INRIA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Team i3D

3D Interaction

Rhône-Alpes

THEME COG

Activity Report

2004

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1. Team

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Ambroise Guabello [Project technical staff - since April 14th, 2004]
Mathias Lorente [Junior technical staff]
Tangui Morvan [Project technical staff - from July 1st to November 30th, 2004]
Thibault Pardos [Project technical staff - from April 1st to September 30th, 2004]
Nicolas Tarrin [Project technical staff - until February 29th, 2004]
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Ph. D. student
Jean-Edouard Coste [CEA-DAM scholarship]
Michaël Ortega [CIFRE scholarship with PSA-Peugeot Citroën - since February 1st, 2004]
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2. Overall Objectives

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

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. We focus 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 the **"Workbench"**, a system that was chosen for its potentialities in terms of interaction and its adequation to the main approaches mentionned above (see 3.3).
Research of the i3d group is organized around three themes:

[1] force or tactile feedback

- **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* [16][15], *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 psychophysic experiments on human perception or evaluation of existing techniques and peripherals, or evaluation of approaches developed in the group.

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

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

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 restitution 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 making it possible to the 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 experiment, in the virtual world there is a continuum between the graphic applications and virtual reality. It is mainly the position of this border which is prone to discussions.

A first brief reply is 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 progress ? We choose this second solution and we will be satisfied to enumerate, in no particular order, some factors improving immersion such as stereoscopic visualization, visualization on large screens, head tracking, spatial interaction, superposition of virtual and real spaces, two-handed interaction, multi-sensory interaction, real time simulation. To summarize, we will say that the more numerous are these factors, the stronger is the feeling of immersion and the more justified is the **virtual reality** expression.

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 [9].

In computer graphics, the race toward realism engaged over the last twenty years has led to impressive results where the virtual world is sometimes not easily discernible from the real one. Who did not hesitate while seeing certain images of complex scenes, with most realistic illumination effects ? Most of us have one day 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. A 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 interacting 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 achieve.

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.
- **a unsatisfactory situation:** poor interfaces: primarily 2D, with a strong under-utilization of the human-application bandwidth.
- **strong potentialities:** very promising configurations and approaches to study or to conceive.

3.3. Virtual Reality Configurations and Workbench

Keywords: *CAVE*, *HMD*, *flat or cylindrical wall*, *immersion*, *workbench*.

Much of the research work and especially of the developments of the i3D group are dictated by the **Workbench** installed at the end of 1999. This paragraph briefly describes this configuration and positions it within the set of other configurations of the same class.

Virtual reality has been identified for a while with head mounted displays. In this class, one finds HMD (Head Mounted Display) which isolate the user from his/her real environment and require the use of avatars. One finds also see-through HMD which have the advantage of allowing to see the real world but whose characteristics in term of resolution, field of view etc... are often too weak for the majority of the industrial applications.
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 [8] for a more detailed introduction of this class of configurations.

[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

The CAVE^{TM} [3] [11] 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 retro-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 to a virtual scene such as architecture, a 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 approximatively 20 persons, like projects reviews for example.
The Workbench (or Responsive Workbench^{TM}[4] [10], by reference to the first developed system [14][13]) is the "lightest" configuration (see Figures 1, 3, 4). 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 range of hands, in front of the observer. A video projector, after reflexion on one or more mirrors, retro-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 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 naturally that the applications of this configuration are those where the user observes and handles data or numerical mockups which rest in front of him, within the range of hands.

4. 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 seems particularly promising to us. These applications are by order of importance:

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

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

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

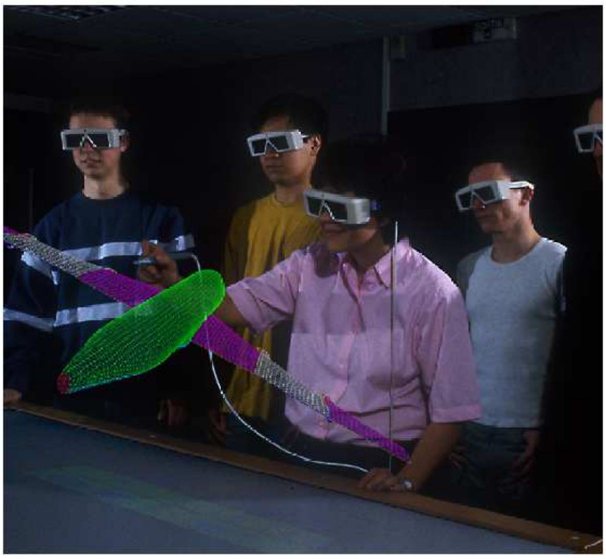

Figure 1. The INRIA Workbench (with special effects)

5. Software

5.1. Panorama

In 2004, a migration from the SGI Onyx to a PC cluster has started. A desktop version of the Spidar [5] has also been installed in order to make the Workbench version more available.

