INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team ALCOVE

Interacting with complex objects in collaborative virtual environments

Futurs

THEME COG

Activity Report

2005

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1. Team

Team Leader

Christophe Chaillou [Professor, section 27, LIFL]

Faculty Member

Fabrice Aubert [Assistant Professor, section 27, LIFL]
Géry Casiez [Assistant Professor, section 27, LIFL]
Fréderic Giraud [Assistant Professor, section 63, L2EP]
Laurent Grisoni [Assistant Professor (HDR), section 27, LIFL]
Sylvain Karpf [Assistant Professor, section 27, LIFL - part-time INRIA]
Betty Lemaire-Semail [Professor, section 63, L2EP)]
Patricia Plénacoste [Assistant Professor, section 16, LIFL]

Research Scientist

Brian Barsky [Professor at Berkeley - currently on sabbatical leave at LIFL]
Samuel Boivin [CR, INRIA, FUTURS-Lille]
Stéphane Cotin [part-time work in Alcove since Oct04]
Samuel Degrande [IR, CNRS, LIFL]
Christian Duriez [CR, INRIA, FUTURS-Lille, starting Jan. 06]

Ph. D. student

Melisande Biet [MENRT, L2EP]
Zheng Dai [Foreign funding, L2EP]
Jérémie Dequidt [MENRT,LIFL]
Sylvain Gaeremynck [MENRT, LIFL]
Julien Lenoir [MENRT, LIFL - currently on post-doc position at CIMIT, Boston, USA]
Damien Marchal [INRIA-Région, LIFL]
Nicolas Martin [France-Télécom INRIA, LIFL]
François Martinot [MENRT, LIFL]
Gaston Mboungui [L2EP]
Qing Pan [INRIA-Région, LIFL]
François Pigache [MENRT, L2EP - currently on post-doc position at LEEI, Toulouse]
Cédric Syllebranque [INRIA-Région, LIFL]
Adrien Theetten [INRIA-CEA, LIFL]
Radu Vatavu [AUF, LIFL]
Johann Vandromme [MENRT,LIFL]

Post-doctoral fellow

Luciana Provenziano [ATER, LIFL]

Project staff

Pierre-Jean Bensoussan [INRIA, dec 2004-]
Frédéric Blondel [INRIA, oct 2003-]
Sylvère Fonteneau [INRIA, nov 2003-]
Ahmed Tahar [University, jan-feb 2005, INRIA mar 2005-]

Research scientist (partner)

Philippe Meseure [Assistant Professor, section 27, IRCOM-SIC Poitiers]
Stéphane Louis dit Picard [Research engineer, France-Telecom - Lanion]
Jean-Philippe Vandeborre [Assistant professor, ENIC]

2. Overall Objectives

2.1. Overall Objectives

Keywords: *3D framework*, *3D interfaces*, *HCI*, *cooperative virtual world*, *interaction models*, *physical modeling*, *virtual reality*.

Our project aims at defining new methods and tools for cooperative frameworks. This work is at the edge of several research areas : physical modeling, virtual reality, and HCI.

- Animation and physically-based simulation is a very active research field. Recent advances, to which our research work contributes, now allow users to interact with physically-based models. Surgical simulation is one of the areas that benefits from this research.
- During the last decade, numerous research works have been carried out that aim at immersing users into virtual worlds. Besides technological aspects (VR devices, ..), these new tools require new kinds of interaction between the users and the environment, as classical WIMP interfaces are no longer suited. It is now clear that many applications do not require the user to be fully immersed into the environment, thus opening a new research area : finding the best compromise between immersion-based realism and new models that allow to navigate in and to interact with the virtual world.
- Graphical Human-Computer Interfaces are now a basic part of any computer. However, they are not well suited to current applications like communication and collaborative work. New research is beeing carried out in order to make them more user-friendly in cooperative environments (Collaborative Virtual Environment, Tangible User Interface).

Our project deals with these three research areas. In the animation and simulation field, we aim at defining virtual objects behaving like real ones. As far as Virtual Reality is concerned, we focus on providing the users with natural interaction with the computer models. Last, we contribute to the HCI community by proposing and experimenting new interaction models and 3D interfaces between the users and the computer objects.

Our team has been developping for several years a non-immersive 3D environment mimicking a meeting room. A group of users, each one using its own computer, can meet in a virtual office and work together. Such a concept involves new problems, like manipulating virtual objects inside a cooperative framework (how to model real objects ? how to interact with these models ?).

Our research currently focuses on two main subjects : Interaction models and Physically-based autonomous objects. Figure 1 shows the topics that we consider in these subjects.

2.1.1. Interaction models

It is still illusive and probably useless to reproduce real world interactions on virtual objects. Therefore, we propose new basic metaphors for interaction (such as selection, picking, moving, assemblage, deformation), and we design corresponding devices (haptic or kinesthesic).

2.1.2. Physically-based autonomous objects

Programming projects nowadays benefit from advanced software concepts like object-oriented or agent-oriented programming. Our goal is to extend these concepts to physical modeling, in order to design autonomous physical objects that can be used inside a distributed cooperative framework. These objects will use such techniques as multi-resolution (physical and geometrical) and multi-representation.

3. Scientific Foundations

3.1. Interaction

Keywords: *3D desktop interaction*, *HCI*, *cooperative virtual environments*.

