratories, or are even built by musicians themselves using do-it-yourself electronics kits and dedicated programming languages. For these instruments to get more interest from musicians, experience of novices must be taken into account. On the audience side, as more and more musicians, including DJs previously using well-known turntables, play with only laptops and control surfaces, which involves subtle gestures and small sensors such as knobs or faders, the

audience needs new solutions to enjoy the musical performance as much as it did with physical instruments.
Furthermore, the investigation of live performances and audience experience is getting more and more attention from the academic sector, with conferences such as “Live Interfaces : performances, art and music” that will be held at the University of Leeds in September 2012, with issues such as Audience Perception/Interaction. Finally, on the same idea of improving the enjoyability and accessibility of new interfaces, a research team of INRIA (French research institute) has recently been created. The Potioc team, led by Dr. Martin Hachet and in which Dr. Berthaut is actually working, aims at opening interactive 3D graphics to anyone.
The location for this project is also relevant both locally and at the European level. The host institute is located in Bristol, city world-renowned for its electronic music. In addition to being the home town of several famous bands such as Massive Attack, or Roni Size, it has a very rich electronic music scene, from which several sub-genres originate. This location is ideal since the project will benefit from contacts with musicians of the local scene. Workshops will be organized to gather informations regarding musicians instruments, and local musicians will also be involved in the experiments both as users and spectators subjects. Preliminary discussions of Dr Berthaut with French musicians reveal a strong interest in this project. At the European level, this project is closely related to a very dynamic electronic music industry with companies based in Germany, United-Kingdom or even France. They produce both software and hardware instruments. A local example is the Nu Desine[1] company which has just produced a novel musical instrument called AlphaSphere. On the academic side, many internationally recognized European laboratories are working on related thematics such as the Music Technology Group at Pompeu Fabra in Spain, the Ircam, Grame and Scrime in France, of course the Bristol Interaction and Graphics group in the United-Kingdom, Steim in Holland, and many others.

**Dissemination for academics, musicians and the general public**
This project comprises many outreach activities, both locally, within Europe and internationally.
First, several symposiums and presentation of the project and results will be held within the host institute. Public workshops with local electronic musicians will be organized in Bristol but also in Bordeaux. Public demonstrations and concerts will allow for the dissemination of the results towards the general public. As this project aims at improving the accessibility of new instruments, this local part of the dissemination is essential.
At an international level, first results of this project will be submitted to potentially several conferences in both the music computing field, such as the conference on New Interfaces for Musical Expression or the International Computer Music Conference (ICMC), and the human-computer interaction field, such as the Computer Human Interaction conference (CHI), the symposium on User Interfaces Software and Technology (UIST), the International Symposium on Mixed and Augmented Reality (ISMAR), and the IEEE Virtual Reality Conference (VR). More detailed results will be submitted to Journals such as the Computer Music Journal and the Presence and Tele-operators journal or the Virtual Reality Journal. Moreover, all developed software will be publicly released under a free open-source licence, so that it can be reused by artists or other researchers. Finally, in order to gather a community of researcher on the issues tackled by this project, two workshops will be proposed for the NIME conference. One will deal with solutions to improve audience perception of digital musical instruments in public performances. The other will explore the strategies for improving learning of new instruments. For each workshop a publication with extended version of the accepted papers will be proposed to a publisher.

### *B1.5 Host scientific expertise in the field*

The research fellow will be part of the Bristol Interaction and Graphics group of the Engineering Faculty within the University of Bristol, UK.

**Bristol University**
Bristol is a research-intensive university supporting both individual scholarship and interdisciplinary research of the highest quality. The University is consistently ranked in the top 20 research universities in Europe1. Furthermore, the University has a strong commitment to disseminate research findings to the public and engage with the public in a closed-loop feedback mechanism that helps drive innovative research. In 2007, the University of Bristol in partnership with another local university won a grant from the Beacons for Public Engagement initiative to act as the National Coordinating Centre for Public Engagement. The aim of the initiative is to change cultures in universities and embed public engagement into the core values and activities of universities. This initiative, the largest of its kind in public engagement, has been established to share learning

[1] http://nu-desine.com/

about public engagement, including training for public engagement, across the Higher Education sector. Through these initiatives the University has several well-established training programs and latent knowledge, which the research fellow can access to help drive his research agenda.

**Bristol Interaction and Graphics Group**

The Bristol Interaction and Graphics group was formed in 2007 as one the research groups recognized by the Engineering Faculty of the University. The group consists of four academic members of staff, 8 PhD students, 5 postdocs and 1 technician all focusing on human-computer interaction research issues around hardware and design. The group is a world leader in the design, implementation and evaluation of interactive techniques and devices, acting as a hub for collaboration between social scientists, artists, scientists and engineers to combine efficient and aesthetic design. The Group is particularly well known for its work coupling human and computer communications through novel input techniques, and prioritizes deployment and evaluation in public settings. The group has used public-engagement as an effective medium for garnering research feedback on its interactive systems. The group's research has spanned novel musical interfaces [21][22][23][24], display devices and interactive systems. Two of the group's current post-docs (Dr. Peter Bennet and Dr. Mark Marshall) have a background in Music Technology, an area of focus in this project.

**Track Record of Group**

Since its inception in 2007 the group has attracted over £5million in research funding including contributions from industry and European and UK funding bodies. The group consists of ERC and other Marie-curie grant holders. The group has collectively published more then 20 full papers at ACM CHI & ACM UIST conference - the flagship venue for publishing high-impact research in human-computer interaction (this include several best-paper awards and nominations). The group has a track record of collaborating with international partners in Canada, USA, Europe, Japan and India. Many doctoral and post-doctoral students from this group (e.g., Dr. Jason Alexander, Dr. Calkin Montero) have gone on to establish their own research career at other Universities around the world. The group is also a core member of the Communications Doctoral training center, which trains up to 45 PhD students over the next 4 years on topics around people-focused mobile communications. Dr. Berthaut's research into musical experiences in public settings can be of interest to PhD students from this cohort who might look at enhancing user experiences in gaming arenas and sports events through the use of mobile devices. In particular PhD students will be able to pursue a research degree in a related topic and be co-supervised by Dr. Berthaut.

### *B1.6 Quality of the group/scientist in charge*

Dr. Berthaut will be part of Dr. Subramanian's team. Dr. Subramanian is a Professor in the Computer Science Department of the University of Bristol where he co-directs the Interaction and Graphics Group. Before joining Bristol, he has worked as a senior scientist at Philips Research Eindhoven, Netherlands and as an Assistant Professor (July 2003 to Dec 2006) at the CS department of University of Saskatchewan, Canada. He has held adjunct positions at the University of Manitoba in Canada, Tohoku University in Japan, and Chalmers University in Sweden. He is a member of the steering committee for ACM Tabletops and Interactive Surfaces and ACM MobileHCI, which oversees the management and organization of the international conferences in those topics. His research interests are in exploring the next generation of interactive systems including novel mobile systems and interactive touch systems. His group is exploring all layers of the interactive system all the way from developing new hardware to creating software solutions and integrating sensible business models to make them attractive to the industry. Dr. Subramanian was part of the £1.5million MobileVCE User-interaction program to investigate hardware, software and novel business models for the next generation of interactive mobile systems (Oct-2008 to June 2012). Over the last 5 years he has received £2.5 million in research funding from various industry and research council bodies including EPSRC responsive mode funding and the EU ERC-Starting grant (with an acceptance rate of 12% from over 4000 submissions). He has published more than 100 peer-reviewed articles include 1 Best paper and 3 honorable mentions at ACM CHI. Dr. Subramanian has successful graduated several PhD students and advised Postdoctoral students. These students have moved to other research facilities within and beyond Europe to establish their own research groups. For example, Dr. Nacenta (co-supervised by Dr. Subramanian at University of Saskatchewan) was recently awarded a Marie Curie Fellowship at St. Andrews, Dr. Pauli (supervised at Bristol University) has joined the Max Plank Institute in Germany as a post-doc and Dr. Alexander (postdoctoral student of Dr. Subramanian at Bristol University) has recently joined as a lecturer in Lancaster University.

