

Virtual Reality at INRIA

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Virtual reality: a major scientific challenge for INRIA

INRIA has been significantly involved in computer graphics for many years. The Institute is developing research, methods and tools in computer graphics for new sectors of research, industry, medicine and media, within some twenty research teams from its six sites at Grenoble, Nancy, Rennes, Rocquencourt, Sophia Antipolis and Bordeaux/Lille/Saclay.

A dynamic policy expressed in INRIA's 1999-2003 strategic plan

Virtual reality is one of the five major scientific challenges defined by INRIA in its strategic plan for the five years to come, namely

mastering the digital infrastructure by being able to program, compute and communicate over the Internet and on heterogeneous networks,
designing new applications using the Web and multimedia databases,
being able of producing reliable software,
designing and mastering the automation of complex systems,
combining simulation and virtual reality.

Extracts from the strategic plan, July 1999

Designing and mastering the automation of complex systems

Developed societies rely on the design and production of increasingly complex objects and large systems. Complexity is now inherent in objects considered individually (automobiles, civilian or military aircraft, telephones, television sets, computers, robots, satellites, each of these objects being itself an assemblage of various components) and to the systems they constitute (satellite constellations, defense systems, manufacturing systems, transportation systems).

(...) Prototyping and virtual reality will be the basic methods in industrial product design, as they make it possible to model objects, simulate and eventually operate them without actually making them. Considerable technical difficulties will have to be overcome to develop the entirely integrated design lines of the future that will combine CAD with simulation, shape optimization and validation models as well as efficient and natural multimodal interfaces, and the design of embedded software.

Combining simulation and virtual reality

(the point is) to build systems that combine image analysis, numerical models, computer graphics and automatic control, in high performance experimental platforms, in order to develop real time simulations, allow for sensory interaction, understand multiscale modeling problems, and be able to optimize designs.

INRIA's involvement in virtual reality

The priority character of virtual reality at INRIA can be seen on several levels

- *Specific budget lines* were opened by the scientific management to develop high impact work in the framework of the Cooperative Research Initiatives (ARC). These initiatives foster multidisciplinary collaborations and associate external teams.

- *New research projects* involving virtual reality were set up and projects that use virtual reality are *encouraged*. Some twenty teams on the hundred or so of INRIA research projects contribute to research in this field.

- *Presentation* of the teams's scientific results in the major scientific conferences in the field (SIGGRAPH, IEEE VR, etc.) and *participation* in a large number of European collaborations in the framework of the IST program.

- *Purchase and operation* of very high level virtual reality platforms. As early as 1999 and at the initiative of Sabine Coquillard and Bruno Arnaldi, INRIA acquired the first virtual reality platform in France equipped with a virtual workbench at the Rocquencourt site, as well as a collective immersive visualization environment based on SGI's RealityCenter™ system at INRIA Rennes-Irisa.

This kind of purchase was financially supported by local authorities (see Appendix *Description of virtual reality platforms*). They are now installed in several of the Institute's sites.

- *Networking the INRIA virtual reality platforms in France*. The interconnection of the different sites makes it possible to set up cooperative virtual environments in which several remote users may visualize and interact with the same digital model. These exchanges leverage the main VTHD network at $n \times 2.5$ GB/s (n is the number of multiplexed wavelengths in the fiber). The Rennes, Grenoble and Sophia-Antipolis sites are involved in this virtual reality network.

- *Support for company foundation*, especially those using technology developed at INRIA: REALVIZ (digital special effects and computer graphics animation) stemming from the former ROBOTVIS project of INRIA Sophia-Antipolis and VSP-Technology (high performance visualization) stemming from project ISA of INRIA Lorraine – Loria. Both startups were helped by INRIA-Transfert, the INRIA incubator specializing in the field of information and communication science and technology (ICST).

Highlights on research projects carrying out work in virtual reality

3D Interaction

i3D

i3D is a recent research group dedicated to one of the main challenges of virtual reality, interaction. Many models and algorithms used in virtual reality can be borrowed from more traditional workstation applications (visualization, simulation,..). However, one of the main pluses, hence primary challenges, of virtual reality is multisensorial, immersive interaction.

i3D concentrates on 3D interaction primarily for virtual environments. Research is being carried out in particular on large screen immersive visualization devices with haptic feedback.