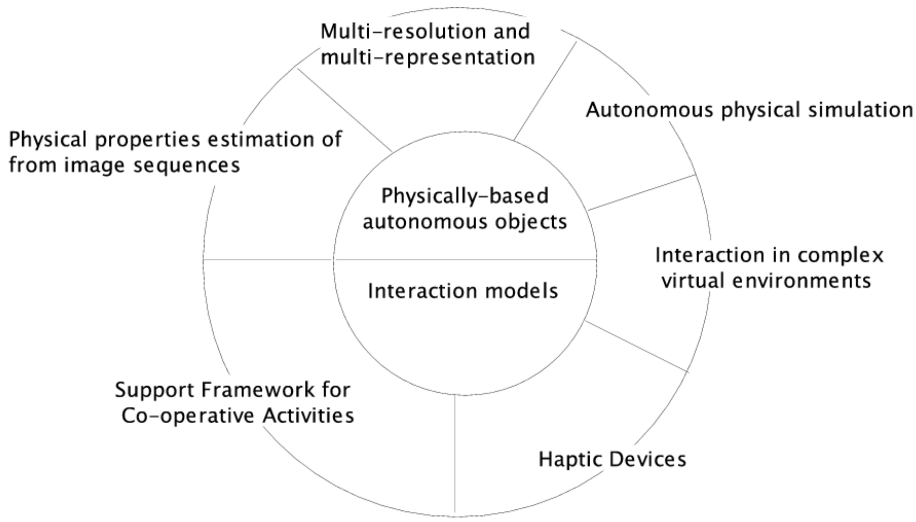


Figure 1. Research areas of Alcove

3.1.1. Collaborative 3D Desktop and 3D Human Computer Interface

Participants: Géry Casiez, Christophe Chaillou, Samuel Degrande, Sylvain Gaeremynck, Nicolas Martin, Qing Pan, Patricia Plénacoste, Luciana Provenzano, Johann Vandromme.

Since more than 20 years, the fundamental concepts of the computer's desktop environments did not really evolve. Windows, Icons, Mouse, Pointer (WIMP) are always the 2D metaphors used by humans to interact with a software application. Current windowing systems tend to use the 3D capabilities of modern computer's video cards, but only to add some specific visual effects, such as transparency or shadows. In our daily activites, we use simultaneously more and more applications, and we display more and more windows on the same screen. However, the 2D windowing environments are not well adapted to the display and the interaction with such a great amount of informations. Some studies did show that the use of a 3D space to organize informations can ease the user's activiy.

Moreover, interpersonnal communications and computer-aided collaboration become more and more natural, and there is a pressing demand of the industry to use a collaborative system that will enable them to interact with 3D objects in a natural manner.

Consequently, the computer-human interfaces must evolve, and we think that the far future computer's desktop systems will be specific 3D environments, seamlessly incorporating collaborative features. If the definition of such a collaborative 3D desktop environment is not yet defined, we can however propose several concepts that it will have to integrate, and that we are studying.

At a low level, virtual tools or action metaphors are needed in collaborative virtual environment to let the user focus on her/his activity rather than on the manipulation of the physical devices. Useless interactions should be removed or replaced with high level virtuals tools. Those tools are used to transpose the user intentions, and in a collaborative framework, each public action is to be represented in the remote user's environments, to let them understand the ongoing global activity. A software framework, based on the M.V.C. paradigm, is proposed to easily develop such tools and metaphors. With this platform, the default behavior of a tool can be dynamically adapted to the object it is acting on, through the definition of application specific interaction rules. Some new interactions metaphors (or 3D widgets) are studied, which are specific to collaborative 3D workspaces. For example, we propose a personal point-of-view manipulator that lets each user orient 3D objects in an independent way, while indicating the orientation adopted by the other users.

At a higher level, the concept of a “3D application” must be defined. A 3D desktop should be able to let the user interact simultaneously with several 3D applications, such as 2D windowing systems let users interact with several 2D applications at the same time. A 3D application is roughly a set of 3D objects and 3D tools. Handling several 3D applications thus means that the 3D desktop has to manage several sets of objects and tools, which are not necessarily spatially related. The 3D desktop must also provide specific tools to handle those 3D applications. We started working on the software and the ergonomic parts needed to create such an environment.

3.1.2. Tactile actuator

Keywords: *normal and tangential strain*, *tactile device*.

Participants: Melissande Biet, Christophe Chaillou, Frédéric Giraud, François Martinot, Betty Semail.

Since several years, research concerning touch parameters in interaction situation plays an increasing role in the fields of robotics and haptics since fast development in sensors and actuators miniaturizations could allow to study and reproduce touch small scale phenomena. So, one of the main interests in haptics applied to virtual reality is to find a general purpose desktop I/O device that could enhance virtual touch interactions by stimulating the finger pulp. A first study has been carried out by François MARTINOT and Patricia PLENACOSTE: using an experimental platform equipped with force and movement sensors, they have started this work by an ergonomical analysis of touch human gestures to predict final users behaviours and advice design guidelines for a desktop tactile display used in active touch conditions. Then, François MARTINOT has measured and analysed the contact interaction phenomena with small microphones to elaborate a touch mark by wavelet transform which could be used for control and evaluation purpose. Melissande BIET is currently designing a 2 dof travelling wave device based on a piezoelectric technology that could provide variable friction cutaneous feelings as well as different periodicity of rough textures, according to wave amplitude control. Besides, in collaboration with the IEMN laboratory (Philippe PERNOD) we participate to the study of a dense pin arrays based either on electromagnetic technology, or pulsed air micro-valve technology. For the next three years, we will focus our attention on the following points:

- the control and improvement of the different tactile displays which are under development, and their evaluation in use. For that aim, the acoustic signals characterising surfaces have to be exploited and interpreted according to a finger mechanical modelling
- the integration of the reverse sensor function on tactile displays, position and force estimation so as to provide inquiries to the associated mechanical modelling of the simulated texture. In particular, this work has to be carried out for soft surfaces
- the integration of tactile and force feedback on a single device

3.2. Simulation

Keywords: *3D virtual environment*, *Interaction*, *collision*, *interaction with haptic devices*, *physically-based simulation*.

