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Project-Team artis

Acquisition, Representation and Transformations for Image Synthesis

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THEME COG

Activity Report

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1. Team

ARTIS is both an INRIA project-team and a subset of the GRAVIR joint research lab of CNRS, Institut National Polytechnique de Grenoble (INPG), INRIA and Université Joseph Fourier Grenoble-I (UJF). The GRAVIR laboratory is part of the IMAG federation (Institut d'Informatique et de Mathématiques appliquées de Grenoble).

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2. Overall Objectives

ARTIS was created in January, 2003, based on the observation that current image synthesis methods appear to provide limited solutions for the variety of current applications. The classical approach to image synthesis consists of separately modeling a 3D geometry and a set of photometric properties (reflectance, lighting conditions), and then computing their interaction to produce a picture. This approach severely limits the ability to adapt to particular constraints or freedoms allowed in each application (such as precision, real-time, interactivity, uncertainty about input data...). Furthermore, it restricts the classes of possible images and does not easily lend itself to new uses such as illustration, where where a form of hierarchy of image constituents must be constructed.

One of the goals of the project is the definition of a more generic framework for the creation of synthetic images, integrating elements of 3D geometry, of 2D geometry (built from 3D geometry), of appearance (photometry, textures...), of rendering style, and of importance or relevance for a given application. The ARTIS project-team therefore deals with multiple aspects of image synthesis: model creation from various sources of data, transformations between these models, rendering and imaging algorithms, and the adaptation of the models and algorithms to various constraints or application contexts.

The main research directions in ARTIS address:

- Analysis and simulation of lighting effects. Development of hierarchical simulation techniques integrating the most general and realistic effects, fast rendering, inverse lighting, relighting, data acquisition based on lighting analysis.
- Expressive (“non-photorealistic”) rendering. Definition and identification of rendering styles. Style extraction from existing documents. Development of new view models (mixture of 3D and 2D) and new rendering techniques.
- Model simplification and transformation. Simplification of geometry and appearance, image-based representations, model transformation for various applications, detail creation and creation of virtual models from real data.

Our target applications include:

- 3D image synthesis;
- illustration (animation, technical illustration);
- virtual and augmented reality;
- virtual archeology;
- radiative transfer simulation.

3. Scientific Foundations

3.1. Introduction

The objectives of ARTIS combine the resolution of “classical”, but difficult, issues in Computer Graphics, with the development of new approaches for emerging applications. A transverse objective is to develop a new approach to synthetic image creation that combines notions of geometry, appearance, style and priority.

3.2. Lighting and rendering

Participants: François Sillion, Cyril Soler, Nicolas Holzschuch, Jean-Marc Hasenfratz, Jean-Christophe Roche, Emmanuel Turquin, David Roger, Ulf Assarsson, Sylvain Paris.

global illumination complete set of lighting effects in a scene, including shadows and multiple reflections or scattering

inverse rendering Calculation process in which an image formation model is inverted to recover scene parameters from a set of images

The classical approach to rendering images of three-dimensional environments is based on modeling the interaction of light with a geometric object model. . Such models can be entirely empirical or based on true physical behavior when actual simulations are desired. Models are needed for the geometry of objects, the appearance characteristics of the scene (including light sources, reflectance models, detail and texture models...) and the types of representations used (for instance wavelet functions to represent the lighting distribution on a surface). Research on lighting and rendering within ARTIS is focused on the following two main problems: lighting simulation and inverse rendering.

3.2.1. Lighting simulation

Although great progress has been made in the past ten years in terms of lighting simulation algorithms, the application of a general global illumination simulation technique to a very complex scene remains difficult. The main challenge in this direction lies in the complexity of light transport, and the difficulty of identifying the relevant phenomena on which the effort should be focused.

The scientific goals of ARTIS include the development of efficient (and "usable") multiresolution simulation techniques for light transport, the control of the approximations incurred (and accepted) at all stages of the processing pipeline (from data acquisition through data representation, to calculation), as well as the validation of results against both real world cases and analytical models.

3.2.1.1. Image realism

There are two distinct aspects to realism in lighting simulation: first the physical fidelity of the computed results to the actual solution of the lighting configuration; and the visual quality of the results. These two aspects serve two different application types: physical simulation and visually realistic rendering.

For the first case, ARTIS' goal is to study and develop lighting simulation techniques that allow incorporation of complex optical and appearance data while controlling the level of approximation. This requires, among other things, the ability to compress appearance data, as well as the representation of lighting distributions, while ensuring an acceptable balance between the access time to these functions (decompression) which has a direct impact on total computation times, and memory consumption.

Obtaining a *visually* realistic rendering is a drastically different problem which requires an understanding of human visual perception. One of our research directions in this area is the calculation of shadows for very complex objects. In the case of a tree, for example, computing a visually satisfactory shadow does not generally require an exact solution for the shadow of each leaf, and an appropriately constrained statistical distribution is sufficient in most cases.

3.2.1.2. Computation efficiency

Computation efficiency practically limits the maximum size of scenes to which lighting simulation can be applied. Developing hierarchical and instantiation techniques allows us to treat scenes of great complexity (several millions of primitives). In general the approach consists in choosing among the large amount of detail representing the scene, those sites, or configurations, that are most important for the application at hand. Computing resources can be concentrated in these areas, while a coarser approximation may be used elsewhere.

Our research effort in this area is mainly focused on light transfer simulation in scenes containing vegetation, for which we develop efficient instantiation-based hierarchical simulation algorithms.

