INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Team i3D

3D Interaction and Virtual Reality

Grenoble - Rhône-Alpes

THEME COG

Activity Report

2008

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1. Team

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Andreas Pusch [INPG/Marie-Curie scholarship - until end-September 2008]
Yann Mazel [INPG/INRIA-ANR scholarship]

Administrative Assistant

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Other

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2. Overall Objectives

2.1. Introduction

The objective of the i3D research team is to contribute to making interaction in virtual worlds as simple and intuitive as in the real world.
To this end, three research axes are privileged:

- Interaction metaphors and paradigms
- Haptic feedbacks [1]
- Human factors study

Within these research axes, focus is put on:

- **Spatial approaches**: spatial input and output.
- **Immersive environments**: immersion of the user into the virtual world or immersion of the application into the user's real world.
- **Better exploitation of the user's various sensory channels** such as visual and haptic.

The research activities are based on both the **"Workbench"** and **"Video See-through HMDs"**. These systems have been chosen for their complementarity and their potentials in terms of interaction and their adequacy to the main approaches mentioned above (see 3.3).

[1] force or tactile feedback

Research of the i3D group is organized around three themes:

- **The study of interaction metaphors and paradigms**. Tasks apparently as simple as displacement inside a virtual scene or catching and repositioning an object are still difficult to realize in a virtual world today. The objective of this theme is to study new paradigms and metaphors of interaction using the approaches quoted above.
- **The study of haptic feedbacks**. There are several ways to return a haptic feedback: *active haptic feedback* (requiring the use of a haptic feedback device), *pseudo-haptic feedback* [27], [26], *passive haptic feedback* (makes use of a prop), and *sensory substitution*. The objective of this theme is to study these different approaches in order to have a better characterization of haptic feedback according to the completed task.
- **Human factors study**. In addition to the two previous themes, the research group aims at carrying out experiments whenever possible. These experiments are either carried out to provide a basis for the research, such as psychophysics experiments on human perception or the evaluation of existing techniques and peripherals, or the evaluation of approaches developed by the group.

The i3D group wishes to emphasize the genericity of the proposed solutions. The solutions are developed with the objective to integrate them into various applications within different application fields. However, concerning applications, the group currently focuses on the most promising applications in terms of industrial use for the Workbench:

- **Interactive exploration of complex data** such as data from scientific computation, fractal models or meshes.
- **Virtual prototyping**: virtual prototyping for industries such as automotive or aeronautic.

2.2. Highlights of the year

- Andreas Pusch, Olivier Martin and Sabine Coquillart received the second best paper award for their research "HEMP - Hand-Displacement-based Pseudo-Haptics: A Study of a Force Field Application" during the 2008 IEEE Symposium on 3D User Interface in Reno (Nevada, USA), March 8-9 2008.
- Sabine Coquillart has been co-chair of IEEE 3DUI'08 (Reno, USA) and of the Dagsthul Seminar on "Virtual Realities" (Dagsthul, Germany).

3. Scientific Foundations

3.1. Virtual Reality

Keywords: *Virtual reality*.

We begin by explaining the expression **virtual reality**. We are not going to propose a $n+1^{th}$ definition. Instead, we propose to position Virtual Reality by reference to the image synthesis field which is older, better specified but which is nowadays too often confused with virtual reality.

Image synthesis gathers all the techniques leading to the production of images (fixed or animated) representing a numerical model, a scene or a virtual world. To simplify, one can say that image synthesis is a reproduction of a virtual scene through a photo album (fixed image) or a film (animated images). Virtual reality makes it possible to enrich perception of the virtual scene by enabling a person to interact with this scene.

It is proposed to him/her to move from a passive role to an active role, to "live" the virtual experiment instead of being satisfied to view it. By taking again the preceding analogy, virtual reality can be compared with the visit of a country while going on the spot as opposed to the photo report or documentary film. However, contrary to the real case, where the photo report or the documentary film are quite distinct from living the experience, in the virtual world there is a continuum between graphic applications and virtual reality. It is mainly the position of this border which is prone to discussions.