On the software side, our software development effort continued mainly in the following directions:

- Improvements to the software haptic platform
- Development of a new version of Minifly, for PC cluster,
- New developments on OpenMask (www.openmask.org)
- New developments on Amira [6]

5.2. Migration from SGI Onyx to PC cluster

Participants: Mathias Lorente, Sabine Coquillart.

The increasing power of PC computers, both in terms of computation and graphics, as well as the cost of graphics computers like SGI Onyx make most virtual reality configuration's owners reconsider the choice of the computers controlling these configurations. A move from an Onyx3 to a cluster of PCs is on the way. The migration has been launched both at the hardware and at the software level.

5.2.1. Hardware Migration

Since its installation, an SGI Onyx graphics computer controlled the Workbench configuration. After several tests and experimentations on a small PC cluster (2 PCs), a platform composed of four bi-processor workstations connected together through gigabyte fast ethernet on a local area network has been installed. Two of the PCs include very high performance graphics cards with hard genlock and swaplock. This platform is connected to the Workbench and running.

As software migration is in process, the two platforms are currently both in use.

5.2.2. Software Migration

The PC cluster works with the GNU/Linux operating system and cannot execute MiniFly[7], nor most other virtual reality software platforms developed on SGI Onyx.

Taking benefit of the experience acquired in developing Minifly, a new version for PC cluster is under development. It will be based on OpenSG [8]instead of Performer. VRPN[9] will be used to manage the various devices. The development of the new software platform has began.

5.3. Haptic Platform

Participants: Ambroise Guabello, Mathias Lorente, Tangui Morvan, Michael Ortega, Nicolas Tarrin, Thomas Vincent, Sabine Coquillart.

Following previous developments made on the Haptic Platform, a particular effort has been undertaken this year to improve and enlarge the underlying software that handles interactions based on the Spidar, particularly on the "String Haptic Workbench" [20]. The first objective was to adapt the existing Haptic Platform to run on the PC cluster recently installed on the Workbench (see 5.2). The second one was to get even more modularity, so that new haptic devices or interaction modules can be easily plugged in/out, thus providing a set of modules

[5] the Spidar is a stringed-based haptic system developed by the Tokyo Institut of Technology
[6] Mercury Systems Scientific Visualization Platform
[7] MiniFly is the i3D software platform, see previous years report for more details on MiniFly.
[8] OpenSG is a portable scenegraph system to create realtime graphic programs, e.g. for virtual reality applications. More details at http://www.opensg.org.
[9] Taylor II, R.M., "The Virtual Reality Peripheral Network (VRPN)", 1998: htmladdnormallinkhttp://www.cs.unc.edu/Research/vrpnhttp://www.cs.unc.edu/Research/vrpn

to be used to create new applications, or to connect to existing ones (such as Amira ©Mercury Computer System, for instance).

5.3.1. Haptic Platform Enhancement

Various functionalities have been integrated into the initial Haptic Platform, such as 6 degrees of freedom Spidar, support for the newest Spidar hardware, haptic device position and speed filters providing smoother information for further computation, adaptive time step for the CONTACT collision detection engine increasing the overall stability, button events handling and configuration files.

5.3.2. PC Cluster Adaptation

Within the frame of the geoBench RNTL project, the initial Haptic Platform has been adapted to run on a PC cluster. The chosen cluster middleware solution for the geoBench project is FlowVR [7]. The main functionalities, as well as new ones, have been translated into FlowVR modules.

Nowadays, 4 FlowVR modules are available, and new ones can easily be added:

- *SpidarAdaptator*. For communication with the Spidar drivers, only available under Windows.
- *Contact*. Embeds the CONTACT Toolkit library [17], providing collision detection within a loaded scene.
- *Virtual Coupling*. Enables interaction through the coupling of the collision detection engine and the haptic device, possibly adding an externally computed force, such as a forces extracted from a data set.
- *CyberTouch*: Handles the cyberTouch glove device, providing control upon the vibration feedback.