3.2.1. Multi-resolution and Multi-models

Keywords: *adaptive models*, *dynamic control*, *multi-models*, *multi-resolution*, *physical simulation*.

Participants: Laurent Grisoni, Fabrice Aubert, Jérémie Dequidt, Damien Marchal, Adrien Theteen.

The global view of this point lies within the decay one can state when, on the one hand, considering the perception human has of the world, and on the other hand, the meaning and limits one can give to the notion of " model ", that is what computer handles for creating animated virtual version of real world. The idea that the perception of an object, in terms of geometry, is hierarchical is quite natural. Such a hierarchy, in the physical simulation context, has to be extended to other domains than geometry in order to gain realism. Physical simulation remains a very difficult field, where one hardly knows how to propose to users complex manipulation protocols, involving sophisticated physical operations, such as dynamic linking, cutting, using thread for suturing, etc... To the best of the community knowledge, it is possible, for each small part, to propose solutions, but it remains very difficult to propose a whole, global, software solution. In order to try to provide such tools, it is necessary to try to comprehend the problem from higher level than physical model, that is currently, to our knowledge, most of practical research activity in the field: we would have to find solutions for manipulating, from a software point of view, mechanical systems as "black boxes", as independant as possible one from each other, that would provide ways to interact together (e.g. collide). In addition to that, such a view opens the way to a whole new field of non-studied problems, among which the question to know how to provide systems with the ability to dynamically change their representation (either visual or mechanical), depending on the context of use, and external constraints (e.g.: CPU consumption). This is what we call "multi-model" objects.

3.2.2. Inverse Dynamics

Keywords: *computer graphics*, *computer vision*, *hysteresis*, *inverse modeling*, *inverse rendering*, *mechanical simulation*, *physical parameter identification*, *rendering*.

Participants: Samuel Boivin, Cyril Ngo-Ngoc, Cédric Syllebranque.

In the Alcove project, we reproduce many different mechanical phenomena using our own physical simulators especially a plateform called SOFA. Such simulators are able to generate very different objects having complex physical behaviors such as human eyes or clothes for example. Guiding these simulators with parameters coming from the observation of real data is essential to enhance and validate the simulation. Therefore, the main goal of this work is to estimate all these physical parameters from a real image sequence, and to use the reconstructed solution in Sofa or any other simulator. This has many applications not only in surgery but also in movie production where the tuning of parameters for deformable obects (cloth for example) is always an issue and often requires weeks or more. Many scientific issues have to be solved to estimate such parameters from image sequences. For example, we need a device that computes the external forces when interacting in real-time with a deformable solid, an error metric to compare real and synthetic videos, a minimization scheme and many other tools to accurately extract the physical parameters of a real object. In order to also obtain a reliable and thorough estimation of these parameters, a validation method has to be investigated.

4. Application Domains

4.1. Medical simulation

4.1.1. Background

Medical simulation has been a very active research field for the past ten years. The ultimate goal is to provide medical students with realistic simulators that reacts like actual human patients.

One of the most challenging task in medical simulation is to realisticaly model soft organs and tissues, and their interaction with surgical instruments, requiring real-time solutions to complex problems like physical modeling, collision detection, ...

4.1.2. Development of medical simulators

We continue our contribution to the developpment of medical simulators. We have recently concentrated our effort on the design of a cataract surgery simulator in ophthalmology. The first step of the operation (namely capsulhorexis) has been modeled. We now have a realistic real-time behavior of the capsule and its interaction with the surgical instruments. The next step will be the realistic modeling of the lens. A first approach based on finite-element modeling has been investigated. It allows for an accurate simulation of the phacoemusification procedure (breaking of the lens).

We are also starting research work for a corneal transplant simulator. Within this project, we are starting a collaboration with Pr Brian Barsky in the field of cornea modeling.

4.1.3. *Towards a new real-time simulation engine*

Following our first experience with the SPORE real-time simulation engine, we have started the development of a next generation engine (called SOFA) that will be more flexible than the previous one. This development is a joint-effort between Alcove, Epidaure (INRIA Sophia), Evasion (INRIA Grenoble) and the Sim group@CIMIT (Boston, USA). Our purpose is also to collaborate with other worldwide research teams involved in simulation.

4.2. Collaborative work on virtual objects

4.2.1. *Background*

Traditionally, virtual environments are used in teaching domains, to simulate physical phenomena or to represent objects taken from the natural environment, notably in such domains as medicine, nuclear industry (EDF), transport industry (SNCF, military or civil aviation). Their goal is to reproduce the environment and the objects as they are in reality, by integrating the natural properties of the objects, physical behaviors and environmental constraints. Our proposal is appreciably different. Indeed, we have choosen to consider co-operative activities of small groups of actors around virtual 2D or 3D objects. Our goal is to provide them with a virtual environment which uses classical computers and input devices, and which could be considered as an extension of their current working environment in the broad sense. Our proposal is built around a virtual representation which immerses the user in a known environment (a meeting room), without beeing a copy of the reality. By minimizing navigation and manipulation gestures, it enables several actors, geographically distant from each other, to focus on the realization of a common technical task. Some abstractions of visual representations and interactions are implemented to help the users understand and apprehend concepts, the 2D/3D objects beeing rather a support to the co-operation activities.