# B2 Training

*B2.1 Clarity and quality of the research training objectives for the researcher*

**Research charter and career development plan**
It is essential for young scientists to develop both scientific (including multidisciplinary and interdisciplinary skills) and complementary organizational and communication skills. During his stay in Bristol, the fellow will adhere to and build upon the principles established in the 'European Charter for Researchers and Code of Conduct for Recruitment of Researchers . The University of Bristol has demonstrated its alignment to the principles of this charter and in recognition of this, recently received the European Commission HR. Excellence in Research badge, which was awarded to only 37 other European universities. In partnership with the host supervisor Dr. Subramanian, Dr. Berthaut will establish a Personal Career Development Plan (PCDP) based on his specific training needs, which will be monitored at regular intervals and developed throughout this fellowship. In addition to continuing building his expertise in the field of HCI and Display technologies, the fellow will also develop his skill of being a researcher.

**Training on communication within the research group**
Communication and interpersonal skills are especially important in a scientific career. The fellow's development in these areas will be enhanced by:

- Regular discussions between the fellow and Dr. Subramanian on the progress of the project, at least once per week. The fellow will also have the opportunity to make a presentation on the project to the research group at least four times a year, as well as presenting posters and oral communications in scientific meetings. Dr. Subramanian and the members of the team will provide feedback after every presentation to help develop communication skills.
- The writing of research papers, for which the fellow will produce the first draft. Later drafts will be written in close collaboration between the fellow and Dr. Subramanian, in the course of which the fellow will receive detailed help and feedback on paper writing in English. The fellow will also be encouraged to write research proposals for work which he will undertake in his future independent career, and will receive help and advice from Dr. Subramanian on scientific and presentation aspects of crafting good research proposals.
- The opportunity (but not obligation) to participate in some undergraduate teaching (tutorials, workshops and practical demonstrating). If he chooses to do this, the fellow will attend a University training course on teaching and will receive mentoring, feedback and advice. This will provide excellent experience for a future career in academia.

**Workshops**
The University of Bristol also offers various workshops on complementary skills, and the fellow will have the opportunity to attend several training courses. A small selection of these is as follows:

- Personal impact and effective networking
- Strong roots: Managing the early stages of your research career
- Working towards a lectureship
- Getting people talking: facilitation skills in research
- Refreshing your approach to people management
- Advanced research grant writing for Science and Engineering
- Handling Information overload: effective reading and note-making
- Papers, rapid, focused, first-draft
- Presenting with confidence and flair
- Science writing for popular publication

*B2.2 Relevance and quality of additional research training as well as of transferable skills offered with special attention to exposure to industry sector, where appropriate*

**Leadership**
Dr Berthaut will benefit from a training in leadership and management. In particular, Dr Subramanian has a valuable experience on building and managing highly successful research projects. Dr Berthaut will benefit from training in publication of results in high-quality international venues such as CHI and NIME. Finally, the host

institute will support the Fellow's participation in international conferences and meetings to allow him to become part of an international peer-community and help establish a leadership position within that community. Overall, the Marie-Curie grant will enable Dr Berthaut to lay down the basis for for his research carrier.

**Complimentary research knowledge**
Dr Berthaut's areas of expertise are music interaction, 3D interaction techniques and devices, collaborative interaction and sound/music visualization. The host institute will provide him complimentary knowledge in display devices prototyping, which will be essential for both this project and future research on the visual immersion aspect of virtual musical instruments. In addition, Dr Berthaut will be able to enrich his knowledge on user studies for human-computer interaction thanks to the expertise of researchers of the Bristol Interaction and Graphics group on evaluation methodologies in public settings.

*B2.3 Measures taken by the host for providing quantitative and qualitative mentoring/tutoring*

**Training programs**
The University of Bristol has significant experience in training researchers, both 'new' (PhD students) and more experienced (research fellows, early career fellows, etc.). The faculty of engineering has staff development programs that are geared towards early-career research fellows who are interested in establishing an independent research career. These include personal mentoring programs as well as course modules a research fellow can attend.

**Experience on hosting/training**
The faculty of Engineering has hosted several research fellows in various stages of their research career. For example, Prof. Nigel Smart and Prof. John Rarity both received Advanced ERC grants while Prof. Jeremy O'Brien and Prof. Subramanian have both received ERC Staring grants. The faculty also includes several EPSRC and Marie Curie research fellows. Of relevance to this project is Dr. David Coyle (a Marie Curie research fellow from Trinity College Dublin) who recently joined the Bristol Interaction and Graphics group further strengthening the group's ability mentor early-career fellows in establishing an independent research career.
The Bristol Interaction and Graphics group has an excellent reputation of training high-quality researchers. The group has over 10 PhD students who are full-time members and another 4 who are affiliate members; it also includes 7 Post-docs and a project technician. The group has successfully mentored its 'researchers to start research fellowships in other parts of Europe. For example, Dr. Tania Pouli (PhD from this group) started a research fellowship in MPI (Germany), Dr. Jason Alexander (Post-doc in this group) started a lectureship in Lancaster University while Dr. Miguel Nacenta (Dr. Subramanian's student from Canada) started a Marie-curie fellowship in St. Andrews University.
The University attaches great importance to staff development. All members of staff receive a personalized induction on arrival and have annual career development interviews. Many courses are offered that are designed to aid personal career development (e.g. on job applications and grant applications, conference organization, teaching). There is also an annual Research Staff conference that encourages researchers specifically to reflect on their own professional development and gives them the opportunity to learn about what is on offer at Bristol and in the UK, as well as to network with other researchers in Bristol.

- The University of Bristol is a world-leading research institution consistently ranked in the top 30 in many world University rankings (Times Higher Education). The Bristol Interaction and Graphics group is a young, dynamic and hugely successful group that routinely attracts the best talents. The host supervisor Dr. Subramanian is an ERC starting grant holder with outstanding reputation for excellent research.
- The Bristol Interaction and Graphics group has over £4 million in research funding and has extensive links with European and International industrial collaborators like BBC, Philips, Samsung, H.P. and Microsoft. The group is well resourced in terms of hardware requirements and access to infrastructure for the project. This provides a well resourced and immediate channel for development and application of Dr. Berthaut's research.

The University of Bristol has a well-defined and tailored personal development program designed to ensure the fellow's career progression. As a full member of staff of the University of Bristol Dr. Berthaut will have full access to all these programs.

# B3 Researcher

*B3.1 Research experience*

**Dr. Florent Berthaut**

**Work experience**

*September 2011-* Lecturer and researcher
Lectures in Computer Science / Research within the INRIA Potioc Team
*University of Bordeaux 1*

*December 2010-February 2011,* Research Engineer
Development of an immersive instrument
*University of Bordeaux / SCRIME*

*November-December 2010,* JST/CNRS Postdoctoral Research Fellow
Research on the use of video game for collaborative musical instruments
*Kwansei Gakuin University*

*July 2007*, Internship
Implementation of a virtual reality center
(Powerwall, 6DOF infrared tracking, head-tracking, passive stereoscopy)
*INRIA Bordeaux*

**Education**

*2007-2010*, Ph.D. in Computer Science
“Building, manipulating and visualizing sound processes
in immersive virtual environments for musical performance"
*University of Bordeaux, France*

*2005-2007,* Master’s degree in Computer Science
Master thesis: “Graphical interaction : State of the art and musical application”
*University of Bordeaux, France*

*2001-2005*, License’s Degree in Computer Science
University of Burgundy, France

*2001*, Secondary School Diploma in Science
Mathematics specialization
*Saint-Cœur High school, Beaune, France*

*B3.2 Research results including patents, publications, teaching etc., taking into account the level of experience*

**International peer-reviewed journals**

F. Berthaut, M. Desainte-Catherine, and M. Hachet. Interacting with 3D Reactive Widgets for Musical Performance. Journal of New Music Research, 40(3):253–263, 2011.