“Our long term objective is to contribute to making interaction with virtual worlds as simple, intuitive and comfortable as with the real world,” says Sabine Coquillart. In this research, i3D comes in on several complementary levels: (1) study and design of interaction paradigms or metaphors, (2) haptic interaction, (3) interaction techniques or peripheral evaluation and human factors.

Since its creation, i3D has selected a virtual reality configuration that is the basis of most of its work. The configuration is a virtual workbench. This choice was motivated by the very strong potential of this configuration in terms of interaction, due to the direct handling of the virtual model, among other factors.

One of the goals of the i3D group is to enrich this configuration, and more generally all virtual reality configurations, with additional interaction and sensory feedback paradigms, such as force feedback.

The i3D teams have already developed specific tools such as

- The MiniFly virtual reality software platform
- The Contact ToolKit collision and constraint management libraries
- The Command and Control Cube application control system
- The 3D Metric Cursor
- Force feedback on the virtual workbench using the SPIDAR system.

i3D is also working on more fundamental aspects such as psychophysical evaluation and non active haptic feedback modes such as pseudo-haptic feedback.

The applications envisioned are the visualization, handling and interactive simulation of complex data in such varied application fields as engineering, geoscience, chemistry and biology, among others.

i3D has always maintained productive collaborations with many industrial or academic partners in France and abroad, such as

- EADS and Dassault on the virtual prototyping theme,
- Renault on the theme of force feedback in virtual reality,
- TGS, the BRGM, IFP, the CEA and the University of Orléans on scientific visualization in virtual reality,
- CEA on force feedback,
- The LRP (Paris Robotics Laboratory) and the University of Evry on virtual prototyping and haptic feedback,
- The IAS on the visualization of the solar system,
- The Technion Institute in Tel Aviv on remote modeling over the Web,
- The GMD in Germany for various works on the virtual workbench,
- The TIT (Tokyo Institute of Technology, Japan) on the integration of the SPIDAR force feedback system into the virtual workbench.

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**Computer graphics, animation, modeling and simulation
SIAMES**

The team focuses on two main topics, movement simulation and virtual reality. The goal is to devise “physical” models whose characteristics are given by the laws of mechanics, for example for the animation of vehicles or the displacement of virtual objects, or of biomechanics for living being animation. One of the first applications concerns the simulation of the behavior of autonomous entities—vehicles or humans—in city surroundings.

Researchers of INRIA Rennes – Irisa are working in collaboration with the Department of Biomechanics and Sports Physiology of the University of Rennes 2, on the analysis of human movements and the measurement of sports gestures for performance evaluation. Transfer to industry was initiated with such partners as Infogrames, Realviz and the Leti in the framework of RNTL projects (1) in the field of motion capture processing of human movements for video games. The “Movement” RNTL project intends to build a multi-sensor motion capture module integrating constraints and biomechanical models.

Concerning virtual reality, project Siames studies new interaction techniques such as force-feedback. A crucial point of this activity concerns the Open Source availability on the Web of a virtual reality software platform OpenMASK (see <http://www.openMASK.org>). This cross-platform tool integrates immersive visualization, interaction and collaboration capabilities. Many academic and industrial collaborations of the team are based on OpenMASK. In particular, the PEFR-RV RNTL project (<http://www.perfrv.org>) intends to factor the research and development on virtual reality for future design offices into different domains of application.

Industry transfer initiatives are ongoing in particular with Renault on the theme of force-feedback and collaborative work in virtual reality (PERF-RV), France Telecom R&D in Rennes in the control of virtual humanoids, Giat-Industry for maintenance training in virtual reality and Kineo and Daesign in the field of interactive fiction for virtual humanoids.

(1) National Research Network on Software Technology set up by the government in 1999

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**Sound-enhanced virtual rendering and environments
REVES**

Project REVES was founded in 2000 with the goal of developing new algorithms to improve and accelerate the computer image and spatial sound generation process. The rendering algorithms apply to virtual or augmented (a mix of virtual and real) environments. The fields of application are virtual cultural heritage, construction and city planning, video games and audiovisual.

The originality of project REVES is in the coherent study and modeling of sound and image for virtual environments. "It is now widely recognized that adding spatial sound to convincing 3D graphics significantly improves the feeling of presence and immersion in virtual environments," says Nicolas Tsingos, an INRIA researcher of project REVES specializing in spatial sound for virtual environments.