4.2.2. *Sofware Framework for Collaborative Virtual Environments*

After some preliminary studies, we have defined a set of software components needed to construct a generic framework dedicated to Collaborative Virtual Environments. Those components are divided into 3 levels :

- a network communication layer, in charge of the handling of the shared objects.
  A distributed architecture with a duplicated 3D database is choosen to ensure interactivity of manipulation and visualization. The network communication layer has to efficiently maintain the coherence between all instances of a duplicated shared data.
  It also provides all services needed to manage the virtual work session (entry/exit of avatars, concurrent access...).
- an object management layer.
  To ease the development of collaborative activites, 3D objects are defined using a descriptive language such as VRML97. An extension to the language is needed in order to be able to define shared data.
  Local interaction mecanisms with 3D objects (indices to help selection, ways of manipulation...) are also integrated into this layer.
- an interface management layer.
  Each user having a personal mental representation of her/his work, this layer provides the user with the ability to organize or adapt her/his own virtual interface. The interface is organized in several spatial domains, each domain having its specific behavior and usage. Users' actions are abstracted independently from the environment before being remotely transmitted.
  High level metaphorics tools used to act on objects or interact with the interface (such as the transfer of object from one spatial domain to another one, or point of view concept) are, also, provided.

- an external application integration layer.
  Several mechanisms are built inside our framework to communicate with external applications, providing a mean for such applications to modify the 3D content displayed by our platform. However, some applications have their own rendering engine and interaction mechanisms. Some mechanisms are also provided to integrate such applications in our framework, implying to cut them into small software pieces that roughly become parts of our software. This way of doing is not always possible, as this is the case for the Odysseus European project. We started studying a less “intimate” mechanism, where the link between our platform and the external application is done through an abstract interaction layer.

5. Software

5.1. Spin 3D

Participants: Samuel Degrande, Sylvain Gaeremynck, Nicolas Martin, Luciana Provenziano, Ahmed Tahar.

Spin|3D is a synchronous collaborative software platform, which implements the Collaborative Virtual Environment concepts presented in 4.2. Spin|3D is developped in collaboration with France Telecom R&D (Lannion’s site). A multi-disciplinary team (computer scientists and psychologists) composed of a dozen of members (one half in Lille, one half in Lannion) works on that project. We aim at providing a complete software environment to ease the development of collaborative applications.
For that purpose, Spin|3D is built on a core layer which can be extended with dynamically loaded external modules. Two kind of external modules can be plugged : viewer plugins, to display objects not directly handled by the core layer (such as an HTML plugin, for example), or autonomous external applications which communicate with the core through a local Corba bus (with that mecanism, a legacy software such as a CAD modeler can be connected to Spin|3D, without needing any heavy cross-integration).

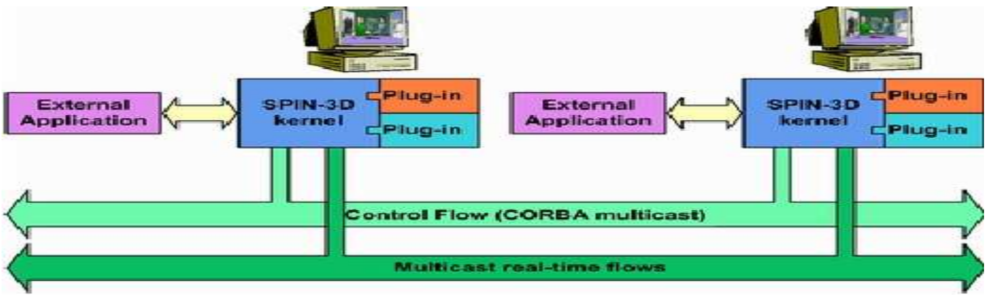


Figure 2. Architecture of an application based on Spin|3D

Until mid-2004, the LIFL worked, mainly, on "low level" layers, furnishing the communication framework and the object handling layer. Since then, we work on providing genericity and configurability to all platform’s layers. We are, also, developping an authoring tool to help designers write a Spin|3D application. France Télécom, on its side, studies human/human communications through the development of avatars, and works on the definition of end-users applications.

The main target applications are digital project reviews, support for medical diagnostics, virtual laboratory works and network games. We have proposed a virtual lab-work (to help students learn the use of an oscilloscope and a signal generator) in the Divilab European project (IST-1999-12017). France Télécom, with IRCAD, has developped, during 2003, a prototype of a medical diagnostic application, called Argonaute 3D. An “industrial” version of this application is currently being developped in the Odysseus European project. Some other applications, in the digital project review domain, are in preparation.

Figure 3. A terminal view of a Spin|3D application

5.2. SOFA

Participants: Pierre-Jean Bensoussan, Stéphane Cotin, Jérémie Dequidt, Sylvère Fonteneau, Sylvain Karpf, Laurent Grisoni, Damien Marchal.

We are currently involved in an open-source, real-time simulation plateform project. The SOFA project is the result of a collaboration between the CIMIT Simulation group (Harvard Medical school, leader Stephane Cotin), and INRIA projects EVASION (leader Marie-Paule Cani, INRIA Rhônes-Alpes) and EPIDAURE (leader Nicolas Ayache, Sophia-antipolis). This project was born when it appeared CIMIT and ALCOVE project, separately, had started quite the same work: propose a framework flexible enough so that people would reuse algorithmic blocks, and change, for a given object, collision representation, visual and mechanic representation, as independently as possible. We chose to join effort, and after EVASION and EPIDAURE joined us in this work, INRIA supported this project by providing 2 engineers, for 2 years, for this project. The alpha version of the SOFA plateform should be made public soon. It provides multi-threaded support for simulation algorithmic (not only for drawing and/or haptic control), proper handling of group (for collision and constraints), and software structure that provides enough flexibility and genericity for people to consider functional blocks as exchangeable, and semantically start to build their own simulator efficiently.

6. New Results

6.1. VROOM-MATE : A Spin|3D demonstration

Participants: Samuel Degrande, Nicolas Martin, Patrica Plénacoste, Johann Vandromme.