**International peer-reviewed conference proceedings**

F. Berthaut, M. Desainte-Catherine, and M. Hachet. Interaction with the 3d reactive widgets for musical performance. In Proceedings of Brazilian Symposium on Computer Music (SBCM09), pages 13–20, Recife, Brazil, 2009.

M. Hachet, A. Kian, F. Berthaut, J.-S. Franco, and M. Desainte-Catherine. Opportunistic Music. In Eurographics, editor, JVRC 2009 (EGVE - ICAT - EuroVR), Lyon, France, 2009.

F. Berthaut, M. Desainte-Catherine, and M. Hachet. Combining audiovisual mappings for 3d musical interaction. In Proceedings of the International Computer Music Conference (ICMC10), pages 357–364, New York, USA, 2010.

F. Berthaut, M. Desainte-Catherine, and M. Hachet. Drile : an immersive environment for hierarchical live-looping. In Proceedings of New Interfaces for Musical Expression (NIME10), pages 192–197, Sydney, Australia, 2010.

F. Berthaut, M. Hachet, and M. Desainte-Catherine. Piivert: Percussion-based interaction for immersive virtual environments. In Proceedings of the IEEE Symposium on 3D User Interfaces, pages 15–18, Waltham, Massachusetts, USA, 2010.

F. Berthaut, H. Katayose, H. Wakama, N. Totani, and Y. Sato. First Person Shooters as Collaborative Multiprocess Instruments. In Proceedings of the International Conference on New Interfaces for Musical Expression, pages 44–47, Oslo, Norvège, 2011.

F. Berthaut, D. Jeanin and B. Martin. Advanced synchronization of audio or symbolic musical patterns: an algebraic approach. To appear in Proceedings of the International Conference on Semantic Computing, ICSC 2012, Palermo, Italy, 2012.

**National conferences**

F. Berthaut, M. Desainte-Catherine, and M. Hachet. Interaction 3D pour la musique. In Actes des 2emes Journées de lAFRV, pages 75 – 81, France, 2007.

F. Berthaut, M. Desainte-Catherine, and M. Hachet. Widgets réactifs 3d. In Proceedings of the Journées d'informatique musicale (JIM08), 2008.

N. Mellado, P. Reuter, and F. Berthaut. Analyse de l'influence des systèmes de visualisation immersif sur l'assemblage virtuel de fragments en archéologie. In AFRV 2009 - 4ème Journées de l'Association Française de Réalité Virtuelle, page p83, Lyon, France, 2009. 4 pages.

**Teaching and supervising**
Dr Berthaut has been teaching at both the University of Bordeaux and the ENSEIRB since 2008. He lectures courses in his area of expertise such as sound and music computing, musical interaction and new instruments, human-computer interaction, virtual reality and 3D interaction. But he also lectures general computer science courses, both theoretical and practical, such as graphs theory, python programming language, object-oriented programming (JAVA and C++), UNIX systems and programming project management.
He has supervised various students projects, both in his areas of expertise (virtual reality, human computer interaction and music computing) and in other areas such as data visualization or image processing and analysis.

**Reviews**
Dr Berthaut is a reviewer for conferences of the music computing and interaction field such as the New Interfaces for Musical Expression conference and the Sound and Music Computing conference.

**Research Results**
This project is an extension of Dr Berthaut 's previous research. His Ph.D. thesis was entitled: "Construction, Manipulation and Visualization of sound processes in an immersive virtual environment for musical

performance". It consisted in exploring new possibilities brought by virtual reality and 3D interaction for musical interaction. Such possibilities include new musical gestures, new representations of sounds and musical structures but also improved mappings between physical gestures/sensors and virtual processes thanks to visual immersion techniques. Dr Berthaut started by studying how to represent sound processes and musical structures in an immersive virtual environment, which resulted in the concept of 3D reactive widgets [3][5], i.e. 3D objects associated to sound processes with bidirectional mappings, taking inspiration from work by Levin [19] and Jordà [15] on graphical musical interfaces and by Healey [13] on information visualization. Then he investigated how to interact with those sound processes by adapting 3D interaction devices, techniques and metaphors to match musical gestures categories defined by Cadoz [11]. In particular, this led to the creation of the Piivert [6] interaction device for excitation and selection gestures and of the 3D tools called Tunnels [5] for modulation gestures. He finally designed and implemented a new musical technique in an immersive virtual musical instrument called Drile [3], taking advantage of these new visualization and interaction possibilities. All these results were published in conferences in both fields of music computing and virtual reality, and in one journal. After his thesis, while refining each of these results in public performances with Drile[2][3] , he pushed his exploration of 3D interfaces for music in new directions.

During a first project, Dr Berthaut spent one month and a half at Kwansei Gakuin University to work with Prof Haruhiro Katayose and three students on the use of collaboration and interaction techniques of 3D video games for musical performance. Dr Berthaut drew inspiration from the research done at Kwansei Gakuin on both entertainment and music computing. The project resulted in a new musical instrument called Couacs and a publication at the New Interfaces for Musical Expression conference [7].

The Fellow also spent one month at McGill University in Montreal, Canada withing the IDMIL laboratory of Prof. Marcelo Wanderley where he improved the interaction techniques used in the Drile instrument with help from the researchers.

For another research project, Dr Berthaut spent two months to the Center for Computer Research on Music and Acoustics (CCRMA) at Stanford University to work with Prof Chris Chafe and Ph.D. student Luke Dahl in order to transpose the collaboration modes used in new instruments orchestras, e.g. the Stanford Laptop Orchestra (Slork) and the Mobile Phone Orchestra (Mopho), in a 3D immersive virtual environment. Based on interviews with CCRMA composers, new 3D metaphors were designed and implemented in the Drile instrument. The implementation is currently being completed and experiments are being designed at the INRIA Bordeaux to evaluate these metaphors with musicians.

Finally, one of his current project is the study of scenography solutions, i.e. use of specific display technologies such as stereoscopy, head-tracking and semi-transparent screens but also audience and musicians placement, in order to ensure a good experience for both spectators and musicians in immersive musical performances.

With this new project in collaboration with the Bristol Interaction and Graphics group, he intends to make use of the possibilities brought by virtual and mixed reality in terms of 3D representation and immersive visualization in order to improve the experience of spectators and musicians of every level of expertise with digital musical instruments.

### *B3.3 Independent thinking and leadership qualities*

**Initiated research projects**

Dr Berthaut has been investigating his own research direction since his master thesis in 2006, when he brought the idea of combining two courses he was taking, i.e. virtual reality and music computing. He then explored new ideas in both human-computer interaction and music computing fields during his Ph.D. Thesis. According to his thesis jury : "Florent Berthaut outlined the great scope of the spectrum of his thesis work: Music computing, Virtual Reality and 3D Interaction. The jury would like to highlight his creativity, scientific rigour, work force and personal commitment." After his thesis, he received two research grants, one from a collaboration between the French institute CNRS and the Japanese institute JST for his project at Kwansei Gakuin University, and one from the Laboratoire Bordelais de Recherche en Informatique (LaBRI) for his project at CCRMA.