REVES is contributing to audio-visual virtual environment rendering for which sound is an integral part of the experience. In this regard, REVES develops new real time algorithms for 3D sound generation, multimodal perceptual criteria based rendering optimization, artificial reverberation and the modeling of the acoustics of virtual venues, as well as combined management of graphical and audio hardware resources.

REVES has developed a common software platform called REVESAPI for sound enhanced rendering and virtual environments. Several modules are being integrated into this common platform:

- ECLAIRES: a complete lighting simulation system for diffuse and specular effects,
- SKEL: an exact visibility computation system based on robust calculations,
- PSM: perspective shadow charts,
- PBR: a fast pointwise rendering system,
- AURELI: a library for spatial audio.

REVES is also in contact with several companies that are interested in various aspects of this software.

Project REVES is strongly involved in virtual and augmented environments in the framework of collaborations and financed programs:

- The IST European project CREATE (CREATE : Constructivist Mixed Reality for Design, Education, and Cultural Heritage). The goal of this project is to increase the realism of virtual environments and to use such environments for "constructivist" learning in virtual cultural heritage and city planning. REVES is collaborating with the CSTB (Construction Scientific and Technical Center) for the city planning aspects, the Hellenic World Foundation (FHW) in Athens for virtual cultural heritage and the REALVIZ company for the capture of real environments. The project is coordinated by the UCL in London. In this framework, REVES is adapting REVESAPI modules for a platform based on the CA VElib and Performer virtual reality packages, that are integrated into an XP script based interaction system developed by the FHW.
- The EVE-Visit PREDIT project in collaboration with the CSTB. Project REVES developed a visual simulation for a "virtual window" system that will be used by INRETS for the evaluation of noise and visual nuisances.
- The ARCHEOS cooperative research initiative is conducted by REVES. The purpose of this initiative is to develop tools for non photorealistic rendering (cartoon-like or more generally in an artistic style) in immersive environments. The intended field of application is archeology and architecture. The initiative gathers together historians, archeologists, and rendering and virtual reality specialists.

INRIA Sophia Antipolis has acquired in April 2000 a Barco Baron virtual workbench, under the responsibility of project REVES. This device is driven by a PC with a standard graphics card, which makes it a lot more affordable than previous installations based on top-of-the-line computers.

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Medical imaging and robotics

EPIDAURE

Project EPIDAURE was launched in October 1992. It now has some twenty researchers. The project goal is to design and develop new tools for the analysis of multidimensional, multimodal medical images (scan, magnetic resonance imaging, ultrasound, nuclear medicine and so forth) to improve diagnoses and therapies, especially when guidance by images is possible (video-surgery, interventional radiology, radiotherapy, etc.).

Based on the analysis of medical images, it is possible to construct geometrical and biomechanical representations that allow for a better visual or even haptic (force feedback) interaction of doctors with images. It is for example possible to make visual models of the organs of a patient that can be used in two different ways:

Surgical simulation

The objective of surgical simulation is to contribute to the training of surgeons in complex surgical techniques such as mini-invasive surgery. There is a parallel to be made with the flight simulators used in aircraft pilot training.

Using a simulator, a surgeon can interactively handle organ models obtained by the finite element method, in order to rehearse an operation without any risks for the patient. Since 1997, project Epidaure has been developing an hepatic surgery simulator that makes it possible to simulate the resection of one or several anatomical segments of the liver using two force feedback systems. A concerted research initiative coordinated by project Epidaure from 1998 to 2000, including several INRIA projects and IRCAD (Institute for Research on Digestive Tract Cancers), resulted in significant scientific advances in this field.

Augmented reality aided surgery

During a surgical operation, a video image of the patient is superimposed with virtual images of his or her anatomy and pathologies. The virtual images are obtained by processing several medical images taken before the operation. The objective of such tools is to help the surgeon better locate in space the anatomical and pathological structures that cannot be observed directly. One of the difficulties in developing these tools resides in the merging and gating of preoperation images with the data observed during the operation.

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Image, synthesis, analysis

ISA

Project ISA is carrying out research in two complementary fields

- computer graphics, whose main goal is to model 3D objects and generate images from such 3D geometrical models,
- computer vision, that conversely tries to geometrically reconstruct 3D models from images.

The software written concern many fields: architecture, Earth sciences, design and engineering, medical imaging. It is generally developed in collaboration with industry. In addition, three startups, T-surf, Neoxy and VSP-Technology, were founded by project members.