5.3.3. Conclusion

The currently developed modules compose the core of a module pool to create applications with haptic interactions. Both objectives of exploiting the PC cluster and increasing modularity were atteined. Further developments include the integration of the Phantom^{TM} [10], the writing of a Spidar module when Linux drivers become available, connection to other (visual) applications, coupling with a scientific simulation engine.

5.4. OpenMask

Participants: Olivier Chenu, Tangui Morvan, Nicolas Tarrin, Sabine Coquillart.

In the framework of the RNRT project VTHD++, i3D together with the SIAMES project from IRISA Rennes worked on adding haptic feedback to 3D distant and cooperative interaction in virtual environments. The VTHD network is used to meet the high requirements of haptic interactions in terms of latency and frequency. OpenMask enables communication and interaction between various virtual reality configurations. For this project, the SIAMES team uses a Reality Center for visualisation and the Virtuose haptic device from Haption. The i3D team uses two configurations: the Stringed Haptic Workbench [20] and a desktop configuration made of a linux workstation for visualisation and a desktop Spidar for Haptic Feedback. i3D contributed mainly on two aspects: the addition of a Workbench visualization to OpenMask, and the integration of i3d tools.

5.4.1. Visualisation on the Workbench

The OpenMASK visualisation module has been modified to take into account the Workbench configuration (screen positions, head tracking,...)

5.4.2. Integration of i3D tools in OpenMASK

In order to add haptic interaction with the Spidar, several tools have been ported to OpenMASK and integrated as OpenMASK modules:

- CONTACT [17], the i3D collision detection library,
- ComLayer, the i3D communication library,
- the i3D Haptic Platform (see 5.3).

[10] PhanTom is an haptic device

5.5. Demonstrators on Collaborative Haptic Interaction

Participants: Olivier Chenu, Tangui Morvan, Nicolas Tarrin, Sabine Coquillart.

Two demonstrators have been developed on OpenMask, as a result of the VTHD++ project.

The first one runs on two virtual reality configuration: the Reality Center and Virtuose device from SIAMES in Rennes, and the Stringed Haptic Workbench from i3D, in Grenoble. A simple (due to the limitations of the computers) application is distributed between these configurations through the VTHD network. The users, on each side, control different simple objects on a table with each haptic device, and are able to collaboratively control objects, or push and interact with each other.

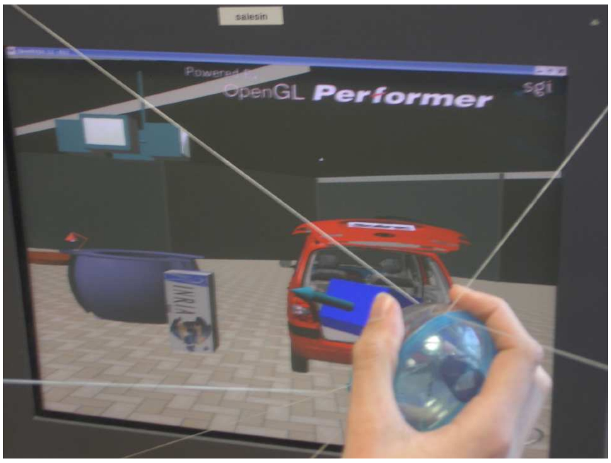

Figure 2. Collaborative application between Rennes and Grenoble

The second application (see Figure 2) involves linux workstations for visualisation and the Virtuose (on one side) and the Spidar (on the other side) for haptic interactions. The better performance of linux workstations allows for more sophisticated interactions. The application consists in manipulating two objects (a bicycle and a case), and trying to insert them in the trunk of a complete Renault "Scenic" model. This application was showcased during the PERF-RV closing seminar.

5.6. Integration of Interaction Tools into Amira

Participants: Ambroise Guabello, Tangui Morvan, Thomas Vincent, Sabine Coquillart.

Within the framework of the Geobench RNTL project, two interaction paradigms developed by the i3D group have been ported and integrated into Mercury Computer System's scientific visualisation software Amira: the Command and Control Cube [12] and the Metric Cursor [18][19]. In addition, force feedback has been added to the Metric Cursor to enable accurate and easy cutting plane setting and motion through a dataset.