3.2.1.3. Characterization of lighting phenomena

One of the fundamental goals of ARTIS is to improve our understanding of the mathematical properties of lighting distributions (i.e. the functions describing light "intensity" everywhere). Some of these properties are currently "known" as conjectures, for instance the unimodality (existence of a single maximum) of the light distribution created by a convex light source on a receiving surface. This conjecture is useful for computing error bounds and thus guiding hierarchical techniques. Other interesting properties can be studied by representing irradiance as convolution splines, or by considering the frequency content of lighting distributions. We also note that better knowledge and characterization of lighting distributions is beneficial for inverse rendering applications as explained below.

3.2.2. Inverse rendering

Keywords: *Global illumination*, *inverse rendering*, *multiresolution*.

Considering the synthetic image creation model as a calculation operating on scene characteristics (viewing conditions, geometry, light sources and appearance data), we observe that it may be possible to invert the process and compute some of the scene characteristics from a set of images.

This can only be attempted when this image calculation process is well understood, both at the theoretical level and at a more practical level with efficient software tools. We hope that the collective experience of lighting simulation and analysis accumulated by members of the project will guide us to develop afficient and accurate inverse rendering techniques: instead of aiming for the most general tool, we recognize that particular application cases involve specific properties or constraints that should be used in the modeling and inversion process.

Example applications include the reconstruction of 3D geometry by analyzing the variations of lighting and/or shadows, or the characterization of a light source from photographs of a known object.

3.3. Expressive rendering

Participants: François Sillion, Gilles Debunne, Jean-Dominique Gascuel, Joëlle Thollot, Stéphane Grabli, Sylvain Paris, Pascal Barla.

There is no reason to restrict the use of computers for the creation and display of images to the simulation of real lighting. Indeed it has been recognized in recent years that computer processing opens fascinating new avenues for rendering images that convey particular views, emphasis, or style. These approaches are often referred to as "non-photorealistic rendering", although we prefer the term "expressive rendering" to this negative definition.

A fundamental goal of ARTIS is to propose new image creation techniques that facilitate the generation of a great variety of images from a given scene, notably by adapting rendering to the current application. This involves, in particular, significant work on the notion of *relevance*, which is necessarily application-dependent. It is necessary to define relevance both qualitatively and quantitatively., Relevance is the relative importance of various scene elements, or their treatment, for the desired result. Examples of specific situations may include rendering specular effects, night-time imagery, technical illustration, computer-assisted drawing or sketching, etc. The notion of relevance will also have to be validated for real applications, including virtual reality settings.

Another research direction for expressive rendering concerns *rendering styles*: in many cases it should be possible to define the constitutive elements of styles, allowing the application of a given rendering style to diffferent scenes, or in the long term the capture of style elements from collections of images.

Finally, since the application of expressive rendering techniques generally amounts to a visual simplification, or abstraction, of the scene, particular care must be taken to make the resulting images consistent over time, for interactive or animated imagery.

3.4. Geometric calculation and model transformation

Participants: François Sillion, Cyril Soler, Nicolas Holzschuch, Gilles Debunne, Xavier Décoret, Hector Briceño, Yannick Le Goc, Samuel Hornus, Elmar Eisemann, Aurélien Martinet.

Creating images from three-dimensional models is a computationally -intensive task. A particularly difficult issue has long been the calculation of visibility information in 3D scenes. We are working on several issues related to visibility, such as the decomposition of a scene into appropriate regions (or cells) to assist in the precalculation of visibility relationships, or the precalculation of object sets visible from a particular view point or region of space.

More generally, we are interested in all aspects of geometric calculation that lead to the creation, simplification or transformation of 3D models. Complex scenes for virtual environments are typically assembled using data from very different sources, therefore coming in very different resolutions or amounts of detail. It is often a requirement to suppress unneeded detail in some parts of the scene, or to generate detail where it is missing. Given the very high cost of manual modeling, fully or semi-automated techniques are essential.

Furthermore, the apparent complexity and the amount of detail should also be adapted to the particular usage in the application, and we advocate that this can be realized by choosing appropriate data representations. We are therefore working on innovative data representations for 3D scenes, notably involving many image-based techniques.

3.5. Virtual and mixed realities

Participants: François Sillion, Jean-Marc Hasenfratz, Jean-Dominique Gascuel, Marc Lapierre, Charles Hansen, Raphaël Grasset.

mixed reality set of techniques involving the addition of real elements to a virtual world, or virtual elements to the real world

The evolution of technology, with high-quality 3D graphics becoming available on consumer-grade computers, while image and video acquisition has become fully digital, has made the convergence of real and synthetic imagery a real possibility. Applications of mixed realities are blooming and we are interested in providing appropriate tools for these new uses of graphics. One fundamental issue in mixing real and synthetic imagery lies in the proper combination of the two image sources. 3D visibility is, of course, a difficulty, requiring some form of 3D reconstruction from real imagery. However our focus is more on the lighting and shadow consistency: Making sure that lighting effects are consistent between the synthetic and real parts of the image remains a challenge, especially for real-time applications.

The notion of relevance-guided rendering, as described above, is also inspiring us to investigate possible constraints placed on the rendering process by virtual reality applications. In this spirit we are studying the effects of virtual reality immersion for performing a given task.

On the other side of the virtual/real continuum defined by Milgram [], augmented reality can provide the possibility to manipulate 3D virtual objects in the real world (while keeping easy eye contact and visibility of real artefacts, as opposed to what happpens with virtual reality). This introduces new issues. Registering (visual and spatially) the two worlds remains a major difficulty: efficient calibration algorithms are required. Providing natural, simple and intuitive new interaction metaphors requires user studies and new explorating solutions (coupled with dedicated input and output devices). Also, we must define a formal frame for the possible interactions with the real world (e.g modify the appearance of the real world).

3.6. Guiding principles

We base our research on the following principles:

3.6.1. Mathematical and geometrical characterization of models and algorithms

In all our target applications, it is crucial to control the level of approximation, for instance through reliable error bounds. Thus, all simplification techniques, either concerning geometry or lighting, require a precise mathematical analysis of the solution properties.