The main contributions of ISA to virtual reality have to do with improving realism and the precision of simulation methods, coupled with immersive visualization methods. The development of new

algorithms has applications in the fields of architectural representation and scientific visualization that call upon virtual environments. One problem for example is to devise solutions for lighting by radiosity that are at the same time precise and fast, in order to create realistic visual surroundings for virtual reality applications in architecture. VSP-Technology markets photorealistic simulation solutions coupled with real time visualization engines based on these new approaches.

In the field of geoscience, the ISA team is working on volumic rendering of large scale data and on the interface of the gOcad software (see below) with virtual reality to give users a feeling of immersion in the subsoil. Oil industry specialists are thus able to visualize oil deposits based on seismic data. Immersive environments are a means of visually entering inside the subsoil, virtually dug galleries and simulate oil well drilling. The gOcad software (Geological Object Computer Aided Design), developed at the Geology School of Nancy (part of the Lorraine National Polytechnic Institute-INPL) in collaboration with researchers from project ISA, makes it possible to model and visualize geologic strata based on data acquired via various geophysics techniques. gOcad is marketed by T-Surf, a startup stemming from the gOcad Consortium and based in Nancy and Houston, Texas.

Other work concerns augmented reality methods and the development of robust automatic tools. The goal is to automatically inlay a movie with virtual objects, taking into account the relative positions of real and inserted objects in order to deal with occultation issues in particular. The computation of camera movements and occultation solving are obtained based on a photometric analysis of the movie. Augmented reality is also used in a medical application in angiography, in collaboration with the Nancy teaching hospital.

The PLASMA cooperative research initiative focuses its work on fusion plasma physics. The stakes of this research (a potential energy source for the future) is commensurate with the difficulties of realistically modeling and visualizing the data obtained. The use of immersive environments has imposed itself as an efficient and unavoidable solution.

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**Automatic programming and decision systems in robotics
SHARP**

Project SHARP's research activity is centered of the study of problems connected to physical interactions in robotics, modeling and automatic generation of movement both in the real and virtual worlds. The former case concerns robots, the latter dynamic simulation.

SHARP is developing efficient geometrical algorithms to process interactions between rigid or deformable objects. The project also designs and implements a modeling and simulation process that is capable of taking into account real world data, and develops computer methods allowing for an haptic interaction with a robot.

The research approach emphasizes physical realism and real time constraints in a dynamic virtual scene. The main challenge is posed by the complexity of the objects to be modeled, their heterogeneity, the nonlinearities and the real time aspect.

The applications especially intended by the team are in medical robotics and in physical movement in a virtual world. They touch on surgical simulation, the creation of deformable models adapted to the simulation of certain bodies (Pug prize), the development of collision computation algorithms (Icarcv prize), the creation of autonomous reactive virtual characters and the development of tools for video games.

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**Working and collaborating on complex virtual objects
ALCOVE**

The ALCOVE team was set up under the direction of Christophe Chaillou based on a few simple assessments: the computer tools for exchange and cooperation are still basic and not very intuitive, 3D environments and objects are being increasingly used but their interaction capabilities with users remain rudimentary.

ALCOVE is developing new concepts—interaction metaphors and autonomous objects—to create new tools to work on complex virtual objects in group.

Faced with the heavy technological aspects developed in certain research activities (immersive rooms, etc.), ALCOVE is exploring a new course by relying on the development of innovative tools that make it possible for a group to represent and handle virtual objects, with as natural as possible interactions.

This work underlies applications that range from gesture and concept learning to scenario preparation and object design. The five year objective is to propose a work terminal composed of visual and gestual interfaces, simulation and network, to let a distributed surgical team—each participant in front of a terminal—to make a medical diagnosis for a 3D reconstructed patient.

The research team already boasts various achievements, through diverse collaborations with France Telecom (Spin 3D platform) and Simedg (surgery learning simulators).

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**Visualizing and handling complex data on mobile communicating terminals
IPARLA**

IPARLA is interested in computer image production and possible interactions with a complex virtual environment on a PDA or a mobile phone on a network (GPRS, UMTS, Wi-Fi). This notion of complexity concerns the quantity of data (urban environment or terrain) as well as its nature (non perceptible scientific information, financial information).

Faced with the numerous constraints due to the context (small screen, small processor, no local storage), IPARLA researchers intend to consider algorithmic chains that are different from the classical 3D algorithmics. The research directions considered are based on non photorealistic rendering, pointwise models, multiresolution approaches, client-server architectures and taking into account the perception phenomena in the human brain.