A first brief reply could be given by consulting the various definitions of virtual reality. The concept most usually associated to the expression virtual reality is that of immersion. One speaks about virtual reality when the interaction is sufficiently realistic to get a feeling of immersion, communion, fusion between the person and the application. This concept of immersion remains quite subjective. Should we specify it ? Or isn't it rather prone to a slow evolution accompanying virtual reality research progresses ? We chose the second solution and would like to list some factors improving immersion, such as stereoscopic visualization, visualization on large screens, head tracking, spatial interaction, two-handed interaction, multi-sensory interaction, real-time control, not forgetting the most important factor, and often considered as required [19]: the first-person point of view.

3.2. 3D Interaction

Keywords: *3D interaction*.

The importance of 3D interaction in virtual reality (see 3.1 for a description of virtual reality) coupled with the immaturity of the field, makes 3D interaction one of the most important **open problems** of virtual reality. In spite of its major importance, the human-application[2] interface is currently far from providing the same level of satisfaction as other computer graphics sub-domains [21].

In computer graphics, the race towards realism engaged over the last twenty years has led to impressive results where the virtual world is sometimes not easy to distinguish from the real one. Who did not hesitate while seeing certain images of complex scenes, with most realistic illumination effects ? Most of us have once doubted while seeing an image or a sequence of images which he/she did not know how to classify: real or virtual ? At the inverse, this feeling of doubt is unlikely as soon as there is interaction. Conversely, it is often a feeling of faintness or awkwardness which dominates. Indeed, the processes of interaction with the virtual worlds are still often very poor. The large majority of the systems is developed on 2D workstations. Even if using 3D configurations, the user interface is frequently inspired by 2D interfaces. The WIMP concept (Windows, Icons, Menu, and Pointing) is often used. As an example, operations as simple as navigation inside virtual 3D scenes, or the handling (displacement) of entities in a virtual 3D scene, are still open research problems. The relative poverty of the interaction with virtual worlds is even more poorly perceived because the real world, in which we live and which we are used to interact with, is a very rich world. Any machine, with some complexity, (car, bicycle, television, telephone, musical instrument...) has its own mode of interaction adapted to the task to perform.

On the other hand, some configurations and some recent approaches are very promising. These approaches are more specifically 3 dimensional or are proposing a better use of the various sensory channels.

In short, the current situation is as follows. One can identify:

- **a well identified need:** increasingly demanding users and a growing number of applications.
- **an unsatisfactory situation:** poor interfaces, primarily 2D, with a strong under-utilization of the human-application bandwidth.
- **strong potentials:** very promising configurations and approaches to study or to conceive.

3.3. Virtual/Augmented/Mixed Reality Configurations, Workbench and See-Through HMD

Keywords: *CAVE*, *HMD*, *flat or cylindrical wall*, *immersion*, *see-through HMD*, *virtual/augmented/mixed reality*, *workbench*.

[2] one will speak about human-application interface instead of human-machine interface, as one would tell in 2D, because the objective is to make the machine transparent and to give the impression to the user to interact directly with the application

Until 2004, much of the research work and especially of the developments of the i3D group were dictated by the **Workbench** Virtual Reality configuration installed at the end of 1999. Last year, the i3D group has acquired a complementary augmented reality configuration, the **Video See-Through HMD** This paragraph briefly describes these configurations and positions them within the set of other configurations of the same class.

Virtual reality has been identified for a while with head mounted displays (HMDs). HMDs isolate the user from its real environment and require the use of avatars.
Currently, projection-based virtual environments often take the place of HMDs. More recent, less invasive and offering better characteristics, these configurations take several forms. In this class, one finds the CAVE^{TM}, the flat or cylindrical walls and the Workbenchs. See [20] for a more detailed introduction of this class of configurations.
The CAVE^{TM} [3] [23] is probably the best known of these configurations. It is also the most expensive and the most complex to install and maintain. It appears as a room of approximatively 3 meters on each side with the virtual world back-projected on 4 (three walls and the ground) to 6 (for some recent configurations) of the faces of the room. This configuration provides a good feeling of immersion thanks to the screens which "surround" the person, to stereoscopic visualization and to head tracking. This configuration is very well adapted to navigation inside large spaces (for example, a visit of a virtual scene such as architecture, an amusement park, or a driving simulation).
The wall is a large flat or cylindrical screen on which the virtual world is visualized generally with the assistance of 3 video projectors. The fact that people sit in front of the screen, without head tracking, makes this configuration more passive. It is a nice configuration for presenting projects to a group of approximately 20 persons, like project reviews for example.
The Workbench (or Responsive Workbench^{TM}[4] [22], by reference to the first developed system [25], [24]) is the "lightest" configuration (see Figure 1). Often less known than the CAVE^{TM}, this configuration is, from many points of view, far from being less attractive. With a horizontal screen (plus, possibly, a second vertical one providing a wider field of view) which represents a tabletop, the Workbench makes it possible to visualize a virtual scene within the reaching area, in front of the observer. A video projector, after reflexion on one or more mirrors, back-projects the image on the screen representing the surface of the table. 3D effects are provided thanks to stereoscopic visualization with shutter glasses. As with the CAVE^{TM}, head-tracking is provided.