**Artistic projects**

Dr Berthaut also collaborates on a regular basis with French artists, both musicians and visual artists, on software

[2] http://vimeo.com/26314178

[3] http://vimeo.com/15945215

projects for live performance and installations. For example, with the graphic design studio Tabaramounien[4], he develops CssLsd[5], a Firefox plug-in for live tweaking of web pages style, and VjPirate[6], a pattern-based visual instrument. Some of his music applications are available in music specialized operating systems such as the Gnu/Linux distribution Tango Studio. Finally, Dr Berthaut is involved in artistic projects such as the organization of electronic music events, such as concerts and jams, in Bordeaux.

### *B3.4 Match between the fellow's profile and project*

Dr Berthaut is the appropriate candidate for this project for three reasons.

**Familiar research direction, existing resources**
The first is that he has already started to explore research issues addressed by both phases of this project during his past research work.

- At the end his thesis he worked on scenography for immersive virtual musical instruments (IVMI)[7], that is how to define virtual cameras, physical screens and place spectators and musicians in order to provide the best experience for every participant in the musical performance. In particular he investigated the consistency between physical musical gestures and the projected virtual 3D instrument. This work was not published but the first results will serve as a basis for the phase of this project related to audience experience.
- For the same phase, the work of the Fellow on 3D representation of sound processes will be essential as it will give insights on how to visualize components of digital musical instruments in order to make them more understandable by spectators. For instance, the 3D reactive widgets [3] developed by Dr Berthaut allows for both the visualization of sound processes with several properties and their integration in a mixed-reality interface which will provide the correct real-virtual consistency needed in this project.
- Dr. Berthaut also investigated how to take musicians level of expertise into account with the hierarchical live-looping musical technique, in which musicians build and manipulate musical trees. These trees give access to different mapping ratios, from a low input complexity with a high musical complexity on the roots to the opposite on the leaves. This technique was implemented in the Drile immersive virtual musical instrument [4]. This instrument is therefore perfectly appropriate for prototyping ideas for the phase of this project investigating adaptive mapping ratios.

**Familiar methodology**
On the methodological side, Dr Berthaut is familiar with user studies and conducted two of them during his Ph.D. Thesis, one on 3D musical interaction and one on audiovisual mappings, both within-subjects studies and both featuring task performances and user judgements measurements. This will be essential to design experiments and do statistical analysis on acquired data for this project. He is also familiar with prototyping electronic devices, although essentially interaction devices such as the Piivert device [6] .

**Position within the artistic community**
Finally, Dr Berthaut has built a lot of connections with musicians of local electronic scenes in both various part of France, as a musician in his projects “Hitmuri”[8] and “The Hobart Phase”[9] and as an organizer. For instance, in Bordeaux he organizes electronic music events with the Octet[10] group . He also works with the “Studio de composition et recherche en musique electroacoustique” (SCRIME)[11], a structure of the University of Bordeaux which researchers and composers, both as as a researcher and as a musician. Finally he is involved in electronic events in Bordeaux such as the “Goûters Electroniques” organized by the “Electronoon addicts”[12]. But he is also

4 http://tabaramounien.com/
5 http://www.hitmuri.net/index.php/Software/CssLsd
6 http://www.hitmuri.net/index.php/Software/VjPirate
7 http://en.wikipedia.org/wiki/Immersive_virtual_musical_instrument
8 http://www.hitmuri.net/index.php/Music/Hitmuri
9 http://thehobartphase.net/
10 http://www.octet-bordeaux.com/
11 http://scrime.labri.fr/
12 http://electronoonaddicts.wordpress.com/

involved in groups in other countries such as the San Francisco electronic musicians meetup group[13], which he discovered during his stay at Stanford University. These contacts and the ones that he will make in Bristol will allow him to rely on the experiences of amateurs and professional musicians for both design and evaluation of the proposed solutions.

### *B3.5 Potential for reaching a position of professional maturity*

Dr Florent Berthaut already has a strong research direction and expertise in his field, as demonstrated by the many projects he has been involved in, both as a conductor and a participant. In addition, he has built many connections with researchers in different laboratories. Therefore, he already has experience on small scale collaborative research projects.
With the help of Dr Subramanian and the Host Institute, he will improve his management skills for large research projects, involving both researchers and artists, in building and research phases as well as dissemination phases. With the Marie-Curie program, Dr Berthaut will be given the opportunity to establish a leading position within the music computing and human-computer interaction research communities, but also to build partnerships with the industry sector. Doing a two years post-doctorate in another country will improve his chances to obtain a position in French national research institutes such as CNRS and INRIA. Given his previous experience in teaching and the supervising he will be able to do during this project, he will also have better chances when applying for an assistant professor position in a French University.

### *B3.6 Potential to acquire new knowledge*

**Previously acquired knowledge**
In most of his previous research projects, Dr Berthaut gained both theoretical and practical knowledge. During his Ph.D. Thesis, he learned about the fundamentals of music computing and 3D interaction, as well as experiment design and interaction devices prototyping. During his post-doctoral projects, he gained expertise on interaction and collaboration in video games thanks to researchers and students from Kwansei Gakuin University, on haptic feedback and musical gestures with researchers of the IDMIL at McGill University and on musical collaboration in new orchestras with composers of the CCRMA at Stanford University. At every stage of his work, Dr Berthaut was able to integrate ideas from various fields into his research.

**Knowledge on new display technologies**
During both phases, he will learn more about mixed-reality display technologies. In particular, he will learn about the existing Mustard prototype developed by the Bristol Interaction and Graphic group. Then he will build his own prototype, in order to adapt the display to specific constraints of this project such as stereoscopic viewing and integration with digital musical instrument configurations.

**Knowledge on user studies**
Dr Berthaut will learn how to design experiments to study users experience: which scales should be used to measure emotions / experience / understanding, which protocol is the more appropriate (conversation / video analysis, questionnaires), and finally which statistical analysis methods should be used. This will complete the knowledge he has on user studies based on tasks performance analysis.

**Knowledge on organology**
During the first phase, he will also learn about the organology of digital musical instruments, with the help of musicians involved in the workshops and by studying the literature on this subject. This will help him develop a visualization tool for the audience adapted to the various software and hardware configurations used.

**Knowledge on learning process**
Finally, during the second phase of the project, he will investigate learning process, first in music by studying musicology and music interaction literature, but also in other fields.

[13] http://www.meetup.com/sf-emm/

# B4 Implementation

*B4.1 Quality of infrastructures/facilities and international collaborations of host*

**University of Bristol**
The University of Bristol is one of the most prestigious universities in the UK. It is a thriving international community combining excellence in research and innovation with a vibrant entrepreneurial culture. Research is at the heart of the University's mission and accounts for its international reputation. The University organizes its academic affairs in 27 Schools and 15 research centers arranged in six faculties: Engineering, Science, Medicine and Dentistry, Medical and Veterinary Sciences, Social Sciences and Law, and Arts. In the 2008 UK Research Assessment Exercise (RAE2008), nearly 93% of research at the University was deemed to be of an international standard. Over 60% of the research assessed was awarded either the top 4* rating, defined as 'world leading', or the 3* rating, 'internationally excellent'. As a result, in 2009–10 the University was allocated the 8th highest share of government research funding in the UK. The University participates in hundreds of international collaborations both within and outside of Europe. In particular, the University is currently participating in over 200 FP7 projects to date. More than 50 of these are Marie Curie fellowships proving that the university is very well placed to support this fellowship. The University of Bristol is a partner in the Worldwide Universities Network (WUN), an alliance of internationally reputed, research–led universities with the aim of promoting a global research culture through collaborative academic activity.

**Department of Computer Science**
The Department of Computer Science is among the top in the UK. As such it naturally possesses all the resources and infrastructures required to carry out a research project in one of its core areas of activity, and to host Dr. Berthaut. These include the usual arrangements (office space, computing facilities and library access) and access to specialist equipment and materials that are part of the Bristol Interaction and Graphics group.
The research group has several novel display environments that are relevant to this project. In particular the group is the only one in Europe and one of only 3 world-wide to have access to multi-view displays that are see-through (the most famous other group being the Google Glass project from California).