Potential applications are focused on guidance in city or country surroundings (pedestrians, cyclists, car drivers), better directional location (touristic site visits, operation on an industrial site), surveillance (medicine, scientific experiments), complex process running and games. Collaborations are ongoing with BeTomorrow and France Télécom R&D.

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Research projects contributing to work in virtual reality

Computer graphics

Virtual environments for animation and computer images of natural objects EVASION

Project EVASION is made up of 18 researchers, working in computer graphics. It started in January 2003 as a follow-up of iMAGIS (ended in December 2002), together with project ARTIS.

In the continuity of iMAGIS, EVASION is interested in the development of tools to design and use 3D digital models, for applications of significant size and important complexity.

The new project especially focuses on natural scenes, including animated scenes—vegetal, animal and mineral (including water and clouds). It is developing fundamental tools for efficient mastery of geometrical complexity, movement and appearance. The project is also interested in practical applications such as displaying an animated forest or prairie for special effects or video games, rockfall simulation, medical simulation and bird movement capture, among others.

EVASION is a team of the GRAVIR/IMAG department, a joint research unit (UMR 5527) of CNRS the Grenoble National Polytechnic Institute (INPG), the Joseph Fourier University (UJF) and INRIA.

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Acquisition, representation and processing of computer graphics ARTIS

Project ARTIS has 19 researchers working on the development of tools to design and use 3D digital models, for applications of significant size and important complexity, in the continuity of iMAGIS. This new project concentrates on the adaptation of the representation of such digital model in order to meet the constraints of diverse applications at best.

Ongoing work in lighting simulation concerns the intelligent use of the structure of the scene, using for example instantiation, for fast computation of extremely complex situations such as lighting in vegetation. Another line of research concerns the extraction of simplified avatars to compute soft shadows in scenarios mixing virtual and real worlds (virtual studio).

On the non photorealist side, ARTIS is especially interested in the different styles of representation that can reinforce perception and understanding of such and such subset of the scene, or that can reproduce such and such classical artistic style (watercolor on a grained paper).

ARTIS is thus applying these concepts in various domains:

- In collaboration with European car industry, definition of complete image creation system for a realistic rendering in a “CAVE” type immersive virtual environment (RealReflect IST European project).
- Simulation of radiative exchanges in scenes including vegetation, for the calibration and simulation of remote monitoring equipment.
- Quantitative measurement of the quality of an immersion, in collaboration with the UFR-STAPS (Physical Activities and Sports Science and Techniques) using experiments that analyze the reactions of a subject performing sensory-motor tasks in a virtual environment.

- Using a watercolor type of rendering to reconstitute an archeological site, in collaboration with the Homerica team of the Stendhal University in Grenoble.
- Founding and development of a startup called Digisens, prizewinner of the “cré@tion” competition of the ANVAR. The goal is to market tools for hand gesture learning, starting with dental surgery teaching.

ARTIS is a team of the GRAVIR/IMAG department, a joint research unit (UMR 5527) of CNRS the Grenoble National Polytechnic Institute (INPG), the Joseph Fourier University (UJF) and INRIA.

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Handling augmented reality images, special effects generation**MIRAGES**

The MIRAGES research team is working in three directions:

- post-production and digital special effects for cinema and audiovisual applications,
- fabric simulation, cloth cutting and draping
- realistic rendering of virtual scenes using radiosity techniques.

MIRAGES is associated with project NEMESIS (ESPRIT) of the European Union coordinated by Thomson Optronics.

An industrial partnership was established with the Mikros Images company in Paris for research applied to post-production.

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Speech analysis, perception and recognition**PAROLE**

The research theme of the Parole team is the study of spoken communication. It covers a wide spectrum of activities including the study of human perception of acoustic hints, speech analysis and automatic recognition. This work is part of an effort to construct efficient voice interfaces for embedded multimodal systems.

The team participated in project SAALSA (Self-Adaptive System for Automatic Lip Sync) in the framework of the RIAM call for proposals (Research and Innovation in Audiovisual and Multimedia). The goal was to develop new production tools for 2D/3D animation to automate the synchronization of voice and character lip movements phase, by applying results of research in automatic speech processing.