3.6.2. Balance between speed and fidelity

We seek to develop representations affording a controllable balance between these conflicting goals. In particular this applies to multiresolution techniques, where an appropriate generic process is defined, that can then be applied to “well chosen” levels of the hierarchy. This aspect is of course key to an optimal adaptation to the chosen application context, both for lighting simulations of geometric transformations and for simplification.

3.6.3. Model and parameter extraction from real data

Modeling geometric shapes, appearance data and various phenomena is the most tedious task in the creation process for virtual scenes. In many cases it can be beneficial to analyse real documents or scenes to recover relevant parameters. These parameters can then be used to model objects, their properties (light sources, reflectance data...) or even more abstract characteristics such as rendering styles. Thus this idea of parameter extraction is present in most of our activities.

4. Application Domains

4.1. Illustration

Although it has long been recognized that the visual channel is one of the most effective means for communicating information, the use of computer processing to generate effective visual content has been mostly limited to very specific image types: realistic rendering, computer-aided cell animation etc.

The ever-increasing complexity of available 3d models is creating a demand for improved image creation techniques for general illustration purposes. Recent examples in the literature include computer systems to generate road maps, or assembly instructions, where a simplified visual representation is a necessity.

Our work in expressive rendering and in relevance-guided rendering aims at providing effective tools for all illustration needs that work from complex 3d models. We also plan to apply our knowledge of lighting simulation, together with expressive rendering techniques, to the difficult problem of sketching illustrations for architectural applications.

4.2. Video games and visualization

Video games represent a particularly challenging domain of application since they require both real-time interaction and high levels of visual quality. Moreover, video games are developed on a variety of platforms with completely different capacities. Automatic generation of appropriate data structures and runtime selection of optimal rendering algorithms can save companies a huge amount of development (e.g the EAGL library used by Electronic Arts []).

More generally, interactive visualization of complex data (e.g. in scientific engineering) can be achieved only by combining various rendering accelerations (e.g. visibility culling, LOD, etc.), an optimization task that is hard to perform “by hand” and highly data dependent. One of ARTIS’ goals is to understand this dependence and automate the optimization.

4.3. Virtual heritage

Virtual heritage is a recent area which has seen spectacular growth over the past few years. Archeology and heritage exhibits are natural application areas for virtual environments and computer graphics, since they provide the ability to navigate 3D models of environments that no longer exist and can not be recorded on a videotape. Moreover, digital models and 3D rendering give the ability to enrich the navigation with annotations.

Our work on style has proved very interesting to architects who have a long habit of using hand-drawn schemas and wooden models to work and communicate. Wooden models can advantageously be replaced by 3D models inside a computer. Drawing, on the other hand, offers a higher level of interpretation and a richness of expression that are really needed by architects, for example to emphasize that such model is an hypothesis.

By investigating style analysis and expressive rendering, we could “sample” drawing styles used by architects and “apply” them to the rendering of 3D models . The computationnal power made available by computer assisted drawing can also lead to the development of new styles with a desired expressiveness, which would be harder to produce by hand. In particular, this approach offers the ability to navigate a 3d model while offering an expressive rendering style, raising fundamental questions on how to “animate” a style.

4.4. Collaborative work

Collaborative Work is an essential activity in the worflow of many companies to coordinate and share information among employees. Groupware have largely emerged during these last years for colocated or distant meeting (e.g. Microsoft NetMeeting). In this context, few results have been etablished for the support of colocated activities for 3D tasks (manipulation and visualization of 3D content). Solutions provided by virtual reality setups (CAVE, Responsive Workbench) seem too limited in terms of intuitive interaction metaphors, good working conditions and collaborative support.

In the continuity of previous years research, ARTIS proposed a new vision-based augmented reality, dedicated to tabletop meeting. Augmented reality delivers a large support for keeping natural metaphors of communication (verbal or gesture), and support for simple and intuitive 3D interaction metaphors. This approach has applications in a large variety of domains related to collaborative work: Architecture, Scientific Visualization, Game, Design etc.

4.5. Mixed Reality

A system that allows to seamlessly blend virtual images generated by a computer and a video stream recorded by a digital camera (e.g. a live footage) would have many applications amongst which we foresee:

- Virtual studio: The speaker of a TV show can be included and interact within a virtual world in real-time. As there is no apparatus, even spectators can come at any moment to play or navigate within the virtual set.
- Teaching/Training: this platform may also be used for teaching or training application. A teacher could manipulate in coordination with students for example molecules or any virtual object, interact with it and see in real-time its behavior. For training applications, it can be used for example to train people with a simulation of intervention in nuclear plants or other sites where real conditions are critical.
- Virtual prototyping: in industry it is common to have one model on which engineers from different fields want to collaborate. With this platform it is possible for them to share and view the same model, for example a car (1:1 scale), so that they can manipulate and expose to others any specific part or behavior.
- Multi-sites: Its possible to imagine communicating platforms like this: it would allow persons from different sites to navigate in the same virtual world, manipulate objects or even interact with each other.
- Virtual Archaeology: for archaeologist it is hard to recreate and imagine how was a ancient site. With this platform you can navigate within a virtual world, and have a realistic idea of the specific lighting of a monument (as you cast shadows on the virtual world).
- Virtual Homes: Virtual worlds can be ancient sites, but also future places: it is now possible to make a customer visit his new kitchen or her home before it is build. He can interact and manipulate any furniture and estimate this configuration in real-time.

5. Software

5.1. Introduction

Artis insists on sharing the software that are developped for internal use. These are all listed in a dedicated section on the web site http://artis.imag.fr/Software.

5.2. X3DToolKit: a 3D model processing library

Participants: Gilles Debunne [contact], Xavier Décoret, Yannick Le Goc.