The development of interaction tools for touching fields data, started in 2003 (see the i3D 2003 activity report), has continued. Several ways of computing forces from the visualized dataset, using density or other parameters have been investigated. Tactile feedback has also been added (see Figures3, 4).

The application has also been ported on a desktop Spidar (see Figure5).

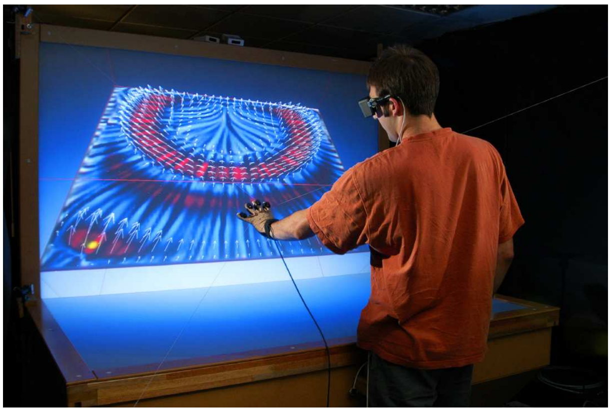

Figure 3. Haptic rendering of sismic geo-scientific data on the Stringed Haptic Workbench (Geobench project, data ©CEA-DAM)

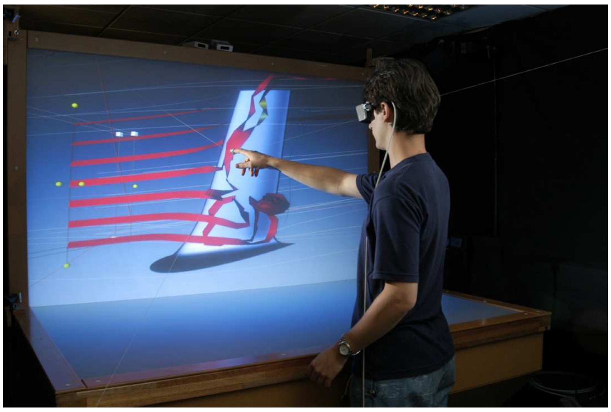

Figure 4. Haptic rendering of air flow on the Stringed Haptic Workbench (Geobench project, data ©Mercury)

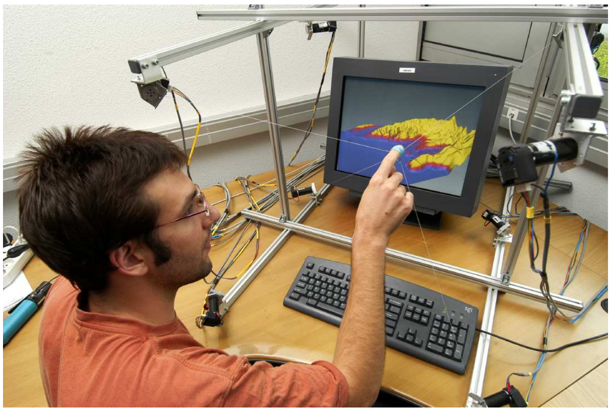

Figure 5. Haptic rendering of geo-scientific data (Geobench project, data ©CEA-DAM)

6. New Results

6.1. Panorama

This year, i3D research results concern mainly haptic interaction. Active, self-constrained, pseudo haptic, and tactile feedback have been studied.

6.2. Investigation of the Pseudo-Haptic Multisensory (visuo-haptic) Conflict

Participants: Michael Alleon, Christophe Arbez, Thibault Prados, Marco Congedo, Sabine Coquillart.

This work lies in a research axis aiming at simulating low cost force feedback. It is the prolongation of previous years research on pseudo-haptic force feedback [16] [15]. It was shown that it is possible to simulate springs stiffness making use of an illusion generated by coupling a visual feedback and a force sensor. A similar result was also demonstrated, last year, for torque feedback [2].

During this research, an important variation of subjects sensitivity to pseudo-haptic force feedback was noted. The purpose of this new study is to caracterize these variations. One hypothesis is an influence of the subject exploration strategy. In the framework of the ECOVIA-ROBEA project, we are studying the influence of the exploration strategy on subjects' sensibility to pseudo-haptic force feedback.