In addition, PAROLE is currently working in collaboration with DATHA, an association for the development of technological aids for handicapped people, on the development of an aid system for hearing impaired persons. This aid would let deaf people communicate in every day life in person as well as on the phone. The current goals are the integration of a deaf child in a normal kindergarten or primary school class, the interaction between a deaf person and other participants in a work meeting

and telephone use. The principle of this system is to automatically reproduce the effect of lip reading and the LPC language (Complemented Spoken Language) consisting of hand gestures to complement lip reading which is not discriminating enough for certain sounds (bad/pad). The system will use automatic speech recognition to recognize the phonemes or syllables pronounced by the teacher or the meeting participant to animate a speaking head and a hand on a video screen placed in front of the deaf person.

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Robotics and augmented reality

Spatio-temporal active vision

VISTA

VISTA is interested in several kinds of spatio-temporal imaging. Its work in active spatio-temporal vision is divided into two large categories:

1. Dynamic scene and physical phenomena analysis, for purposes of sensing, measurement, learning and recognition of spatio-temporal information.
2. Coupling perception and control in automated or robotic systems, for positioning, surveillance, tracking, handling, decision or exploration.

The project recently got involved in augmented and virtual reality themes. Research work on this subject is based on the project's know-how in the field of robotic perception and visual servocontrol in particular. The team thus got interested in problems of camera control in virtual environments and in real time augmented reality problems.

Camera control in virtual environments

The goal is to propose a general framework for controlling a camera in a virtual environment. The camera must not only position itself in relation with its environment, but it also must be capable of reacting to modifications in the environment. The methods advocated are based on visual servocontrol theory that makes it possible to automatically generate 3D movements for the camera based on a task specified in the image. The possibility of taking into account the modifications in the environment dynamically and in real time stems from the use of constraints integrated into the control laws considered. This approach is thus adapted to highly reactive contexts (virtual reality, video games). Generally speaking, one of the original features of this approach in this context is the expression of a control in the image itself. In effect, it consists in specifying the tasks to be performed in a 2D space, but the camera trajectories are then automatically computed in 3D. It is in fact a very intuitive, although well formalized, approach to animation, since the latter is obtained as a function of what users wish to observe in the produced image sequence.

The team then became interested in the command of computer generated humanoids, in collaboration with project Siames. Once again, visual servocontrol is an interesting approach for generating low level commands for such avatars. In this case, the avatar's eyes must be regarded as a camera attached to the actuator of a hyperredundant robot and even more if walking is also considered. This control methodology for humanoids was also integrated into larger behavior management systems.

Visual servocontrol for augmented reality

Project VISTA recently proposed using visual servocontrol techniques in the context of augmented reality. Virtual visual servocontrol consists in considering the computation of the 3D position of the camera with respect to an object as the inverse problem of servocontrol. This approach was therefore used to take into account such visual information as straight lines, circles, points, cylinders, etc. The gain is thus both in modeling and implementation simplicity, and in the variety of information that can be used. The quality of results is comparable to that resulting from the best callibrations methods currently available. Here again, the problem of modeling and underlying algorithms are nonetheless much simpler in this form.

The corresponding software was transferred to industry during 2002, with Total-Immersion, a company specializing in augmented reality for audiovisual.

Project VISTA is joint project of CNRS, INSA Rennes, the University of Rennes 1 and INRIA Rennes-Irisa, under the direction of Patrick Boutheymy.

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APPENDICES

Technology companies stemming from INRIA

REALVIZ

REALVIZ was born of the meeting of Luc Robert, a researcher of project ROBOTVIS, with Dominique Pouliquen, an executive of Medialab, a production company then a subsidiary of Canal+, in 1997. They founded REALVIZ with four collaborators in March 1998. By leveraging the computer vision technology developed within project ROBOTVIS, the company develops and markets software for graphics and audio-visual creation. For four years this high tech company thus developed a range of 2D and 3D image processing software for digital special effects and animated computer graphics.

REALVIZ carries out research and develops technology that make it possible to construct a very high quality photorealistic 3D object based on a series of photographs taken from different angles (ImageModeler). It is also possible to design virtual visits of existing environments by combining again a series of photographs (Stitcher). Using two other products (SceneWeaver, MatchMover), the company controls the production and integration of 3D objects into 2D images or sequence of real images, thus creating actual interactive 2D/3D environments. Finally, certain applications such as ReTimer concern the time dimension. It is now possible using ReTimer to generate slow or fast motion from image sequences, in particular by interpolating virtual images between the real images.