One of the annoying problems in Computer Graphics is 3D file format manipulation. There are many proprietary file formats, making conversion or even loading a tedious task. In this context, X3D, a new open file format developed by the W3C consortium, based on an XML representation and hence extensible, appears as a promising future standard.

Another common need is for a set of tools that process 3D models and meshes in order to make them suitable for the application (removal of degeneracies, simplification, API to access the topological structure...).

Yannick Le Goc was hired by INRIA as a junior engineer to develop the X3DToolKit library, which addresses these requirements by providing a complete loading mechanism for X3D data, as well as a scene graph representation and clear processing mechanisms. X3DToolKit has become a standard software component in our group, facilitating the adoption of X3D as a standard data format. X3D is distributed under the LGPL licence and is freely available for download [1].

Yannick finished his contract in September 2004 and released a stable final version. Future developments are open to the community and a savannah project [2] will be created for that.

5.3. libQGLViewer: a 3D visualization library

Participant: Gilles Debunne [contact].

libQGLViewer is a library that provides tools to efficiently create new 3D viewers. Simple and common actions such as moving the camera with the mouse, saving snapshots or selecting objects are *not* available in standard APIs, and libQGLViewer fills this gap. It merges in a unified and complete framework the tools that every one used to develop individually. Creating a new 3D viewer now requires 20 lines of cut-pasted code and 5 minutes. libQGLViewer is distributed under the GPL licence since January 2003, and several hundreds of downloads are recorded each month [3].

5.4. PlantRad

Participants: Cyril Soler [contact], François Sillion.

PlantRad is a software program for computing solutions to the equation of light equilibrium in a complex scene including vegetation. The technology used is hierarchical radiosity with clustering and instantiation. Thanks to the latter, PlantRad is capable of treating scenes with a very high geometric complexity (up to millions of polygons) such as plants or any kind of vegetation scene where a high degree of approximate self-similarity permits a significant gain in memory requirements. Its main domains of applications are urban simulation, remote sensing simulation (See the collaboration with Noveltis, Toulouse) and plant growth simulation, as previously demonstrated during our collaboration with the LIAMA, Beijing.

5.5. High Quality Renderer

Participants: Cyril Soler [contact], Jean-Christophe Roche, François Sillion.

[1] http://artis.imag.fr/Software/X3D
[2] http://savannah.gnu.org
[3] http://artis.imag.fr/Software/QGLViewer/

In the context of the European project RealReflect, the ARTIS team has developed the HQR software based on the photon mapping method which is capable of solving the light balance equation and of giving a high quality solution. Through a graphical user interface, it reads X3D scenes using the X3DToolKit package developed at ARTIS, it allows the user to tune several parameters, computes photon maps, and reconstructs information to obtain a high quality solution. HQR is not yet available for download.

5.6. MobiNet

Participants: Samuel Hornus, Joëlle Thollot.

The MobiNet software allows creation of simple applications such as video games or pedagogic illustrations relying on intuitive graphical interface and language allowing to program a set of mobile objects (possibly through a network). This software is available in public domain for Linux and Windows at http://www-imagis.imag.fr/mobinet/ The main aim is pedagogical: MobiNet allows young students at high school level with no programming skills to experiment with the notions they learn in math and physics by creating simple video games. This platform was massively used during the INPG "engineer weeks": 150 senior high school pupils per year, doing a 3h practice. This work is partly funded by INPG. Various contacts are currently developed in the teaching world. Finally, mobinet was decribed in a publication at the eurographics conference [27] in 2004.

5.7. Basilic : an Automated Bibliography Server

Basilic is a tool that automates the diffusion of research results on the web. It automatically generates the publication part of a project web site, creating index pages and web pages associated to each publication. These pages provide access to the publication itself, its abstract, associated images and movies, and anything else via web links[4].

All bibtex related information is stored in a database that is queried on the fly to generate the pages. Everyone can very easily and quickly update the site, thus garanteeing an up-to-date web site. BibTeX and XML exports are available, and are for instance used to generate the bibliography of this activity report. Basilic is released under the GPL licence and is freely available for download[5]

5.8. XdkBibTeX : parsing bibtex files made easy

This program provides parsers and utility functions for the BibTeX file format. The core of the library is a C++ compiled as a library. Based on this library, bindings for different languages are provided using SWIG.

The long term goal is to replace the bibtex program and its associated BST language for style files by a more recent and powerful scripting language (such a Python, Ruby, Php, Perl...) or by Java. The other goal is to allow easy writing of BibTeX related tools such as converters to other format. XdkBibTeX is used by Basilic to import from bibtex files. XdkBibTeX is released under the GPL licence and is freely available for download[6]

6. New Results

6.1. Lighting and rendering

Participants: François Sillion, Cyril Soler, Nicolas Holzschuch, Jean-Marc Hasenfratz, Jean-Christophe Roche, Sylvain Paris.

6.1.1. Lighting simulation in complex environments

We have developed a technique for computing solutions to the problem of light equilibrium in complex scenes that include plants. Our technique is based on hierarchical radiosity with clustering and instantiation.

[4] See for instance http://artis.imag.fr/Publications

[5] http://artis.imag.fr/Software/Basilic

[6] http://artis.imag.fr/Membres/Xavier.Decoret/resources/xdkbibtex/

While this technique may be applied to any kind of scene, instantiation benefits highly from the multi-level approximate self-similarity of plants. Self similarity saves memory and thus the program in able to treat very large scenes.

In collaboration with *Noveltis*, Toulouse, our software called *PlantRad* now takes place in a large pipeline for simulating embedded remote sensing captors on satelites. By pre-computing the reflectance of a soil covered by a given kind of vegetation, and comparing the results to those measured by the sensor (See Fig. 1), it is indeed possible to infer what is remotely seen by the sensor. These results have led to a publication [25].