For this goal, a computer program which makes use of a PHANToM (Sensable Technology) haptic device has been developed. This device allows to simulate various springs, either physically correct or not. The program allows to make comparisons of two springs: a reference one which is physically correct (the force and the visual feedback follow the same Hooke law), and a comparison one with a haptic stiffness different of its visual stiffness (the force feedback and the visual feedback follow two different Hooke laws). This program will soon be used to conduct psychophysical experiments in order to study the variation of subject sensitivity by varying the subjects exploration strategy.

6.3. Self Constrained Haptic Device

Participants: Alexis Paljic, Sabine Coquillart.

This work is the prolongation of previous years research on simulating low cost force feedback. Previous work concerned pseudo-haptic force feedback [16]. It was shown that it is possible to simulate springs stiffness making use of an illusion generated by coupling a visual feedback and a force sensor. A similar result was also demonstrated for torque feedback in[2]. The Self-Constrained Haptic Device proposed this year is also

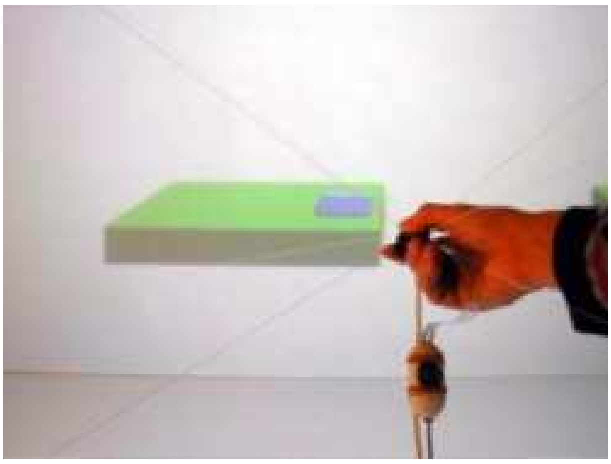

Figure 6. The breaking device

based on an interaction between visual and haptic information. It is called "self constrained" because the user himself is the source of energy for the force feedback.

The device is made of a tracking device and a force sensor embbeded into a breaking system (see Figure6).

The user held the breaking system that can slide along strings. When the user moves an object in free space he does not have to press the device and his movements are free. Forces (friction, viscosity) are simulated, by lowering the object displacement gain, so that the user sees it slow down. In order to be able to control the object with a 1:1 displacement gain, the user has to press the device. This action constrains his movements along the wires.

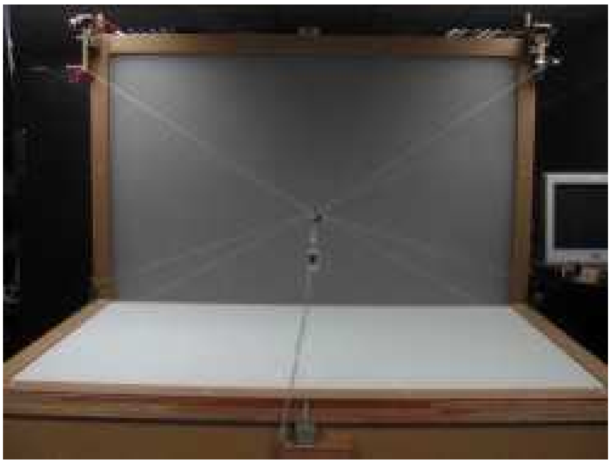

Figure 7. The self-constrained haptic device installed on a two-screen workbench

Several experiments have been conducted to evaluate the new device. Results show that it provides the user with actual forces that are consistent with simulated physical properties, and that it enhances user performance compared to the purely visual situation.

The system has also been installed on our two-screen workbench on which informal tests show that it provides the users with haptic sensations (see Figure7).

This work has been published in [3].

6.4. Two-Finger Haptic Interactions for Scientific Visualisation

Participants: Tangui Morvan, Sabine Coquillart.

One of the main problems of scientific visualisation lies in the visualisation of multiple simultaneous information. It can occur when trying to visualise the divergence or curl of a vector field on top of its representation, or when visualizing complex multivariate data such as tensor fields.... Such complex information often leads to visual clutter. Adding haptics to the visualisation can be a good way to tackle this problem.

One of the particularities of the Spidar haptic device [20] is its reconfigurability, with an 8-motor configuration it is for example possible to have 3 Dof haptic feedback on two fingers. This configuration provides an additional information compared to traditional one point configurations: the information of thickness between the two fingers.