REALVIZ intends to strengthen its expansion strategy by continuing to grow in its primary markets (special effects for cinema and advertising, architecture, industrial design, video games) and by ensuring the development of new technology in connection with the Internet, in order to put 3D images and special effects into general use for all digital image users.

REALVIZ is in partnership with Apple, Macromedia, Discreet, Cinesite, K AidAN, Alias/Wavefront, Dassault Systemes and Intel.

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<http://www.realviz.com>

VSP-Technology

Walking around in a 3D model in real time and with unprecedented rendering is a feat achieved by VSP-Technology. The company was founded in December 2001 by former INRIA members. It is based in Nancy and Paris. VSP-Technology publishes software solutions for lighting simulation in 3D environments and for high performance visualization intended for the automobile, railroad, maritime and aerospace markets. These solutions help industry reduce the costs attached to the design and making of their models.

Candelux is a software package that makes it possible to move around a 3D model in real time. It features unparalleled rendering. The software is primarily of interest to manufacturing automobile, railroad, maritime and aerospace industry.

The technology used in Candelux—in particular the radiosity algorithm—is based on advanced INRIA research in the mathematical representation and lighting of parametric surfaces.

Thus, Candelux complements the digital design line with a leading edge realistic visualization technology, which makes it possible not only to reduce design times and costs and to make the digital line more reliable, but also to boost innovation by opening up the field of design possibilities.

In addition to realistic rendering, the computation of global illumination is obtained in times never attained up to the present: the power of the algorithms results in a reduction of computational time from several days to several hours. Once the computation is done, users can interactively handle the model and modify the intensity of lightings in order to better evaluate the shapes, colors and contrasts of the model under study.

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Description of virtual reality platforms

INRIA Rennes - IriSa

The RealityCenter™ equipment of cylindrical immersive screens includes

- an Onyx2 InfiniteReality2 SGI supercomputer with 6 to 8 processors and 1 to 3 graphic cards,
- a triple screen in arc of cylinder (4m in radius, width from 9m to 12m and height from 2.70m to 3.50m),
- three Barco projectors,
- a 3D display device, CrystalEyes by Stereographics, using goggles with liquid crystal shutter,
- a spatial sound system with 3 to 8 channels.

INRIA Rhône-Alpes

The INRIA Rhône-Alpes research unit has the same equipment as Rennes, together with a virtual workbench including

- an Onyx2 SGI computer with 4 processors and 2 graphic cards (IR2),
- a visualization system marketed by TAN, a German company, comprising two perpendicular screens (1.10mx1.80m each) and two three-tube video projectors,
- a 3D display device, CrystalEyes by Stereographics, using goggles with liquid crystal shutter,
- a head movement recording system that allow a person to observe a scene under different angles based on his or hers movements,
- a Fastrack six degree of freedom stylus by Polhemus.

This visualization system comes in the form of a table on which the application is displayed in three-dimensions following head movements (each image is computed based on the exact position of the user). In addition to simulating a workbench, this equipment has two major advantages: direct handling for better comfort and new research directions in 3D interaction, and an immersion of the application within the user's real environment, as opposed to immersion of the user in a virtual world as often advocated in virtual reality, which makes for more versatility and comfort.

INRIA Sophia Antipolis

The INRIA Sophia-Antipolis virtual reality platform is also a workbench composed of

- a biprocessor 1GHz Intel Pentium III PC equipped with a GeForce4 Ti 4600 running under Linux,
- a Baron Barco screen of 1.5m in diameter, that can be oriented horizontally like a table as well as vertically, equipped with a BarcoReality 908 projector,
- a Polhemus 3D Fastrack capture system with six degrees of freedom equipped with a stylus and a sensor that lets users observe a scene under different angles based on their movements.

The stereo is provided by a StereoGraphics EPC-2 frequency doubler and liquid crystal shutter goggles (CrystalEyes by StereoGraphics and 60GX by NuVision).

INRIA Lorraine - Loria

- A 56 processor Onyx 3800 computer (Mips R1200 at 400 MHz, to be replaced with Mips R1600 at 700 MHz), 4 graphic pipes (Infinite Reality3 engine),
- a cylindrical screen (radius 4.37m, 125° opening, height 2.70m, 12.5% overlap between the two projectors),
- 3 Barco 909 projectors consisting of fast phosphorus cathode ray tubes for stereo, with integrated edge blending management and memory blocks to store the settings of 48 different video sources per projector. They can use RGBHV, video-composite and S-video signals.
- 5 Crystal Eyes infrared transmitters and one audio system.