The form of the Workbench predestines it with manual manipulations on a table. This configuration is also characterized by a strong potential for interaction. Its head tracking feature allows a superposition of the visualization and the manipulation spaces (virtual and real spaces) and opens the way to simpler and more intuitive interactions. In addition, whereas a maximum immersion of the person into the virtual world was preached a long time, in particular with the HMDs, this configuration introduces the opposite approach, which is more comfortable: the immersion of the application into the user's (real) environment. This configuration is thus integrated into the users real world, providing him with very pleasant feelings, close to what he/she is used to when manipulating objects on a table in the real world. It is thus quite natural that the applications of this configuration are those where the user observes and handles data or numerical mock-ups which rest in front of him, within the range of hands.

Projection-based configurations only allow a limited mixing of the real and the virtual worlds. The real world has to be in front of the virtual one. Optical see-through HMD overcome this limitation but introduces the inverse one, the virtual world has to be in front of the real one. The only VR/VA configuration allowing for a free mixing of the real and the virtual worlds is the video see-through HMD. The video see-through HMD is an HMD configuration equipped with two small cameras, one in front of each eye. The cameras are capturing the real world which is mixed together with the virtual one within the computer and then, the mixed world is displayed onto the HMD. Even if presently, the characteristics of see-through HMD in terms of resolution, field

[3] CAVE is a trademark of the university of Illinois
[4] "Responsive Workbench" is a trademark of GMD

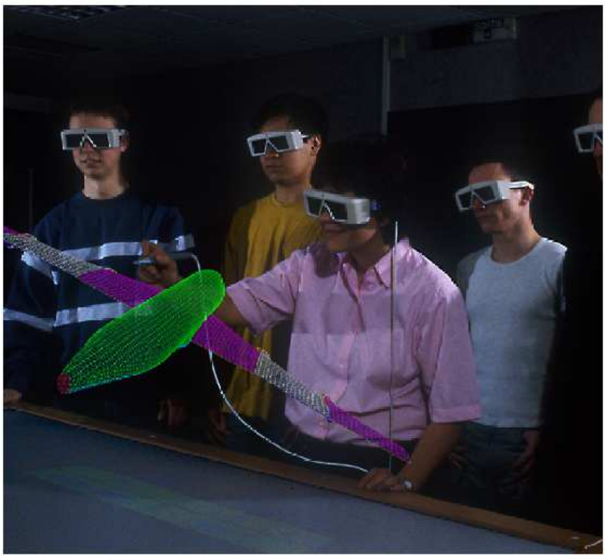

Figure 1. *The INRIA Workbench (with special effects)*

of view etc... are not sufficient for some industrial applications, acquiring expertise on these configurations is of great interest because they potentially allow unique applications.

4. Application Domains

4.1. Application Domains

In 3D interaction, applications are of a great interest. In addition to their significant role regarding industrial transfer, they are essential for our research. They make it possible to validate our work, to make the Workbench more known, and to cause new interaction problems therefore new research problems.
We are concentrating on applications for which the use of the Workbench (more recently, we also focus on applications for the see-through HMD) seems particularly promising to us. These applications include:

- the visualization and analysis of complex data (geological data, fractal models, complex meshes, graphs...),
- virtual prototyping (assembling/disassembling...),
- neuroscience applications.

On the other hand, we do not set any constraint on the domain to which we apply our results.

5. Software

5.1. Panorama

In 2005 the i3D software development effort was mainly dedicated to the move of the i3D MiniOSG platform from SGI Onyx to a PC cluster. In 2006, the development of the MiniOSG platform continued mainly toward the integration of the see-through HMDs and associated functionalities. In 2007, this effort continued in three ways: cleaning and simplification of the core of the software platform, development of new functionnalities, transfert of Onyx demos. In 2008, most of the work on the platform has been dedicated to the integration of new see-through HMDs with a higher resolution and new video acquisition system.