Using our Spin|3D platform, we designed a specific demonstrative application for the Siggraph 2005 exhibition, held in August 2005 at Los Angeles. This application shows the main concepts of our current researches concerning the Collaborative Virtual Environments :

- conceptual assembly/desassembly, based on virtual magnets elements for fast and easy assembly of mechanical parts
- configurable interaction areas, defined through a modified MVC paradigm and interaction rules that enable to dynamically adapt interaction modalities to the current user's activity

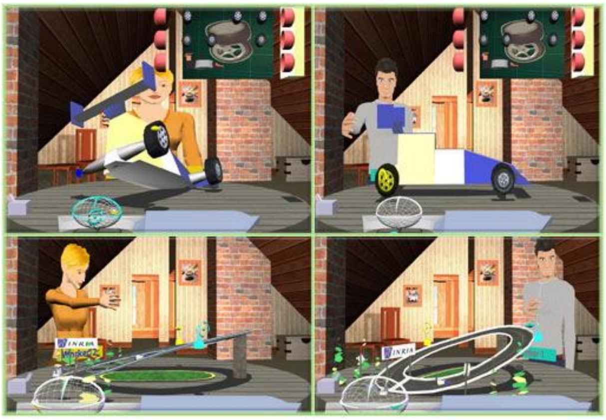


Figure 4. VROOM-Mate screenshots

6.2. Adaptation of the MVC paradigm to CVE

Participants: Samuel Degrande, Nicolas Martin, Ahmed Tahar.

Nowadays, 3D computer graphics technologies are more and more used to build computer-human interfaces. The use of the third dimension brings some improvements to computer interfaces, but existing systems only integrate 2D applications inside a virtual environment, without proposing real innovations in terms of 3D HCI. We did explore the use of the MVC paradigm to adapt it to the architecture of our 3D collaborative desktop (Spin|3D) [20]. Such a design pattern enables to easily create configurable 3D interaction areas, and provides reusability of software components. We modified the basis MVC paradigm to add a configurable interaction mechanism, in order to dynamically adapt interaction modalities to the current user's activity.

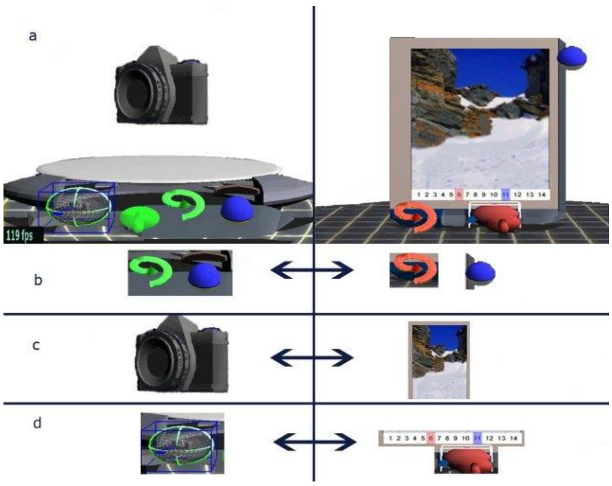


Figure 5. Component reusability

6.3. Cataract Surgery Simulation

Participants: Fréderic Blondel, Sylvain Karpf.

We have recently concentrated our effort on the design of a cataract surgery simulator in ophthalmology.The first step of the operation (namely capsulorhexis, or removal of the membrane covering the lens) has been modeled using a mass-spring structure. We now have a realistic real-time behavior of the capsule and its interaction with the surgical instruments (see figure 6). The next step of the surgical procedure, called phacoemusfication, consists in breaking the lens with an ultrasonic tool. We are simulating this using a volumic thetrahedral representation of the lens (see figure 6).

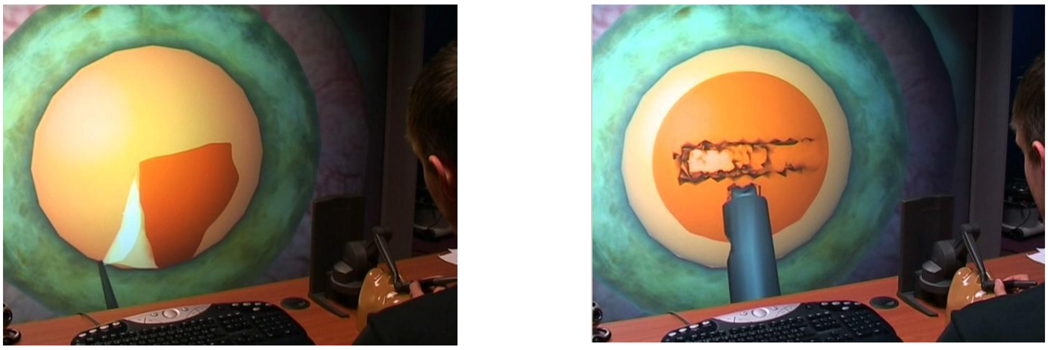


Figure 6. Left : capsulorhexis. Right : phacoemulsification

6.4. Collaborative Simulation

Participants: Jérémie Dequidt, Laurent Grisoni.

We proposed a system that provides interactive simulation over the network, and allows for collaborative manipulation of physically-simulated objects [17]. This system preserves user interaction in case of network performances degrading. It does not, in the general case, provide strong synchronization between simulation hosts; yet, it guarantees that all hosts converge (when left without interaction) to the same, physically plausible, scene configuration.

6.5. Knot tying

Participants: Laurent Grisoni, Julien Lenoir, Philippe Meseure.

This work is a new step toward tools for surgical thread manipulation within virtual scenes. The real-time, dynamic B-spline model, proposed in previous publications, is combined with classical geometric manipulations such as knot insertion, and removal. The global result is a 1D deformable model that can dynamically adapt its resolution, for example to knot tying, for reasonnable computation cost [19]. The knot insertion theory allows for the simulation to allow, without no extra efforts, dynamic cutting of the thread, at any arbitrary parameter value.

6.6. Time critical animation

Participants: Jérémie Dequidt, Laurent Grisoni, Damien Marchal.