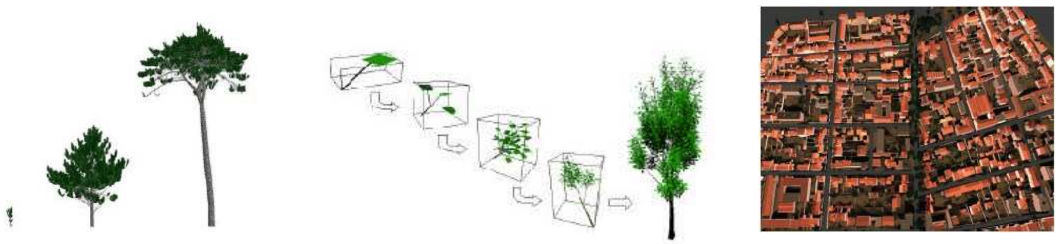


Figure 1. Lighting simulation in complex environments. Left: very complex models of trees are accounted for by the software using clustering and instancing techniques (middle) so as to obtain global illumination solution on very large scenes such as this entire region inside the town of 'Toulouse' (right).

6.1.2. Real time rendering of faceted gemstones

We present an algorithm for rendering faceted colored gemstones in real time, using graphics hardware. Beyond the technical challenge of handling the complex behavior of light in such objects, a real time high quality rendering of gemstones has direct applications in the field of jewelry prototyping, which has now become a standard practice for replacing tedious (and less interactive) wax carving methods. Our solution is based on a number of controlled approximations of the physical phenomena involved when light enters a stone, which permit an implementation based on the most recent – yet commonly available – hardware features such as fragment programs, cube-mapping and floating-point rendering.

The developed algorithm works in two pass. For a given viewpoint, a tree of internal reflection of light coming from outside the stone to the observer's eye is first constructed. The contribution of incoming light at all levels of this hierarchical structure are then summed up from back to front. Both pass highly beneficiate from the graphics hardware, which permits to render faceted gemstones at interactive to realtime framerates, depending on the complexity of the geometry.

Although raytracing based methods precedently had been applied to render diamonds, none of them could produce such pictures at such speed while accounting for complex light behavior such as birefringency, as demonstrated in our publication [2].

6.1.3. Combining Higher-Order Wavelets and Discontinuity Meshing for Radiosity

The visual impact of lighting simulations depends on the quality of shadow boundaries. Several algorithms have been developped that precompute the position of light discontinuities, such as shadow boundaries, using geometrical tools, then use these boundaries as the basis for the finite elements used in the radiosity method. The set of discontinuities computed includes all discontinuities of the radiosity function, as well as its first and second derivatives. The mesh computed is therefore a complex mesh, and these methods suffer from robustness problems. These discontinuity-based methods usually produce a large number of triangles, resulting in a larger number of finite elements in the radiosity solution, thus also causing memory problems.

On the other hand, radiosity methods using higher-order wavelets achieve a compact representation of smooth variations of the radiosity function. These methods usually produce a very compact mesh, resulting in

Figure 2. Real time rendering of faceted gemstones. From left to right one can see the photograph of a real andalusite gemstone, a simulated andalusite using our system, and an example of application to virtual jewelry prototyping involving a diamond.

a lower memory cost, except on places where there is a sharp variation of illumination, such as sharp shadow boundaries. At these places, the wavelet base is unable to accurately represent the sharp variation.

Higher order wavelet bases in 2D are defined as the tensor product of 1D wavelet bases. As a consequence, they are only defined over a square domain, and were long thought to be incompatible with discontinuity meshing, which produces complex, non-square domains.

We have developped an algorithm [26] that nevertheless combines both methods. Our algorithm uses wavelet radiosity most of the time, and introduces discontinuities during the refinement process, if they are providing a better refinement. Figure 3 shows a detail of an architectural scene computed using our algorithm.

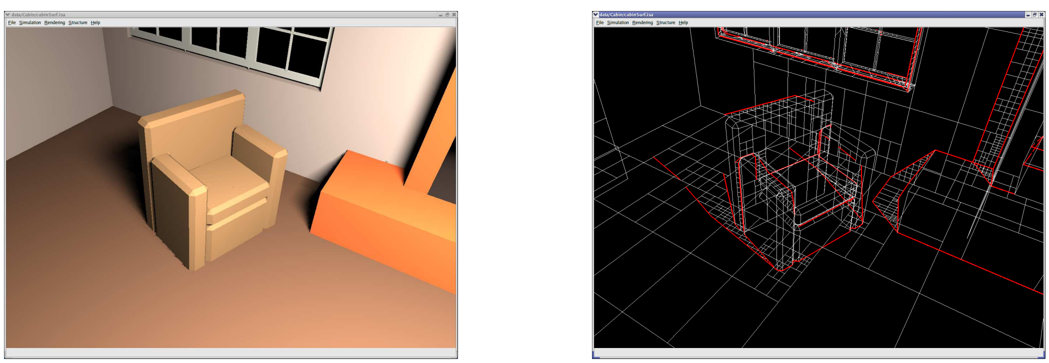


Figure 3. Combining higher-order wavelets radiosity with discontinuity meshing. Left: a detail of an architectural scene illuminated with our algorithm. Right: the underlying mesh. Shadow boundaries have been inserted in the mesh, resulting in a more compact representation. In some places, where there is a smooth variation of the radiosity function, boundaries have not been inserted, since the variations of the illumination are already captured by the wavelet base.

6.1.4. Space-time hierarchical radiosity

We have addressed the issue of computing diffuse global illumination solutions for animation sequences, in which the movement of the objects in the sequence is known beforehand. We have adapted the hierarchical radiosity algorithm to include the time dimension in the hierarchical decomposition algorithm. Our algorithm refines the temporal dimension when there is a fast variation of the illumination and avoids refinement when the illumination remains constant.