5.2. MiniOSG

Participant: Thomas Amory.

The new nVisor video see-through HMDs have been integrated to the MiniOSG platform (both at the visualization and at the acquisition level). A calibration program has been developed for the cameras, both for the intrinsic and the ARTracking calibrations. The module for mixing virtual and real has been reworked to make it compatible with the new HMDs. All the functionalities developped for the old HMDs have been updated, in particular the hand extraction.

6. New Results

6.1. Panorama

This year has been marked by a continuation of the researches on the Stringed Haptic Workbench. It has also been marked by an increase of the video see-through HMDs and the pseudo-haptics activities.

6.2. Study of a New Pseudo-Haptic Solution

Participants: Andreas Pusch, Sabine Coquillart, Olivier Martin.

In the continuation of the work on pseudo-haptic (see [2]), in 2008, i3D proposed HEMP - Hand-Displacement-Based Pseudo-Haptics, a new pseudo-haptic concept based on a visuo-proprioceptive conflict. Thanks to video see-through HMDs, one can perturb the position of the visual feedback of a body part (for instance the hand) and create a visuo-proprioceptive conflict. The purpose of this work was to study this conflict and to check whether it could be exploited to provide haptic sensations. The study has been conducted in the context of force-field simulation (see 2). Several experiments have been conducted. Qualitative results demonstrate that some force sensations can be perceived by subjects. Quantitative evaluations confirm these results by showing that a yet limited number of force levels can be discriminated. This work has been published in the IEEE symposium on 3D User Interfaces and has been awarded the second best paper award (see [15]).

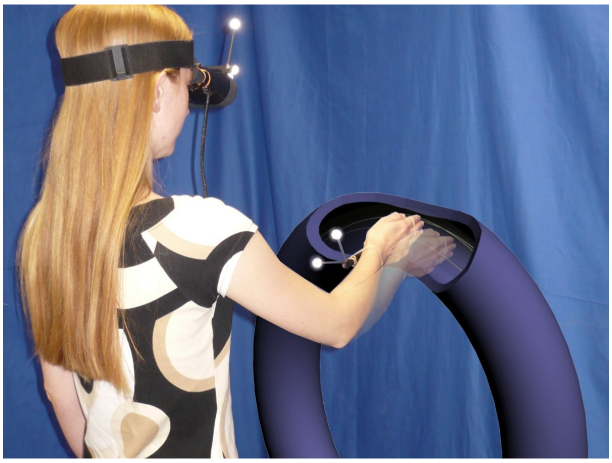

Figure 2. The HEMP - Hand-Displacement-Based Pseudo-Haptics experiment.

6.3. Local first person collaboration with haptics

Participants: Yann Mazel, Sabine Coquillart.

The Part@ge ANR platform is dedicated to Collaborative Interactions. Within the framework of this platform, i3D is working on immersive, local, first person, collaboration with haptics. The simulation of collaborative tasks is increasingly sought by industry. At present, most simulations of collaborative tasks are not in co-location. They also often do not integrate first person haptic feedback. Thanks to video see-through HMDs, first person collaborations should be possible. After writting a survey on local collaborations (Part@ge deliverable), the implementation of the platform is now in progess.

6.4. Influence of haptic guidance on visuo-manual tracking of 2D trajectories

Participants: Jérémy Bluteau, Sabine Coquillart.

Within the framework of the PRESENCE ISLE cluster, i3D started in 2007 a collaboration with Edouard Gentaz from LPNC-Grenoble (Psychology and Neuro Cognition Laboratory) and Yohan Payan from TIMC-Grenoble (Techniques for Biomedical Engineering and Complexity Management Laboratory) on the influence of haptic feedback on visuo-manual following of trajectories. Learning to perform new movements is usually achieved by following visual demonstrations. Haptic guidance by a force feedback device is a recent and original technology which provides additional proprioceptive cues during visuomotor learning tasks. The effects of two types of haptic guidances-control in position (HGP) or in force (HGF) - on visuomanual following of trajectories are still under debate.

In 2008, the experiment on handwriting, started in 2007, has been completed.