Several interaction techniques have been developed under Amira to take advantage of this additional haptic information in order to visualise multiple or complex data [20]. These techniques consist in the haptic representation of classical vector and tensor field visualisation primitives: streamlines, streamtubes and hyper-streamlines. For each of these primitives a visual representation was first developed under Amira, a haptic representation was then added on top of it.

Streamlines are one of the most basic stream primitives. They represent the trajectory of a massless particle in a vector field. Their haptic representation is well-known and consists in constraining one of the fingers on the line, with what is called a virtual fixture.

Streamtubes are an extension of streamlines: they are obtained by sweeping a circular cross-section, with a radius proportional to the divergence, along the streamline. The divergence can then be seen as an additional thickness information on top of the streamline. The haptic representation is then straightforward: one finger is constrained on the streamline while the other collides with the cross-section. This way, the divergence is felt by the user as the thickness between its two fingers (see Figure 8).

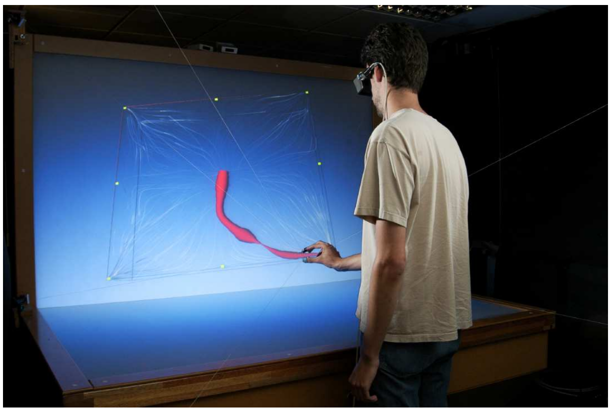

Figure 8. Haptic exploration of a streamtube in flow data under Amira on the Stringed Haptic Workbench (Geobench project, data ©CEA-DAM)

Hyper-streamlines are the extension of streamlines to symmetric second-order tensor fields. They are obtained by sweeping an elliptic cross-section whose axis correspond to the minor and medium eigenvectors along the streamlines of the major eigenvectors. They bear some similarities with streamtubes, their haptic representation is thus also quite similar to that of the streamtubes. One finger is constrained around the streamline while the other collides with the elliptic cross-section. The user can then feel the 3 eigenvectors simultaneously.

6.5. Tactile Interaction for Scientific Visualization

Participants: Xavier Lepaul, Ambroise Guabello, Thomas Vincent, Sabine Coquillart.

In parallel to the two-finger interaction study, enhancing scientific visualization with tactile interaction has also been investigated. For that purpose, two devices have been employed. A vibratory tool for producing vibrations on the fingertip, developed from a cellphone vibrator by the SED department of INRIA Rhône-Alpes. A CyberTouch^{TM}[11] with 18 sensors and 6 vibrators (one per finger, and one in the palm), also used for application control.

Four paradigms[5] have been proposed for:

- scalar datasets exploration,
- time control,
- vector field exploration,
- cutting plane positionning.

6.6. Haptic Interaction for the Automotive Industry

Participants: Michael Ortega, Sabine Coquillart.

A new study on haptic interaction for automotive applications started this year in collaboration with PSA Peugeot Citroën. Two main tasks which could benefit from force feedback have been chosen: assembling and painting. The study is conducted on the Stringed Haptic Workbench [20], a two-screen workbench with 6dof direct haptic manipulation. New interaction approaches combining props and force feedback are currently under study.

7. Contracts and Grants with Industry

7.1. PSA Peugeot Citroën

Participants: Michael Ortega, Sabine Coquillart.

PSA Peugeot Citroën and i3D are collaborating within a CIFRE contract.

7.2. INRIA

- **Siames Project**: Several collaborations are running with the Siames Project. As they all involve other partners, they are presented in the section on "National" or "International" actions.
- **Apache Project**: i3D is collaborating with the Apache project within the framework of the Geobench project. As this project involves other partners, it is presented in the section on "National" actions.

[11] CyberTouch is a trademark of Immersion

7.3. Régional

- i3D is working on Pseudo-haptic feedback with LPNC - Laboratoire de Psychologie et Neurocognition of Grenoble - within a Robea project called "Ecovia" (see 7.4).
- i3D is working with the ID lab. within an RNTL project called Geobench (see 7.4).