We have recently [1] improved this algorithm to combine it with hierarchical radiosity with clustering and using higher-order wavelets for the temporal dimension, resulting in a smoother variation of the illumination.

6.1.5. Hard shadows

We have developed a simple yet novel way to implement the rendering of hard shadows using the stencil shadows technique (as used in the video-game Doom III). The basic technique has been well kown for more than ten years, but we express it in a slight different way, that affords the use of advanced rasterizing methods of modern graphics hardware (triangle strips and vertex arrays, for optimized data transfers to the graphics card). This is joint work of Samuel Hornus, Jared Hoberock (UIUC), Sylvain Lefebvre (INRIA/EVASION) and John Hart (UIUC). This work has been submitted for publication.

6.2. Inverse rendering

Participants: François Sillion, Sylvain Paris, Hector Briceño.

6.2.1. Image-based surface reconstruction

Lambertian A surface is said to be Lambertian if the image intensity I depends only on its normal N and on the light direction L with the law $I = N.L$. A Lambertian model may be extended to any law depending only on N and L; it is then equivalent to saying that the surface image is view-independent.

The proposed method targets the reconstruction of the 3D shape of an object using several photographs taken from different viewpoints. The originality of this work is to avoid relying on the classical Lambertian assumption. We deal with objects which may be glossy or shiny: Their aspect may change with the viewpoint because of the highlights.

To overcome this difficulty, we present a new reconstruction algorithm. First, we construct an estimate of the final shape with a carving approach which ensures both the photometric consistency (i.e. the color of each surface point satisfies the assumption that it is composed of a diffuse color and specular reflection) and the silhouette consistency (i.e. the contour of the object projects onto image discontinuities in each photograph). This first estimate is a basis for the final refinement step which involves a graph-cut optimization based on texture-correlation. This last step is more precise while still being robust to non-Lambertian effects. But it cannot be used without the first step since texture-matching requires information on the local tangent plane of the surface to achieve satisfying results.

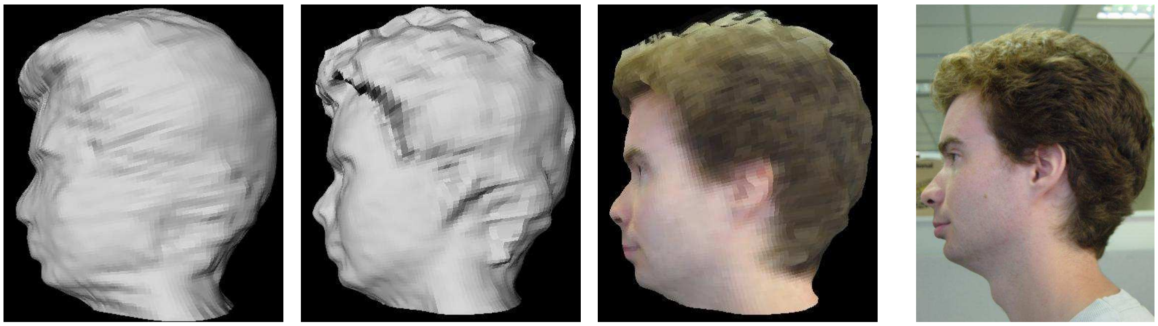
This technique is illustrated on heads under unknown illumination which are a typical examples of non-Lambertian setup, as demonstrated by Figure 4.

6.2.2. Capture of hair geometry

The creation of virtual models from real data is an important goal. Within this context, we aim at capturing the hair geometry of existing people.

Traditional 3D capture systems, such as laser scanners, have trouble with hair due to its complex reflection properties, and thus yield erroneous results. Alternatively, modeling a real person's hair by hand is a tedious and time-consuming process. We propose a method to capture the geomtry of hair from multiple pictures; this model can be used by itself or as input to a user-based system.

The novelty of this work [7] is that we draw information from the scattering properties of the hair that are normally considered a hindrance. To do so, we analyze image sequences from a fixed camera with a moving light source. We first introduce a novel method to compute the orientation of the hairs in the images from their anisotropic behavior. This method for computing orientation is proven to subsume and extend existing work while improving accuracy. This orientation is then raised into a 3D orientation by analyzing the light reflected by the hair fibers. On Figure 5 we show an example of our results. The image on the left shows a sample input image, and the image on the right shows our reconstructed model.



(a) (b) (c) (d)

Figure 4. Illustration of the steps involved into the reconstruction of a head from a collection of photographs. (a) *first estimate of the shape of the head.* (b) *refined shape.* (c) *refined shape with texture.* (d) *original photograph.*

Figure 5. Sample result of our hair capture technique. Left: one of the original images; right: the reconstructed model. Our contribution is to capture the original hair geometry of a person. Our technique automatically captures a dense set of hairs from image sequences with fixed viewpoints and a moving light source.

6.3. Visibility

Participants: François Sillion, Gilles Debunne, Xavier Décoret, Denis Haumont, Samuel Hornus.

Occlusion culling Task of quickly discarding the object that cannot be seen from the current viewpoint (prior to hidden face removal) so to avoid unecessary processing.

Visible Set Set of objects that are visible from a given viewpoint. For a region of space, the visible set is the union of all visible sets for all viewpoints in the region.

Potentially Visible Set Set of objects that an algorithm *thinks* are visible from a given viewpoint or a given region. Typically, it should contain the visible set for the algorithm to be *conservative*, that is to ensure all visible objects are processed.

6.3.1. Per Object Certainly Hidden Regions for Occlusion Culling

To quickly determine the visible set (VS) of the current viewpoint, a classical solution is to partition the navigable space into a finite set of regions called *viewcells*, and to precompute a potentially visible set (PVS) per viewcell. The current viewpoint's VS is then approximated by the PVS of the current viewcell, that is the one containing the viewpoint.