**Bristol Interaction and Graphics group**
The research groups also has a large number of international collaborations, with various leading research labs around the world from Osaka, Tohoku and Tokyo University in the far-east to Philips Research (NL), HP labs (UK), University of Copenhagen (Denmark) and FBK Trento (Italy) in Europe and University of Toronto, AutoDesk, Microsoft Research (Seattle), UC Berkeley and University of Manitoba in North-America to name a few. The group has a fantastic seminar program[14] that brings visitors from all over the world to visit its research facilities and establish new collaborations. This means Dr. Berthaut will get unparalleled exposure to the international peer-community allowing him to
a) establish his own collaborations with these visitors.
b) giving his the opportunity to serve on international program committees
c) providing access to resources and equipment that may not be available at Bristol but available with these collaborators
The Bristol Interaction and Graphics group also collaborates on a regular basis with artistic structures such as the Pervasive Media Studio[15]. The Pervasive Media Studio is a structure which gather "artists, creative companies, technologists and academists" around artistic projects involving new technologies. In particular, these explore installations in public spaces, artistic performances, games but also new interfaces. This structure will be a good environment for workshops and demonstrations part of this project. Another contact of the host research group is the BBC Bristol, which organizes many public shows during the summer. These festivals will provide good opportunities, notably using the BBC large public screen, to demonstrate the results of this project in real performance situations.

*B4.2 Practical arrangements for the implementation and management of the research project*

[14] http://www.big.cs.bris.ac.uk/seminars

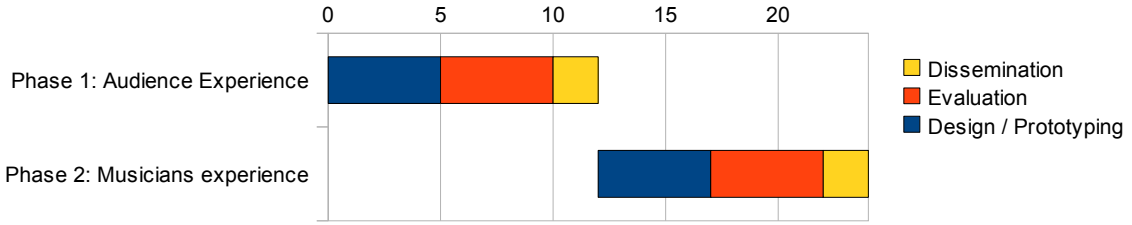
[15] http://www.pmstudio.co.uk

The researcher will be hosted as a postdoctoral fellow, in the Department of Computer Science, participating in the Bristol Interaction and Graphics group. The scientific management will be with the research group as a whole, with which the collaboration will be undertaken. The group meets weekly to discuss scientific developments - both within the group itself and in the field - as well as organizational issues.
Throughout the project, Dr Berthaut will have the opportunity to consult and collaborate with Prof. Subramanian in a number of ways, both in person and via electronic means. More formal meetings will be held at the end of each month.
Dr. Berthaut will have unrestricted access to our custom built see-through display. He will also have access to high-end workstations that are specifically equipped with graphics cards required for driving such displays. Dr. Berthaut will also be able to assemble custom configurations of these displays (different sizes, resolutions and arrangements of display elements) and will at the same time benefit from the expertise of the respective lab members who use these facilities on a regular basis.
The principal host (Sriram Subramanian) acts as a manager of all administrative issues arising. The University of Bristol has experienced staff for dealing with external funding, and especially support from the European Commission. As for the local arrangements, they will be the usual ones, such as assigning office space, providing computing facilities, access to electronic and standard communications, Internet and information services of the university.
Research reports will be produced at six-month intervals for Professor Subramanian during the fellowship and yearly reports will be produced to the European Commission to inform on the scientific advances of the project.
An induction programme will be timetabled to ensure orientation to access the various facilities at Bristol University and the BIG group. This will include induction to the lab and its hardware facilities, setting up the IT infrastructure and so on. Additionally, to help researchers with their career management, dedicated courses offered by the University of Bristol are attended as indicated in section B2. The fellow will also be involved in the research group activities in order to make use of project learning synergies between the Marie Curie project and related research projects, such as within the ERC and UltraTouch project of Dr. Subramanian, in which also GIST group of the University of Glasgow is involved; helping the fellow establish new research contacts.

### *B4.3 Feasibility and credibility of the project, including work plan*

**Strong research background**
This research project heavily relies on research done by both Dr Berthaut and by other researchers including those of the host institute. For instance, display technologies that will be used have already been successfully built, resulting in several scientific publications. Interaction and representation metaphors which will serve as a basis for this project are used in several musical instruments (Drile, Couacs ...) which were validated by both scientific publications and artistic performances. This project also relies on validated work by other researchers, including Jordà on graphical interfaces for music, especially interactive tables, Benford on the experience of spectators in mixed-reality performances, and of course work by the Host Institute and Dr. Subramanian on both mixed-reality multi-user displays and liveness of digital musical instruments. Finally, each idea developed during this project will be evaluated with user studies as explained in section B1.2 and in this section.

**Structured work plan: Phases and parts**
As explained in section B1, two issues will be investigated in this project, dividing it into two phases.
The following chart gives an overview of their overall structure. Both phases are composed of two research parts, already described in section B1: Design /Prototyping and Evaluation. In addition, as expressed previously, both phases include a dissemination part involving software release, demonstrations, concerts and conferences. The chart does not display the overlapping between parts of each phase nor the inner tasks of each part. These are described in the following paragraph and depicted on the Gantt chart.



**First phase, Software and hardware prototyping with user feedback (months 1-5)**
The first part of this phase will involve software and hardware prototyping based on 3D metaphors designed by the Fellow and mixed-reality displays of the Host Institute, combined subsequently with refinements with artists during workshops, following several iterations. After a first month of prototyping, a first workshop with local musicians (10-15) will be organized in order to gather informations on used instruments. Then one workshop will be organized every month (4 workshops in total) in order to evaluate the successive refinements and adapt the prototype to participants instruments. At the end of the 5 months of prototyping, 5 representative digital musical instruments will be chosen from the ones of the participants to be used for the evaluation. Deliverables and risks for this part are displayed in the following table.

| *Methods* | *Analysis* | *Deliverable* | *Risks* | *Mitigation* |
|---|---|---|---|---|
| Hardware and software prototyping: Building a see-through multi-user display and developing a 3D interface connected to digital musical instruments. Classification / Analysis of instruments in order to design 3D representations of their components. | Feedback from researchers of the group.<br><br>Hands-on evaluation and discussions with musicians: adaptation to their system, Refinement of instruments components representations. | 3D digital musical instrument visualization software. Associated see-through multi-view display. | Technical problems when building the display device<br><br>Prototype not compatible with one or several common digital musical instruments | Help of the researchers of the host institute<br><br>Early testing by musicians |

**First phase, User study (months 5-10)**
The second part will consist in the design of a user study, including pilot testing. The design will start during the prototyping phase because modifications may be needed after pilot testing. A first version of the experiment will be defined including exact conditions, physical setup, protocol, questionnaires. The study will investigate several variables such as the collocation of the visualisation and the musicians gestures, or the visualisation of links between sensors components and sound components, or the level-of-detail of the 3D representation, i.e. if only groups of components are represented, or all components. Each subject will watch one performance with each of the 5 selected instruments under different conditions. The condition/instrument pairing will be distributed among subjects with methods such as the Latin Squares to prevent biases such as learning effect. Subjects understanding of the instrument will be evaluated with a questionnaire, for example by asking them which sounds the musician was playing and which was played by a predefined sequence and comparing to the ground truth, together with their emotion regarding the performance. This first experimental protocol will be evaluated with a pilot testing on 5 subjects. If biases are detected, or if subjects experience troubles participating, the protocol or the prototype itself will be refined. Then the proper study will be conducted between months 8 and 10 on 20-30 subjects and results from questionnaires will be analysed. Results from the user study will be combined with description of the prototype and other gathered data such as the classification of digital musical instruments components in a conference paper and submitted. The following table sums up the methods used together with the deliverable and risks.