7.4. National

- **VTHD++** As a follow-up of the RNRT project VTHD, i3D and Siames take part in the VTHD++ project. The purpose of this project is to develop collaborative solutions upon Siames' OpenMask platform. This year, a focus has been put on collaborative haptic feedback. A collaborative haptic platform has been developed within OpenMask, and a demonstration allowing collaborative haptic interactions between Rennes and Grenoble has been set up.
- **Perf-RV** Siames and i3D are also working together with other partners on an RNTL platform project called Perf-RV. i3D is part of two actions: one on virtual prototyping together with EADS, Dassault and CEA, and the other one on collaborative interaction, together with Siames, Limsi, LaBRI and Renault. More than fifteen partners are involved in PERF-RV.
- **Geobench** i3D, Apache, TGS, BRGM, CEA and the University of Orleans collaborate on the RNTL project "Geobench". Concerning i3D, the purpose of this project is to integrate the Spidar system into Amira with a PC cluster and to propose new interaction techniques making use of the Stringed Haptic Workbench configuration.
- **Ecovia** i3D, Siames, College de France and LPNC-Grenoble collaborate on the Robea project "Ecovia". The purpose of this project is to pursue previous researchs on pseudo haptic feedback.
- **CNRS Specific Initiative on "Haptics"** i3D takes part in CNRS Specific Initiative on "Haptics".
- **CNRS Specific Initiative on "Collision Detection"** i3D takes part in CNRS Specific Initiative on "Collision Detection".

7.5. 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 Siames are in the core group of the "Intuition" Virtual Reality Network of Excellence.

8. Dissemination

8.1. Leadership within 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 Editorial Board of the "Computer Graphics Forum" journal.
- Sabine Coquillart is a member of the Editorial Board of the journal of "Virtual Reality and Broadcasting".

8.2. Teaching

- **DEA I3 University Paris-Sud-Orsay**, Sabine Coquillart is teaching in the "Virtual Environments and Advanced Interfaces" module.
- **DEA VRMSC, University Evry and Versailles Saint-Quentin-en-Yvelines**, Sabine Coquillart is teaching in the "Virtual Reality" module.

8.3. Conference and Workshop Committees, Invited Conferences

- Sabine Coquillart has been a member of the International Program Committee of the following conferences: CASA'04, CGI'04, GRAPHITE'04, ICAT'04, IPT'04, EGVE'04, VRIC'2004, SCCG'2004, Solid Modeling'04, SMI'04, WSCG'2004, Eurographics'2004, IEEE Virtual Reality'2004, and has reviewed papers for the following journals: IEEE CG&A.
- Sabine Coquillart has been co-chair of the 2004 Eurogaphics Symposium on Virtual Environments organized in Grenoble.
- Sabine Coquillart has been tutorial co-chair of the Eurogaphics'2004 conference.

See the list of references for a list of conferences where i3D presented papers.

9. Bibliography

Doctoral dissertations and Habilitation theses

[1] A. PALJIC. *Interaction en environnements immersifs et retours d'effort passifs*, PhD dissertation, University Paris 6, 2004.

Publications in Conferences and Workshops

[2] A. PALJIC, J. BURKHARDT, S. COQUILLART. *Evaluation of Pseudo-Haptic Feedback for Simulating Torque: a Comparison between isometric and elastic input devices*, in "Haptic Symposium 2004, USA", 2004.

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

Internal Reports

[4] *PERF-RV - Rapport de Synthèse Final*, RNTL report, 2004.

Miscellaneous

[5] X. LEPAUL. *Retour Tactile et Exploration de Données Scientifiques*, DEA report, DEA IVR, 2004.

[6] T. MORVAN. *Retour d'effort pour la visualisation scientifique*, DEA report, DEA IVR, 2004.

Bibliography in notes

[7] J. ALLARD, V. GOURANTON, L. LECOINTRE, S. LIMET, E. MELIN, B. RAFFIN, S. ROBERT. *FlowVR: a Middleware for Large Scale Virtual Reality Applications*, in "Euro-Par'04", 2004.

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

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

[10] 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.

[11] 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.

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

[13] 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.

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

[15] 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.

[16] 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.

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

[18] T. STEIN, S. COQUILLART. *The Metric Cursor*, in "Technical Sketch, Siggraph'2000, New-Orleans, USA", ACM Siggraph, July 2000.

[19] T. STEIN, S. COQUILLART. *The Metric Cursor*, in "Pacific Graphics'2000, Hong-Kong", IEEE Computer Society, October 2000.

[20] 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.