Unfortunately, the partitionning in viewcell is not an easy task. If viewcell are too large, they would yield too conservative PVS. If they are too small, the pre-computation time and storage cost can dramatically increase, especially if the navigable space is large and 3D (as opposed to 2D e.g. a viewpoint constrained to the ground level). The fundamental question behind is that the partition should approximate the visibility complex which is known to be very hard to compute and whose shape is almost impossible to anticipate.

In this work, we proposed to store visibility information at the object's level. We encode which regions of space see an object, instead of which objects are seen from a region. We showed that it implicitely captures the correct visibility events and supress the arbitrary space partition in viewcells. The complexity therefore no longer depends on the size of the space but only on the number of objects.

This work has been submitted at the Symposium on Rendering 2004 but was rejected. We are improving the results for a new submission.

6.3.2. D-Buffers

We developped the D-buffer as a tool for multiresolution occlusion testing. This *distance buffer* encodes the value and position of local distance maxima at different scales in an image cube, in contrast to the image pyramid of hierarchical occlusion maps (see fig. 6). The resulting increase in storage space is largely compensated by the following benefits: objects of any size can be culled in constant time against an occlusion map using four depth lookups; D-buffers can be computed very efficiently, and possibly implemented in hardware. We studied the performance gains that can be expected when using D-buffers for occlusion testing in walkthrough applications and showed that they allow a dramatic reduction in the number of depth tests.

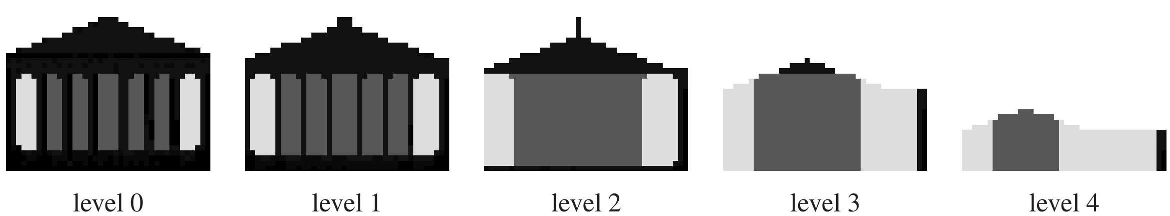


Figure 6. An exemple of the 5 levels of a D-buffer for an occlusion map of a greek temple

This work was submitted at Siggraph 2004 but was rejected. The encouraging reviews allowed us to design even more convincing tests and we will re-submit this work to Siggraph 2005.

6.4. Expressive Rendering

Participants: François Sillion, Jean-Dominique Gascuel, Gilles Debunne, Joëlle Thollot, Sylvain Paris, Stéphane Grabli, Pascal Barla.

6.4.1. Procedural manipulation of style for line drawings

6.4.2. Line simplification and abstraction

Line drawing is an important aspect of modern graphics. It allows an intuitive depiction of complex scenes with a remarkable economy of means. Artists have since long learned to use this perceptual property to provide stunningly expressive pictures, by cleverly tuning line density accross their drawings. However, most of the time in computer graphics, lines do not come with an appropriate density. The reasons for that may be numerous, but they lead to the same observation: there is a need to reduce the number of lines in a drawing, otherwise the effectiveness of such a representation may be compromised. Moreover, there is not a single way to accomplish this task, so we must be able to adapt to the needs of different contexts.

Pascal Barla, Joëlle Thollot and François Sillion have begun to address this problem by considering a set of vectorized lines in input and producing another set of lines containing fewer lines than the original.

This problem arises in many different contexts such as:

- Progressive editing (sometimes called oversketching) where the user refines a curve by successive sketches. This approach is often more natural than control point editing, in particular for “sketch-based modeling”.
- Adjusting line density in a drawing. This is needed when scaling a line drawing, as well as when rendering from a 3d scene, where too many lines may project in a given region of the image. In this context only the most “significant” lines should be drawn.
- Creating level-of-detail representations for line-based rendering (contours and hatching), where the number of lines should vary with scale. The main difficulties with all existing methods are the selection of lines and the transition between LODs.

Each of these contexts has its own way for guiding the simplification: for progressive editing the key is ergonomy, usually ensured by a set of heuristic rules that must be known to the user. For density control the goal is to draw the most significant lines while maintaining a limit on image density. With LODs, their creation is guided either by aesthetic considerations or by conservation rules, such as tone preservation for hatching groups.

We propose a common framework for these problems, where simplification is controlled by a single scale parameter ϵ, which will have a slight different meaning depending on the application goals. A first result has been published in [12], see Figure 7.

*Figure 7. A set of lines(**left**) and two simplified versions (**middle and right**) with two different scales.*

6.5. Virtual Reality

Keywords: *3D interaction*, *augmented reality*, *mediated reality*, *mixed reality*, *painting*.

Participants: Jean-Marc Hasenfratz, Jean-dominique Gascuel Lapierre, Marc Lapierre, Jean-dominique Gascuel, Raphaël Grasset.

6.5.1. CYBER

In the context of Augmented Reality applications, our goal is to simulate, in real-time, the presence of a person (e.g. a TV anchorperson or a teacher) in a virtual environment. This simulation consists mainly in visualizing the combined scenario, and possibly in providing tools for interaction between the real person (Figure 8), the virtual environment, and the observer (e.g. TV spectator or pupil).