| *Methods* | *Analysis* | *Deliverable* | *Risks* | *Mitigation* |
|---|---|---|---|---|
| Short-term user study. Subjects watch performances of instruments with different conditions. | Statistical analysis of understanding scores from questionnaires (ANOVA). Evaluation of subjects emotions | Conference paper on measured impact of additional 3D visualization system on the understanding and enjoyment of | Non significant results | Pilot testing to adapt the study and eventually refine the prototypes. |

| | | | | |
|---|---|---|---|---|
| Questionnaires to see what subjects understand on the instruments and their emotion regarding the performance. | (Likert Scale, Geneva Emotion Wheel). Correlation between understanding and emotion (Pearson). Subjects background with electronic music. | digital musical instruments by the audience, and correlation between understanding and enjoyment. | | |

**First phase, dissemination to researchers, musicians and the general public (months 10-12)**
At the end of this phase, a paper describing the developed solutions will be written and submitted for a conference, together with a scientific workshop proposal on "Improving audience experience". Longer versions of papers from that workshop will later be gathered and proposed to a publisher. The dissemination will also involve demonstrations of the system to the general public and a concert with musicians of the workshops using the developed system. Developed software will also be released with access to the source code under a Free Open-source license and an online guide for musicians for building the display will be published.

**Second phase, Software prototyping based on existing instrument and display device(months 13-17)**
The second phase, which investigates the improvement of the experience of musicians with different level of expertise using adaptive mapping ratios, will follow the same steps.
The first part will involve the modification of the first see-through multi-user display prototype to add stereoscopy and increase its size, and the modification of Drile to allow for level-of-detail views of the musical trees.

| *Methods* | *Analysis* | *Deliverable* | *Risks* | *Mitigation* |
|---|---|---|---|---|
| Hardware and software prototyping: Adding stereoscopy and increasing screen size of the first display. Modifying Drile. | Feedback from researchers of the group. | Modified Drile version with separate levels-of-detail views. Large-size multi-user see-through stereoscopic display. | Technical problems when modifying the display device | Help of the researchers of the host institute |

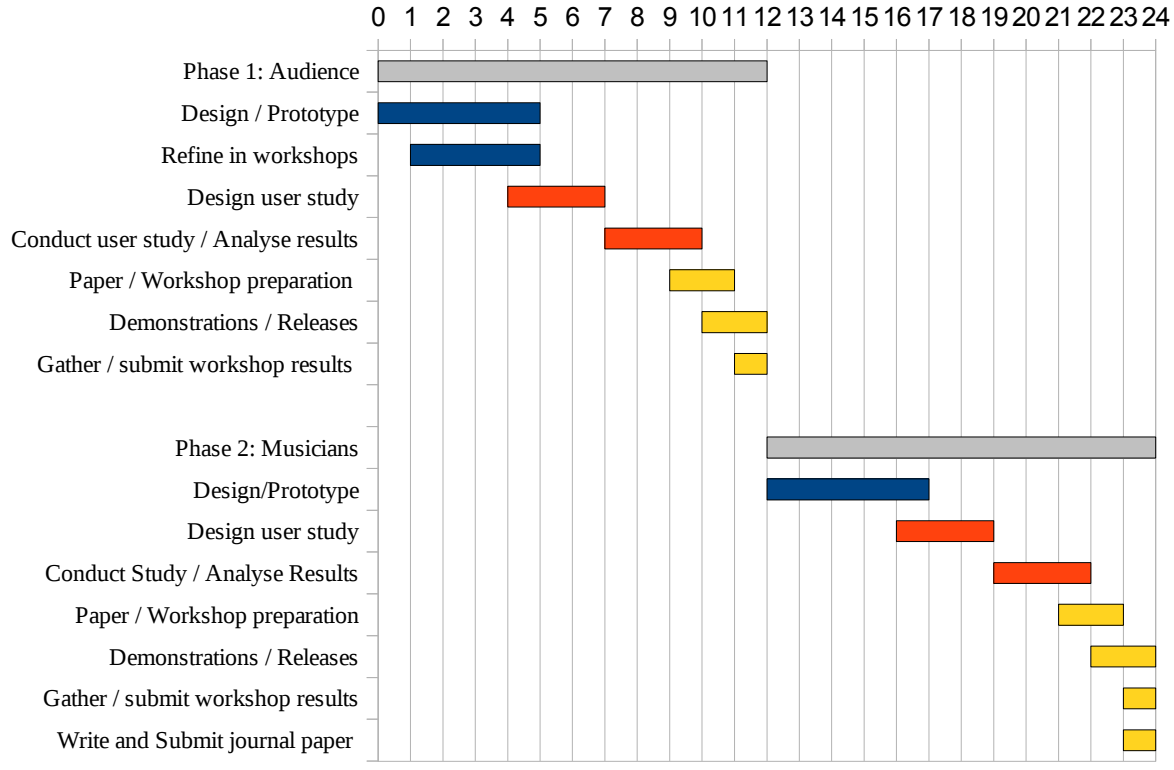
**Second phase, Short / long term user studies (months 17-22)**
During the second part of this phase, both long-term and short-term user studies will be designed during three months then conducted during the three next months , as described in section B1.2. Once again, the design will start during the prototyping part, as pilot testing may uncover some needed modifications on the prototype. A first draft of the experimental protocol, which might be modified after the pilot testing, is as follows:
A first, short-term between-groups study will involve two groups of subjects. Subjects of the first group will simply play with the prototype but only with the highest musical/graphical level-of-detail. Subjects of the second group will play successively with increasing level of details. Questionnaires will then be given to them to evaluate their experience with the instrument, notably using specific scales such as the Likert Scale and the Geneva Emotion Wheel. This first study will be held during the first month of the study. The long-term study will span over three months. It will also involve two groups of subjects. All subjects will practice the instrument once a week, subjects of the first group with adaptive mappings, i.e. level of detail increasing each month, and subjects of the second group only with the highest level of detail. At the end of the three months, a musical task consisting of replaying a musical sequence will be given to each subject and evaluated by measuring similarity. During the whole process, questionnaires will be filled after each session, in order to evaluate the experience of subjects throughout the learning process.

| *Methods* | *Analysis* | *Deliverable* | *Risks* | *Mitigation* |
|---|---|---|---|---|
| Short-term between-groups user study to measure enjoyment | Statistical analysis of performances on musical tasks. | Conference paper on the impact of the adaptive | Non significant results | Pilot testing to adapt the study and eventually refine the |

| | | | | |
|---|---|---|---|---|
| with and without the adaptive mappings. Long -term study with evaluation of the learning process. Questionnaire on subjects experience | Evaluation of subjects emotions using specific scales. | gesture/sounds mappings on accessibility and learning process of digital musical instruments | | prototypes. |

**Second phase, dissemination to researchers, musicians and the general public (months 23-24)**
Once again, the dissemination part will consist in a paper submitted to a conference and the organization of a scientific workshop on "Improving accessibility and learning process of digital musical instruments". Papers from this workshop will be gathered and submitted to an editor for publication. Concerts and public demonstrations will also be organized with help from the contacts of the Host Institute, and software source code and hardware guidelines will be released.
Finally, a journal paper will be written and submitted to sum up all the results of this project.