This work presents a first, generic, tool for solid animation [14]. Some octree is used as a FFD on a mesh, and allows for deformation. Adaptive model of collision, and mechanics, are presented; a control loop is

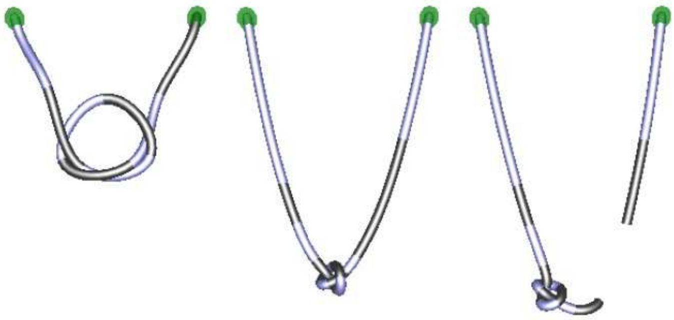


Figure 7. applications of the dynamic B-spline model

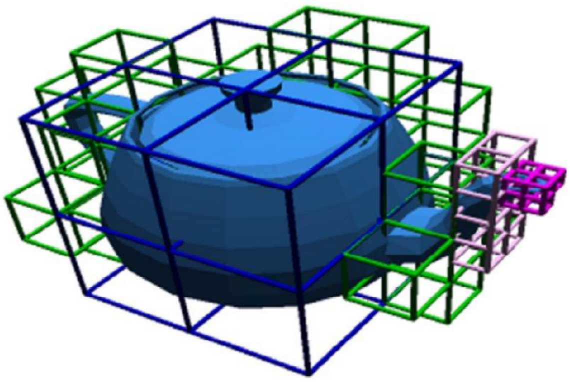


Figure 8. The octree structure

also described, that provide dynamic adaptation to some pre-imposed computation cost (without any specific knowledge of the computation power available).

6.7. Inverse Dynamics of a Deformable Solid

Participants: Samuel Boivin, Cédric Syllebranque.

We propose a new method for estimating the physical properties of complex objects from an image sequence. Actually, we want to approximate the mechanical properties of a deformable object directly from a real video. We have been working on a new algorithm being able to recover the parameters of a deformable solid simulated by a finite element method, directly from a real image sequence. As first step of this research area, we have also developed a new device that is able to capture the external forces produced by a human acting on a real deformable solid (see pictures of figure 9).

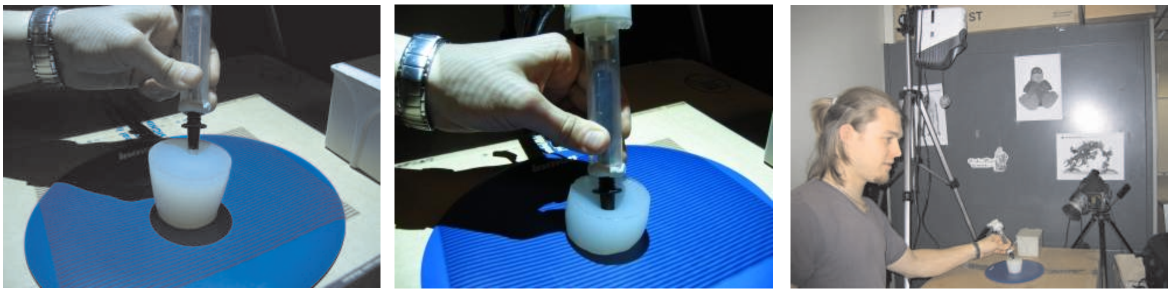


Figure 9. Left and middle: our device for capturing external forces applied on an object in real-time (left for a hard material and middle for a soft one). Right: the whole capture system for recovering the parameters of a deformable solid from videos.

6.8. Inverse Dynamics of Nonlinear clothes

Participants: Samuel Boivin, Cyril Ngo-Ngoc.

We have created a new cloth model that simulates the fabric as a complex yarn interlacing structure through three components (bending, traction and shearing). Our physical model is also based on the Kawabata Evaluation System (KES). It reproduces the behavior of a cloth using the parameters coming from direct measurements on real clothes. Therefore we propose an identification procedure to compute all the physical parameters of our model from the KES curves. Since many textile manufacturers use this KES to design their fabrics, we are able to accurately simulate their real fabrics in computer graphics using the manufacturer's parameters. We are currently working on the production of a high quality movie. We have filmed a fashion show with a real mannequin wearing complex clothes, and we are reproducing this video in computer graphics by creating a virtual fashion identical to the original one using our cloth model.

6.9. Digihaptic evaluation

Participants: Géry Casiez, Christophe Chaillou.

We investigated the use of a new haptic device called DigiHaptic in a 3D navigation task [16]. Unlike other devices intended to interact in 3D with one end-effector, the DigiHaptic has three levers that the user may handle simultaneously or not in elastic mode to rate control objects. We compared it to the SpaceMouse - another elastic device - to evaluate the influence that degrees of freedom (DOF) separation and force feedback have in terms of accuracy (errors) and speed (time) in a 3D navigation task. We first explain the simulation of virtual walls on elastic force feedback devices before presenting the experiment. We found that users

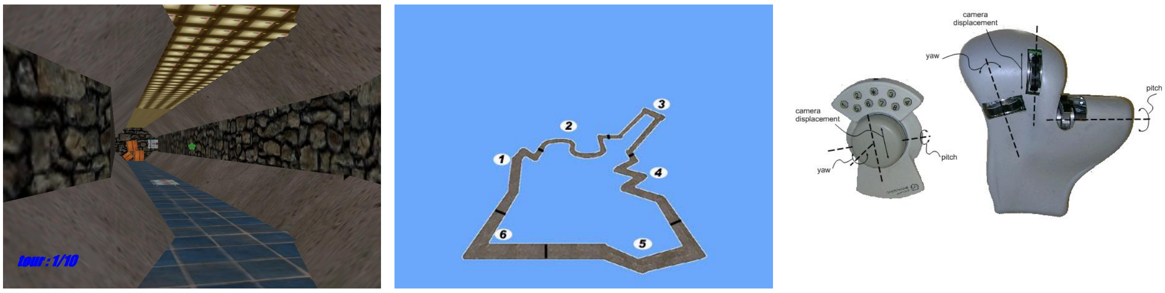


Figure 10. Digihaptic evaluation - Left : Screenshot inside the tunnel. Center : a global view of the 3D tunnel. Right : degrees of freedom of the camera controlled with the DigiHaptic and the SpaceMouse

performed the task with the same amount of time on both devices but that DOF separation increases the control accuracy of the camera. We also presented the effects of force feedback on users performances for the task involved.