Additional information

Photos – Videos

These documents are available on demand at the Multimedia Scientific Communication Department

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INRIA's Research Teams Software

OpenMASK

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A platform for the development and execution of modular applications in the fields of animation, simulation and virtual reality

<http://www.openMASK.org>

yav++

cdri.sop@inria.fr

General-purpose C++ Medical Image Library

<http://www-sop.inria.fr/epidaure/personnel/delingette/yav++.html>

AlaDyn

Christian.Laugier@inria.fr

Geometric and dynamic simulator for virtual reality and robotics applications

<http://www.inrialpes.fr/sharp/modelisation/AlaDyn/>

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- Nicolas Tsingos, Thomas Funkhouser, Addy Ngan and Ingrid Carlbom, *Modeling Acoustics in Virtual Environments Using the Uniform Theory of Diffraction*, proceedings of SIGGRAPH 2001
- Lecuyer, S. Coquillart, A. Kheddar, P. Richard and Ph. Coiffet, *Pseudo-Haptic Feedback : Can Isometric Input Devices Simulate Force Feedback?*, IEEE Virtual Reality'2000, New Brunswick USA, mars 2000
- S. Coquillart and G. Wesche, *The Virtual Palette and the Virtual Remote Control Panel : A Device and an Interaction Paradigm for Projection-based Virtual Environments*, IEEE Virtual Reality'99, Houston USA, mars 1999
- S. Coquillart, *Environnements virtuels à base de projections sur grands écrans*, Journées du groupe de travail Réalité Virtuelle, Issy-les-Moulineaux, mars 1998

Useful links

- <http://www.loria.fr/~tombre/VirtReal/maillist.html>
RÉVERIES: the electronic newsletter of the workgroup that federates research by French academic and industrial teams in the field of virtual reality.
- <http://www.vthd.org>

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INRIA, a research institution at the heart of the information society

INRIA, the national institute for research in computer science and control, operating under the dual authority of the Ministry of Research and the Ministry of Industry, is dedicated to fundamental and applied research in information and communication science and technology (ICST). The Institute also plays a major role in technology transfer by fostering training through research, diffusion of scientific and technical information, development, as well as providing expert advice and participating in international programs. By playing a leading role in the scientific community in the field and being in close contact with industry, INRIA is a major participant in the development of ICST in France.

Throughout its six research units in Rocquencourt, Rennes, Sophia Antipolis, Grenoble, Nancy and Bordeaux-Lille-Saclay, INRIA has a workforce of 3,000, 2,500 of whom are scientists from INRIA's partner organizations such as CNRS (the French National Center for Scientific Research), universities and leading engineering schools. They work in 100 joint research projects. Many INRIA researchers are also professors whose approximately 700 doctoral students work on theses as part of INRIA research projects.

INRIA develops many partnerships with industry and fosters technology transfer and company foundation in the field of ICST—some sixty companies have been founded. Startups are financed in particular by INRIA-Transfert, a subsidiary of INRIA that supports four startup funds, I-Source 1 and I-Source 2 in the field of information and communication technology, C-Source for multimedia and T-Source for telecommunications.

INRIA is participating in such standardization committees as the IETF, ISO or the W3C of which INRIA was the European host from 1995 to 2002.

INRIA maintains important international relations and exchanges. In Europe, INRIA is involved in ERCIM which brings together 16 European research institutes. INRIA is participating in one hundred active European projects. INRIA also collaborates with numerous scientific and academic institutions abroad (joint laboratories in Moscow, Beijing, Mexico, etc., associated research teams, training and internship programs).

INRIA has an annual budget of 120 million euros, one quarter of which comes from its own research contracts and development products. During the 2000-2003 period, these resources were increased by 50 % within the framework of the Institute's four-year contract.

The Institute's strategy closely combines scientific excellence with technology transfer. Five major scientific challenges were identified:

- mastering the digital infrastructure
- designing new applications using the Web and multimedia databases
- producing reliable software
- designing and controlling automation in complex systems
- combining simulation and virtual reality.

INRIA focuses its efforts on a small number of major application fields, giving priority to telecommunications and multimedia, health and biology, as well as transportation, environment and engineering.

For more information, see: <http://www.inria.fr>