Three training techniques of haptic guidance (HGP, HGF or control condition, NHG, without haptic guidance) were evaluated in two experiments. Movements produced by adults were assessed in terms of shapes (dynamic time warping) and kinematics criteria (number of velocity peaks and mean velocity) before and after the training sessions. Trajectories consisted of two Arabic and two Japanese-inspired letters in Experiment 1 and ellipses in Experiment 2. We observed that the use of HGF globally improves the fluency of the visuo-manual tracking of trajectories while no significant improvement was found for HGP or NHG.

These results show that the addition of haptic information, probably encoded in force coordinates, play a crucial role on the visuo-manual tracking of new trajectories (see [9] for more details.

6.5. Study of haptic feedbacks

Participants: Jérémy Bluteau, Sabine Coquillart.

Within the framework of the PRESENCE ISLE cluster and in collaboration with Edouard Gentaz from LPNC-Grenoble (Psychology and Neuro Cognition Laboratory) and Yohan Payan from TIMC-Grenoble (Techniques for Biomedical Engineering and Complexity Management Laboratory), i3D continued the study of haptic feedbacks (see 2.1). Based on the Stringed Haptic Workbench which proved to be a very unique visuo-haptic configuration (see [7] and previous activity reports for a description of the configuration and of several applications, including one in use in the industry), the purpose of the present study is both to evaluate alternative haptic solutions (passive haptic) and to study the parameters which make the Stringed Haptic Workbench so convenient compared to many other configurations. Concerning the first point, the proposed study is evaluating different levels of inertia. On the second point, parameters like the influence of the workbench frame are studied.

A first experiment has been started on 3D trajectories following (« ring-on-wire » type). The experimental setup has been designed and the experiment is underway.

7. Other Grants and Activities

7.1. INRIA

- **Bunraku Project**: Several collaborations are running with the Bunraku Project. As they all involve other partners, they are presented in the section on "National" or "International" actions.
- **Alcove and iPARLA Projects**: i3D is collaborating with both the Alcove project and the iPARLA projects within the framework of the Part@ge project. As this project involves other partners, it is presented in the section on "National" actions.

7.2. Regional

- i3D is collaborating with Theophile Ohmann from LPNC-Grenoble (Psychology and Neuro Cognition Laboratory) on possible VR applications for studying neural disorders.
- i3D is collaborating with Edouard Gentaz from LPNC-Grenoble and Yohan Payan from TIMC-Grenoble on the influence of haptics on manual trajectory drawings. Funding through Presence Cluster ISLE.

7.3. National

- **PERF-RV2** i3D is participating to the ANR platform "PERF-RV2" on Virtual Humans at Work. i3D is involved in researches on immersive haptic feedback for industrial applications.

- **PART@GE** i3D is participating to the ANR platform "PART@GE" on Collaborative Interaction. i3D is involved in researches on Local Collaboration with Augmented Reality.

7.4. International

- Collaboration with Sato-Koike research group from the Tokyo Institute of Technology. Collaborations on the Spidar system.
- Within the Sixth European Framework Programme, i3D together with Bunraku-Rennes is in the core group of the "Intuition" Virtual Reality Network of Excellence. i3D and Bunraku are the INRIA representatives.

8. Dissemination

8.1. Contribution to the Scientific Community

- Sabine Coquillart is a member of the EUROGRAPHICS Executive Committee and of the EUROGRAPHICS Working Group and Workshop board.
- Sabine Coquillart is a member of the EuroVR temporary Executive Board.
- Sabine Coquillart is a member of the Editorial Board of the journal of "Virtual Reality and Broadcasting".
- Sabine Coquillart has been a member of the evaluation committee of the COSINUS ANR Program.
- Sabine Coquillart has been a member of the CR2 evaluation committee of INRIA Saclay Ile de France.
- Sabine Coquillart has co-chaired IEEE 3DUI'08, Reno, USA.
- Sabine Coquillart has co-chaired the Dagstuhl Seminar on "Virtual Realities", Dagstuhl, June 2008.
- Jérémy Bluteau, Sabine Coquillart and Yann Mazel presented demos on the Stringed Haptic Workbench during the Gravit Forum, Montbonnot, 2008.
- Jérémy Bluteau was "Young Reporter" at ICT Information and Communication Technologies 2008, Lyon, November 2008.