6.10. Haptic perception of textures with a bare finger

Participants: Christophe Chaillou, François Martinot, Patrica Plénacoste.

The understanding of roughness perception in active touch is an essential requisite in the design of innovative and realistic tactile displays for virtual reality.

Using a custom-built 3 dof force platform in a preliminary study, we first identified the amplitude, force and speed range of the index finger in lateral touch. Then, using a miniature microphone and a LASER doppler vibrometer, we evaluated the vibration at contact. Comparable signals with both techniques [22] allowed to conclude that, in addition with the protrusions of the texture, the epidermal ridges of the fingerprint play an important role in the interaction. Wavelets allowed to discover that the orientation of movement is also a determinant. Using the roughness descriptor of the SENSOTACT®, a tactile reference frame created by Renault, we computed the correlations between the energy contained in the frictional sounds and roughness magnitued estimates attributed by an expert panel. As a result, we confirmed that tribologic events occuring at contact at different spatio-temporal scales [21] could mediate the perception of a topographic state.

Figure 11. the 3 dof force platform

6.11. A variable friction 2D device

Participants: Frédéric Giraud, Betty Lemaire-Semail, François Pigache.

Within the framework of force feedback for Human Computer Interface, we have studied a standing wave ultrasonic actuator used as an adjustable brake, able to oppose a resistant force to the user [23]. This kind of devices is comparable to a planar clutch. The piezo-electric actuator is decribed in fig 12: when supplied with an alternative voltage, a standing wave is created through the actuator. According to the feet location, the actuator either moves in X,Y directions or stands in place, creating a variable resistant friction force with the standing wave amplitude control.

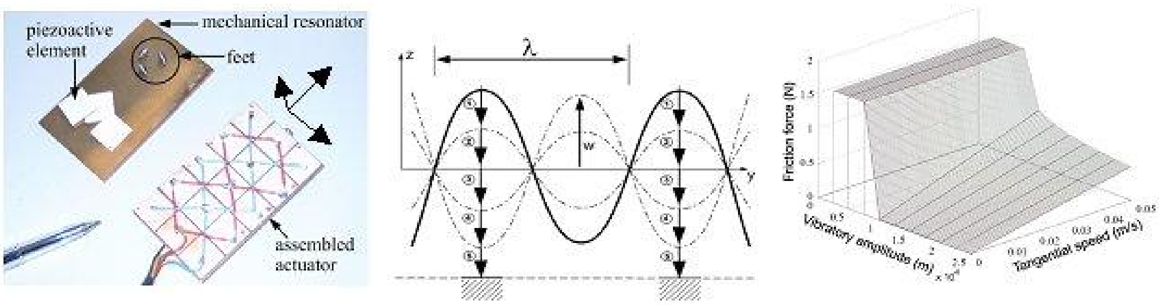


Figure 12. Left : Front and bottom view of the actuator. Center : Vibrating principle. Right : Controlled friction coefficient

6.12. Ultrasonic Motors

Participants: Frédéric Giraud, Betty Lemaire-Semail.

In this work, we tried to improve torque response at low rotational speed of the output torque of ultrasonic motors. In that purpose, a control scheme has been proposed. It includes the phase shifting of the supply voltage, which helps to avoid stick-slip problems when a low torque is required at low rotational speed. In addition to this control, a specific closed loop control of the rotational angle of the motor has been developed in order to be sufficiently robust besides the external load torque [18]. These control schemes have been tested on a force feedback stick, on which elastic behaviours have been simulated (fig 13). To achieve that, we had to design a specific torque sensor.

7. Contracts and Grants with Industry

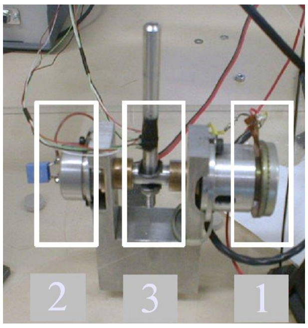
7.1. Contracts and Grants with Industry

France Télécom R&D

We work in collaboration with France Télécom since 1994. In a first period, from 1994 to 1997, a CTI contract was established to develop a first prototype of a collaborative work interface, called Spin. Two PhD thesis were defended in the LIFL, one of them being supported by the contract.

In 1999, France Télécom showed its interest in our research by creating a project-team in its Lannion's site, recruting the first PhD student who was on the CTI contract, and supporting a third PhD student who defended his thesis in 2001 on the articulation between action and communication in non-immersive virtual environments.