**Structured work plan within the phases and parts**
The following Gantt chart gives an overview of the organisation of the two phases and the inner tasks.
It should be noted that conferences dates might not match the defined timeline. Conference will be selected from the list established in section B1.4 according to their deadline, and by giving priority to most recognized conferences such as CHI, UIST, VR, ISMAR, NIME. In the same manner, the gathering and submissions of scientific workshop results, included in the dissemination parts, will depend on chosen conferences.




**Identified management risks**

| *Risks* | *Probability and Consequences* | *Mitigation* |
|---|---|---|
| Under-estimating effort | High probability<br>Not finishing parts on time,<br>Delaying following parts/phase | Regular evaluation of progress with Dr Subramanian .<br>Each part of each phase is designed |

| | | |
|---|---|---|
| | | to make a substantial research contribution in itself. This approach gives each of the phase the best possible chance of success. In the unlikely event that any one components fails completely, the entire program will still be a success, since each of the components are very significant in their own right. |
| Not finding enough participants for prototyping workshops and user studies | Medium probability<br>Not adapted prototype<br>Non significant study results | Early search for participants.<br>Search in both Bristol in structures working with the Host Institute and France in structures known by Dr Berthaut. |
| Publications not accepted at desired venues | Medium probability<br>Results not published | Training with Dr Subramanian on writing papers for these specific conferences. |
| Not being able to have performances/demonstrations in the city | Medium probability<br>No dissemination of results to the general public | Relying on contacts of the Host Institute |

*B4.4 Practical and administrative arrangements and support for the hosting of the fellow*

The University of Bristol's Positive Working Environment (PWE) initiative is designed to make working life productive, rewarding, enjoyable and healthy for all its staff. In June 2009 the University received the Outstanding Human Resource Initiative Award at the *Times Higher Education* Leadership and Management Awards, in recognition of the groundbreaking success of its PWE agenda. As part of the PWE agenda, the University is committed to supporting and developing Research Staff and has built up a program of activity in this area over the last 13 years. In 2010/11 this program was embedded into the central University Staff Development strategy and Academic Staff Development (including research staff) forms one of the 3 main strategic areas of activity for 2011/12. In 2010, the University was awarded the European Commission's HR Excellence in Research badge in recognition of its approach to the recruitment, management and development of researchers. As part of this recognition process, the University has set out an action plan for the Implementation of the UK Concordat to support the Career Development of Researchers. The current provision for research staff is managed by a dedicated Staff Development Manager responsible for Academic Staff Development and includes over 40 short career development workshops on a variety of topics from research skills such as presenting and writing papers and grants through to sessions on careers outside academia; a longer leadership and management programme; a two-day teaching and learning programme; access to 1:1 career coaching; a mentoring circles scheme; a dedicated research staff career development website and weekly e-mail bulletins; an annual Staff Review and Development process; and a research staff departmental representatives committee to enhance two-way communication at all levels. An important part of the Academic Development Strategy since 2010 has been to provide leadership and management development for supervisors of research staff, thereby improving the working environment of research staff at the University. The University has also implemented Academic Career Pathways and role profiles, clarifying what is expected from researchers at different levels and making the pay and grading process much fairer and more transparent. These role profiles will form the basis of an Academic Staff Development framework currently being developed by Staff Development. The University employs a dedicated Senior International Staff Adviser who coordinates an advice and guidance service on a range of issues to ensure the process of arriving in the UK and settling at the University is a smooth one, from arranging accommodation and setting up a bank account to medical care, driving in the UK and childcare. If they should choose, individuals can be paired with existing members of staff from the same country of origin to facilitate any transition to UK life. This service includes 1:1 drop-in and a dedicated website. The University Finance Services have extensive experience of managing European project grants and it will be responsible for administrating the project budget. The University's Division of Research and Enterprise Development, also extremely experienced in the management of European projects, will manage the contract.

# B5 Impact

*B5.1 Impact of competencies acquired during the fellowship on the future career prospects of the researcher, in particular through exposure to transferable skills training with special attention to exposure to the industry sector, where appropriate*

Competencies acquired during this project will have an impact on several levels.

**Management**
First, Dr Berthaut will gain expertise on the organization of scientific events and projects. This knowledge will make it easier for him to start and manage new research project, including raising funding and gathering researchers. This is extremely important as research done in France is more and more project-based, as it is in Europe.

**Communication skills**
Moreover, Dr Berthaut will benefit from a training with Dr Subramanian on writing research papers targeted at the most important conferences in his field such as CHI, NIME, UIST. This will be essential for the dissemination of his future research projects and the establishment of a leadership position within the research community.

**Displays technologies**
On the research aspect, knowledge acquired on display prototyping will be helpful as the use of visual feedbacks is more and more prominent in research in the music interaction field. Furthermore, the display prototype that Dr Berthaut will develop during this project will be an essential component of his future research projects combining virtual reality and music interaction, as it will combine new see-through and multi-user possibilities with traditional immersive aspects such as head-tracking and stereoscopy. For instance, he will be able to use these displays to pursue the investigation of scenography for immersive virtual musical instruments.

**User studies in public settings**
Also, the design of user studies oriented towards public settings and spectators will be essential in the recent trend that consists in investigating the accessibility of new musical instruments and more generally of user interfaces, in particular with the idea of “natural interfaces”. In addition, he will learn different ways of measuring subjects emotions, through questionnaires or conversation analysis, which will be very important for his future research.

**Contacts with the industry sector**
Moreover, instruments and techniques developed during this project may easily be transferred to the industry sector, for example with the help of Dr Berthaut's contact at Infusions systems[16]. In fact, companies such as Reactable[17] or Smule[18] have already proven that new musical interfaces coming from laboratories and pushed by researchers themselves might lead to very successful products. Another possibility of industrial output might be the French company Immersion[19], with which Dr Berthaut's current research team (INRIA Potioc) collaborates for the finalization of research prototypes and the commercialization of the finalized products.

**Research mobility**
Finally, this post-doctoral project in another country will be an important advantage when applying for a position in a French research institute such as INRIA, where Dr Berthaut has already worked, or the CNRS. Dr Berthaut already has a good experience in teaching and this project will allow him to establish a strong research position within the human-computer interaction and music computing research communities. Therefore, this project will also improve Dr Berthaut's chances of obtaining a position as an assistant professor (maître de conférences) in a French University.

[16] http://infusionsystems.com/catalog/
[17] http://www.reactable.com/
[18] http://smule.com/
[19] http://www.immersion.fr/

*B5.2 Benefit of the mobility to the European Research Area*

Dr Berthaut has already been involved in projects in Japan, the U.S.A and Canada, each time with both researchers and students. These trips allowed him to encounter different approaches on music computing and interaction. In the same manner, this project will benefit from the variety of approaches used by UK researchers of Bristol and other universities in the fields of human-computer interaction, mixed-reality and music computing. For instance, much research was done on mixed-reality from the audience point of view by Steve Benford of the University of Nottingham. Also, setting the project in the city of Bristol, with its rich electronic background enables useful collaborations with artists who will provide essential insights.

*B5.3 Development of lasting cooperation and collaboration with other countries*

Collaborations will be developed between the Bristol Interaction and Graphics group, the fellow and the following laboratories/structures.

**France**
The first and strongest connection will be created between the host institute and the French INRIA Potioc Team in which the fellow currently works. In fact, research done in these two teams is very complimentary. For instance, the Potioc team focuses on human-computer interaction techniques and metaphors, including 3D interaction, multi-touch surfaces or brain computer-interfaces, while the Bristol Interaction and Graphics group focuses among other subjects on display technologies, haptic feedback or audience experience. This project will initiate a fruitful cooperation which will likely result in many research projects.
Another cooperation will be set up with the Scrime at the University of Bordeaux. This structure gathers local musicians and composers and researchers from the University of Bordeaux so that can exchange competencies and build artistic and research projects. Collaborations could be set up between the Bristol Interaction and Graphics group and the Scrime in the form of workshops for example to provide composers with new tools and researchers with new ideas / outcomes.