8.2. Courses

- **Master 2R I3 University Paris-Sud-Orsay**, Sabine Coquillart is teaching in the "Virtual Environments and Advanced Interfaces" module.
- **Master 2R Ingénierie du Virtuel et Innovation, Laval**, Sabine Coquillart is teaching the 3D Interaction module.
- **ENSIMAG 3rd Year**, Course on 3D User Interfaces, Virtual Reality and Augmented Reality Systems, Sabine Coquillart and Yann Mazel.
- **Master 2 - GVR**, Course on 3D User Interfaces, Virtual Reality and Augmented Reality Systems, Sabine Coquillart and Jérémy Bluteau.

8.3. Conference and Workshop Committees, Invited Conferences

- Sabine Coquillart has been a member of the International Program Committee of the following conferences: IEEE 3DUI'08, 3DPVT'08, CASA'08, CGV'08, EGVE'08, GRAPP'08, IEEE VR'08, Intuition'08, ISVC'08, VRIC'08, PacificGraphics'08, SMI'08, SVR'08, VRST'08, VSMM'08, WSCG'08.
- Sabine Coquillart has been a member of the IEEE VR'08 Best Papers Award Committee.

- Sabine Coquillart has chaired the VRST'08 Best Papers Award Committee.
- Sabine Coquillart has reviewed articles for the following journals: ACM Transactions on Applied Perception, Presence journal.

8.4. Invited Conferences

- Sabine Coquillart, "Tasks Simulation", Forum Gravit, Montbonnot, July 2008.
- Sabine Coquillart, "Haptics and Pseudo-Haptics: from Research to industry", Invited conference at ICAT'08, December, Yokohama, Japan.

Andreas Pusch, Olivier Martin and Sabine Coquillart received the second best paper award for their research "HEMP - Hand-Displacement-based Pseudo-Haptics: A Study of a Force Field Application" during the 2008 IEEE Symposium on 3D User Interface in Reno (Nevada, USA), March 8-9 2008.

9. Bibliography

Major publications by the team in recent years

[1] J. GROSJEAN, S. COQUILLART. *Command & Control Cube: a Shortcut Paradigm for Virtual Environments*, in "IPT-EGVE'2001", EUROGRAPHICS, May 2001.

[2] A. LÉCUYER, S. COQUILLART, A. KHEDDAR, P. RICHARD, P. COIFFET. *Pseudo-Haptic Feedback: Can Isometric Input Devices Simulate Force Feedback ?*, in "IEEE Virtual Reality 2000, New Brunswick, NJ, USA", IEEE, March 2000.

[3] M. ORTEGA, S. REDON, S. COQUILLART. *A Six Degree-of-Freedom God-Object Method for Haptic Display of Rigid Bodies*, in "IEEE Virtual Reality 2006, USA", Second Best Paper Award, 2006.

[4] A. PALJIC, J.-M. BURKHARDT, S. COQUILLART. *A Study of Distance of Manipulation on the Responsive Workbench*, in "IPT'2002 Symposium (Immersive Projection Technology), Orlando", 2002.

[5] A. PALJIC, S. COQUILLART. *A passive stringed force feedback system for immersive environments*, in "EuroHaptics 2004, Germany", 2004.

[6] S. REDON, A. KHEDDAR, S. COQUILLART. *CONTACT: Arbitrary in-between Motions for Continuous Collision Detection*, in "IEEE ROMAN'2001", September 2001.

[7] N. TARRIN, S. COQUILLART, S. HASEGAWA, L. BOUGUILA, M. SATO. *The Stringed Haptic Workbench: a New Haptic Workbench Solution*, in "EUROGRAPHICS'2003, Granada, Spain", EUROGRAPHICS, September 2003.

Year Publications

Doctoral Dissertations and Habilitation Theses

[8] A. PUSCH. *Visuo-Proprioceptive Conflicts of the Hand for 3D User Interaction in Augmented Reality*, Ph. D. Thesis, INPG, October 2008.

Articles in International Peer-Reviewed Journal

[9] J. BLUTEAU, S. COQUILLART, Y. PAYAN, E. GENTAZ. *Haptic guidance improves the visuo-manual tracking of trajectories*, in "PLoS ONE", vol. 3, March 2008, http://dx.doi.org/10.1371/journal.pone.0001775.