In order to jointly develop a pre-industrial framework, based on the first prototype studies, a second contract (External Research Contract) was signed between the University of Lille 1 and France Télécom in 2000, for 2



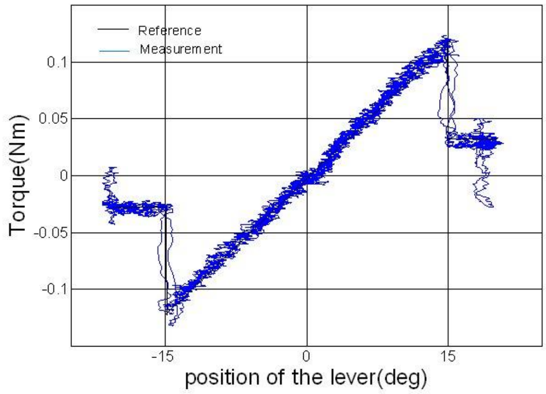


Figure 13. Left : One DOF test device. Right : Torque vs position characteristics of the force feedback device

years, for a global amount of 1,1MF HT. Since 2001, the Spin|3D team in France Télécom is composed of 5 full-time members.
In 2003, two other contracts have been signed between the University of Lille 1, INRIA and France Télécom. The first one, for an amount of 240kEuros HT, concerns the finalization of the core framework, and the integration of some new features. The second one supports one half of Nicolas Martin's PhD thesis, the other half beeing financed by INRIA.
A new contract started in 2005 in order to integrate Nicolas Martin's results into the SPIN framework. This work is done by Ahmed Tahar. Our partners from France Télécom now focus on the development of applications.

CEA

We are collaborating with Claude Andriot (LIST Team, CEA, Fontenay-Aux-Roses) through a co-funded PhD Thesis (Adrien Theeten). This work aims at modeling slightly deformable 1D objects for CAD applications (simulation of the behavior of large cables) in urban projects, building design, ...

8. Other Grants and Activities

8.1. National initiatives

- SIMV@L (RNTS 2003 - Partners : Thales Training and Simulation, Ecole des Mines de Paris, Ecole de Chirurgie de l'APHP, Evalab (Lille II), Primal Cry, Graphix/Alcove team)
  This project aims at proposing and validating a certification process for medical simulators. Our team brings its expertise in the field of real-time simulation engines.

8.2. European initiative

- Odysseus (Eureka - Partners : IRCAD (Strasbourg), France Telecom, Storz (Germany), SimSurgery (Norway), INRIA (Alcove, Evasion, Epidaure)).
  The three main objectives of this project are :
  - develop an operational patient 3D-reconstruction tool or commercial service
  - develop a 3D tele-diagnosis software based on the SPIN platform
  - develop a urology and liver-surgery simulator

  We are involved in the last two sub-projects.

8.3. STIC Asian project on virtual reality

We participate in developping a research network that regroups French teams (IRIT, LIRIS, LSIIT, Lab. Info. Alcove, I3D, Iparla, Siames) and Korean, Chinese, Japanese, Taiwan, and Singapore labs. The research topic is virtual reality around Geometric Modelling, Real-time images, 3D interaction and CVE.

Christophe Chaillou and Laurent Grisoni were members of the French group of researchers that visited Korea in January 2005. They visited several research labs, and attented the first ICT Workshop on VR in Seoul [28]. Members of the Alcove project also attended the second ICT Workshop on VR in Strasbourg, France, November 2005 [29][25].

We hope to start scientific collaborations with some Asian labs in 2006.

8.4. Visiting scientists

8.4.1. Pr. Brian Barsky

Following an initiative by S. Boivin, Pr. Brian Barsky from Berkeley is visiting us for one year, starting september 2005. He is working on two of our projects : real-time simulation of 1D-Splines based objects, and modeling of the eye for a corneal transplant simulator. We hope this will lead to a strong collaboration between Alcove and the University of Berkeley.

8.4.2. Dr Stéphane Cotin

Dr Stéphane Cotin, lead of the Simulation Group at CIMIT (Boston, USA), has been part-time researcher in the Alcove team in 2005, in order to supervize the SOFA project.

9. Dissemination

9.1. Leadership within scientific community

- We organized the GTAS 2005 (French Animation and Simulation Workgroup) in Lille in May (see http://www.lifl.fr/gtas05/accueil.html).
- Alcove attented the '12èmes Rencontres INRIA-Industrie" in February 2005, with a demonstration about Interacting with Deformable Virtual Objects.
- Alcove attended the "ZOOM Sciences et Technologies : Technologies émergentes des TIC" organized by the University of Lille in December 2005 during the NET 2005 meeting, with a demonstration about Interacting with Deformable Virtual Objects.
- Christophe Chaillou was reviewer for the French research network RNTL (2 projects reviewed) and ARA Masse de Données (3 projects reviewed). He was also reviewer for the Telecom Group of the CAMPUS MOBILE french research network. He was also reviewer for 3 PhD Thesis.
- Christophe Chaillou is a member of the program committee of VRIC and Vriphys 05 (second workshop on virtual reality interaction and physical simulation)

9.2. Teaching

- Master students (University of Lille I) :
  - Samuel Boivin : computer graphics (rendering and inverse rendering)
  - Christophe Chaillou : digital image processing.
  - Laurent Grisoni : computer graphics (Animation, geometric modeling)
- Engineer students (Polytech'Lille)
  - Géry Casiez : Haptic, HCI, GTK
  - Christophe Chaillou : Computer Graphics, HCI, VR, Data and Image Compression
  - Laurent Grisoni : Animation, Advanced Computer Graphics
  - Sylvain Karpf : Computer architecture, Computer Graphics
  - Patricia Plénacoste : HCI - Ergonomics
  - Betty Semail : electromagnetism, piezo-electric control
- Engineer students (ENIC - Lille)
  - Géry Casiez : Haptics
- Faculty students (University of Lille I)
  - Fabrice Aubert : 3D Programmation, Introduction to Computer Graphics
  - Géry Casiez : 3D Programming
  - Patricia Plénacoste : HCI - Ergonomics.

9.3. Other

Damien Marchal, Nicolas Martin and Christophe Chaillou have participated in the Regional Operation "Chercheurs à l'Ecole" (Researchers in Schools). They gave several lectures to children in primary schools.

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