**Canada**
Infusion systems is a company based in Montreal, Canada and run by Dr. Axel Mulder, whose work also relates to immersive virtual musical instruments. Dr. Berthaut and Dr. Mulder regularly exchange ideas on the subject of 3D interfaces, making Infusion systems an appropriate industrial output for the results of this project.

**United States**
As a result of Dr. Berthaut's research project at CCRMA at Stanford University, a research collaboration is already active which might extent to the issues investigated in this project. In fact, improving the audience experience that researchers of CCRMA are very interested into, given their work on laptop orchestras, where the actions of musicians are even more unclear than for single musicians.

**Switzerland**
Finally, a collaboration will also be started with Alain Crevoisier of Future Instruments[20] in Switzerland. Future instruments is a research network composed of people from "the Music Conservatory of Geneva (HEM-GE), the Swiss Federal Institute of Technology in Lausanne (EPFL), and several Schools of the University of Applied Sciences Western Switzerland (HES-SO)" which develops new hardware and software for musical interaction, mostly based on interactive surfaces. Some ideas investigated in this project come from discussions with Alain Crevoisier and results, namely new visualization and interaction metaphors and technologies, will likely be integrated in their own products.

*B5.4 Contribution to European excellence and European competitiveness regarding the expected research results*

Research on new musical instruments is already a field of excellence in Europe, in both the academic and industry sectors. For instance, several European laboratories are recognized as leaders in this field such as the

[20] http://www.future-instruments.net/fr/index.php

MTC group at Pompeu Fabra University in Barcelona, Steim in Amsterdam, SARC in Ireland, or the IRCAM in Paris. Some of these laboratories have produced successful, in a commercial and artistic manner, musical instruments such as the Reactable. Moreover, European companies, mostly located in Germany, ranging from small to large, produce worldwide famous hardware and software musical instruments such as the Eigenharp by Eigenlabs (U.K.) or Live by Ableton (Germany).
This project will feature significant contributions to the fields of music interaction and human-computer interaction. First of all, new insights on audience perception of musical interaction will be brought by studying visualization technologies and metaphors. These findings will add up to research by Benford on public performance, bringing European laboratories to a leading position on this issue.
This will also be the case for the contributions made on the learning process for musical instruments., as they will push further the ideas developed by Jordà. These findings might also be transposed to other fields of human-computer interaction where learning is an important component. Software solutions will also be developed in a way that makes them easy to integrate into existing instruments, with appropriate licenses for open-source and proprietary software. Assistance will be be given in priority to European companies.

### *B5.5 Impact of the proposed outreach activities*

**Dissemination to the general public**
To the general public, concerts and organized to demonstrate results will hopefully help them perceive the complexity and richness of electronic music performances and of the associated new musical instruments. Demonstrations of instruments made more accessible might also simply encourage people to start practising them as any acoustic instrument. It is essential for this public research to be disseminated as much as possible. Therefore, as many public demonstrations will be held, both in Bristol for example during the BBC festivals but also during the many events organized by the Scrime in Bordeaux, France. Another impact of the organization of public demonstrations could be partnerships with schools as the testing and improvement of learning process could benefit children who want to learn an digital musical instrument. In Bordeaux, the Scrime already has contacts with teachers who experiment new musical instruments in their classroom, which could be a good starting point for this idea.
Moreover, by conducting online user studies, subjects which would not come for a “live” experiment, in particular people not much interested in electronic music might enjoy a new experience that they are not used to.

**Tools for musicians**
A very important point is that all developed software will be publicly released under a free open-source licence (GNU General Public License) so that it can be used directly by musicians and so that components can integrated in existing instruments. Results from public research should be accessible to everyone.
Workshops with local artists in Bristol and in Bordeaux will help them integrate resulting tools with their hardware and software configurations, possibly improving their public performances. In addition, online guides will be published with tutorials on how to build the hardware part of the solutions.

**Scientific impact**
Every part of this project will produce scientific results:
a)classification of components of digital musical instruments
b)3D representations of these components
c)impact of additional visualization on the understanding of electronic music performances
d)correlation between understanding of performances and enjoyment
e)combination of graphical and musical level-of-detail
f)impact of adaptive mappings on experience with digital musical instruments
g)impact of adaptive mappings on the learning process
Scientific workshops will gather researchers around the specific issues of this project, potentially raising new questions and new research leads together with innovative solutions. These specific issues might therefore propagate to other laboratories. Finally, scientific publications will serve as a basis of knowledge and results on both the issue of audience experience and learning process. They will then be accessible to other researchers for their own work. The publications gathering papers from workshops will in addition include state of the art sections in order to provide a good basis for students beginning research on these particular subjects. Finally, if studies of both phases give significant results, solutions developed could be applied/transposed to other instruments being developed by other research laboratories.

# B6 Ethical Issues

**Research on healthy adult volunteers**
Studies during both phases of this project will involve healthy adult volunteers as subjects. They will be asked to watch short musical performances and to manipulate a digital musical instrument.

**Processing of personal data**
For the purpose of the analysis, age and background regarding electronic music of subjects will be recorded. However, this data will be anonymous.

**Observation of people**
Depending on the chosen evaluation method of subjects experience, they will be asked to fill questionnaires or their reactions will be recorded. Additional conversations will also be stored for analysis.

ETHICAL ISSUES TABLE

(Note: Research involving activities marked with an asterisk * in the left column in the table below will be referred automatically to Ethical Review)

| | Research on Human Embryo/ Foetus | YES | Page |
|---|---|---|---|
| * | Does the proposed research involve human Embryos? | | |
| * | Does the proposed research involve human Foetal Tissues/ Cells? | | |
| * | Does the proposed research involve human Embryonic Stem Cells (hESCs)? | | |
| * | Does the proposed research on human Embryonic Stem Cells involve cells in culture? | | |
| * | Does the proposed research on Human Embryonic Stem Cells involve the derivation of cells from Embryos? | | |
| | I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL | X | |

| | Research on Humans | YES | Page |
|---|---|---|---|
| * | Does the proposed research involve children? | | |
| * | Does the proposed research involve patients? | | |
| * | Does the proposed research involve persons not able to give consent? | | |
| * | Does the proposed research involve adult healthy volunteers? | X | 27 |
| | Does the proposed research involve Human genetic material? | | |
| | Does the proposed research involve Human biological samples? | | |
| | Does the proposed research involve Human data collection? | | |
| | I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL | | |

| | Privacy | YES | Page |
|---|---|---|---|
| | Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)? | X | 27 |
| | Does the proposed research involve tracking the location or observation of people? | X | 27 |
| | I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL | | |

| | Research on Animals | YES | Page |
|---|---|---|---|
| | | | |
| | Are those animals transgenic small laboratory animals? | | |
| | Are those animals transgenic farm animals? | | |
| * | Are those animals non-human primates? | | |
| | Are those animals cloned farm animals? | | |
| | I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL | X | |

| | Research Involving Developing Countries | YES | Page |
|---|---|---|---|
| | Does the proposed research involve the use of local resources (genetic, animal, plant, etc)? | | |
| | Is the proposed research of benefit to local communities (e.g. capacity building, access to healthcare, education, etc)? | | |
| | I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL | X | |

| | Dual Use | YES | Page |
|---|---|---|---|
| | Research having direct military use | | |
| | Research having the potential for terrorist abuse | | |
| | I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL | X | |

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PART B

"IXMI"