[10] D. A. BOWMAN, S. COQUILLART, B. FRÖHLICH, M. HIROSE, Y. KITAMURA, K. KIYOKAWA, W. STUERZLINGER. *3D User Interfaces: New Directions and Perspectives*, in "IEEE Computer Graphics and Applications", vol. 28, n^{o} 6, Nov-dec 2008, p. 20-36.

[11] A. PUSCH, O. MARTIN, S. COQUILLART. *HEMP - Hand-Displacement-Based Pseudo-Haptics: A Study of a Force Field Application and a Behavioural Analysis*, in "International Journal of Human-Computer Studies", accepted for publication, 2009.

[12] I. TSIRLIN, E. DUPIERRIX, S. CHOKRON, S. COQUILLART, T. OHLMANN. *Uses of virtual reality for diagnosis, rehabilitation and study of unilateral spatial neglect: review and analysis*, in "Cyberpsychology and Behaviour", accepted for publication, 2009.

International Peer-Reviewed Conference/Proceedings

[13] J. BLUTEAU, S. COQUILLART, Y. PAYAN, E. GENTAZ. *Haptic guidance increases the visuo-manual tracking of untrained ellipses drawing*, in "Proceedings of XXIX International Congress on Psychology, Berlin, Germany", July 2008.

[14] J. BLUTEAU, E. GENTAZ, S. COQUILLART, Y. PAYAN. *Haptic guidances increase the visuo-manual tracking of Japanese and Arabic letters*, in "International Multisensory Research Forum, Hamburg, Germany", poster, June 2008.

[15] A. PUSCH, O. MARTIN, S. COQUILLART. *HEMP Hand-Displacement-Based Pseudo-Haptics: A Study of a Force Field Application*, in "Proceedings of IEEE 3D User Interfaces 2008, Reno, USA", Second Best Paper Award, March 2008.

Scientific Books (or Scientific Book chapters)

[16] S. COQUILLART, M. ORTEGA, N. TARRIN. *Virtual Prototyping*, A K Peters Ltd, Ming Lin and Miguel Otaduy (Editors), 2008.

[17] M. ORTEGA, S. REDON, S. COQUILLART. *Six-Degree-of-Freedom Rendering of Rigid Environments*, A K Peters Ltd, Ming Lin and Miguel Otaduy (Editors), 2008.

Books or Proceedings Editing

[18] G. BRUNNETT, S. COQUILLART, G. WELCH (editors). *Virtual Realities*, n^{o} 08231, Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, Germany, Dagstuhl, Germany, 2008.

References in notes

[19] D. A. BOWMAN, E. FRUIJFF, J. LAVIOLLA, I. POUPYREV. *3D User Interfaces Theory and Practice*, Addison Wesley, 2004.

[20] S. COQUILLART. *Environnements virtuels à base de projections sur grands écrans*, in "GT-RV'98", 1998.

[21] S. COQUILLART, J. GROSJEAN, A. LÉCUYER. *Interaction et systèmes haptiques*, Technical report, Séminaire INRIA "Environnements virtuels à base de projections sur grands écrans", 2000.

[22] S. COQUILLART, G. WESCHE. *Interaction Techniques and Applications on the Workbench*, Technical report, Séminaire INRIA "Environnements virtuels à base de projections sur grands écrans", 2000.

[23] C. CRUZ-NEIRA, D. SANDIN, T. DEFANTI. *Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE*, in "Computer Graphics (SIGGRAPH Proceedings)", August 1993, p. 135-142.

[24] W. KRÜGER, C. BOHN, B. FRÖHLICH, H. SCHÜTH, W. STRAUSS, G. WESCHE. *The Responsive Workbench: A Virtual Work Environment*, in "IEEE Computer", July 1995, p. 42-48.

[25] W. KRÜGER, B. FRÖHLICH. *The Responsive Workbench*, in "IEEE Computer Graphics and Applications", May 1994, p. 12-15.

[26] A. LÉCUYER, J.-M. BURKHARDT, S. COQUILLART, P. COIFFET. *"Boundary of Illusion": an Experiment of Sensory Integration with a Pseudo-Haptic System*, in "IEEE VR'2001, Japan", March 2001.

[27] A. LÉCUYER, S. COQUILLART, A. KHEDDAR, P. RICHARD, P. COIFFET. *Pseudo-Haptic Feedback: Can Isometric Input Devices Simulate Force Feedback ?*, in "IEEE Virtual Reality 2000, New Brunswick, NJ, USA", IEEE, March 2000.