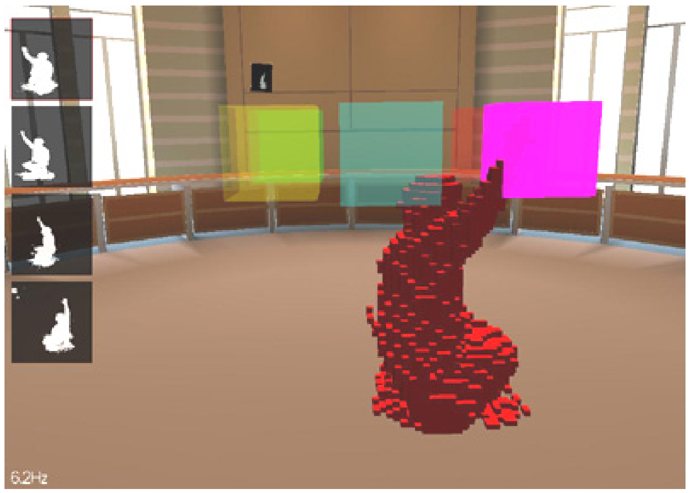


Figure 8. Interaction with the virtual world: actions can be triggered by appropriate gestures by detecting when the actor's arm enters a region of space.

The main overall technical requirements are thus a highly realistic visualization, which works in real time. We have proposed new methods to capture an actor with no intrusive trackers and without any special environment such as a blue-screen set, to estimate its 3D-geometry and to insert this geometry into a virtual world in real-time. We use several cameras in conjunction with background subtraction to produce silhouettes of the actor as observed from the different camera viewpoints. These silhouettes allow the 3D-geometry of the actor to be estimated by a voxel based method. This geometry is rendered with a marching cube algorithm and inserted into a virtual world. Shadows of the actor corresponding to virtual lights are then added and interactions with objects of the virtual world are proposed (Figure 9).

The main originality of this work is to propose a complete and scalable pipeline that can compute up to 30 frames per second. It has been published in the "Vision, Video and Graphics" workshop [21] and a more interactive version has been published in "Virtual Environments" [4].

6.5.2. Interactive Mediated Reality

Virtual Reality researchers have largely demonstrated new working methods during the last years with "proof-of concept" prototypes in the context of virtual prototyping, interactive sculpting or painting tools. Nevertheless, these tools remain inadequate in terms of usability, with lack of proprioperception, sufficient haptic feedback and good stability of 3D devices.

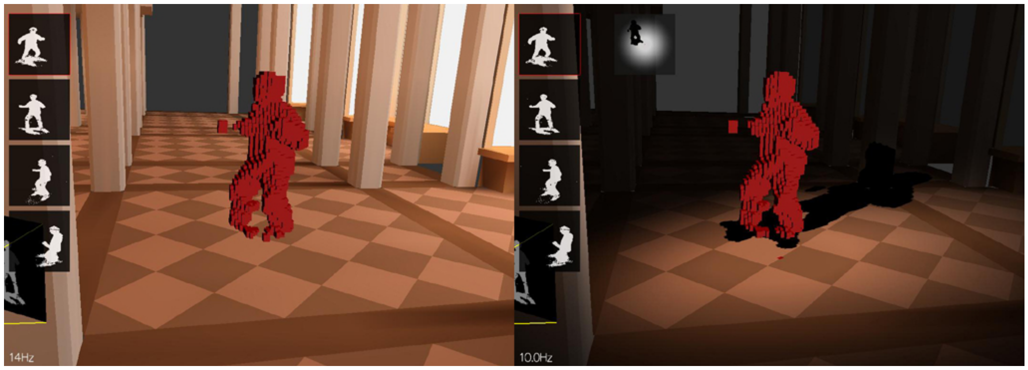


Figure 9. Shadow due to a virtual light. Left: the actor seems to be "flying" above the floor. Right: shadows remove this impression

In this context we proposed a new approach based on augmented reality, where a user can interactively and easily modify a simple real mockup. Our approach is based on *Mediated Reality*, which refer to the concept of filtering our vision of reality, typically using a head-worn video mixing display (as opposed to a projection approach). A large panel of domains can benefit from this concept: architecture, cosmetic, packaging, prototyping etc. For this we introduced a general framework of interactively mediated reality, and realized a first prototype that proposes new tools for modifying appearance or geometry of real mockups (i.e. painting, grabbing and glueing together real and virtual elements).

After a preliminary user experiment, a new enhanced prototype and a completed formal evaluation have been concluded at the begining of the year, and a first version have been submitted.

Figure 10. Interactive Mediated Reality

Raphaël Grasset defended his thesis *"Multi-users Augmented Reality Environment for small group configuration"* on April 19th, 2004. Since then, he is doing a PostDoc at the HITLabNZ, in NewZeland, with Mark Billinghurst.

6.5.3. *Survey*

In order to get a better understanding and overview of the numerous and multidisciplinary research on augmented reality and its collaborative aspect, we decided to conduct a large literature study under the prism of user-centered design. The knowledge and experience we have collected during the past three years led us to the publication of a survey [19], and the creation of a new reference website on augmented reality, focused on multimedia and research aspects[7].

6.6. Geometric analysis

Participants: Samuel Hornus, Aurelien Martinet, Cyril Soler, Nicolas Holzschuch, Francois sillion.

6.6.1. *Texture sprites*

We propose a representation for efficiently and conveniently storing texture patches on surfaces without parameterization. The main purpose is to texture surfaces at very high resolution while using very little memory: patterns are stored once while instance (i.e., sprites) attributes (pattern number, size, orientation) are stored in an octree-like structure (requiring no surface parameterization). Our representation correctly handles filtering while most other methods suffer from filtering artifacts at patch boundaries. Implemented as texture sprites, the texture patches of a composite texture can be updated dynamically. This provides natural support for interactive editing, and also enables various kinds of animated textures, from wavy stationary features to crawling spots. We extend this basic scheme with two examples which would be uneasy to achieve with other methods: complex blending modes between the texture patches, and rigid scales on a deforming surface. Since our representation is particularly well suited for interactive applications and texture authoring applications, we focus in the paper on its GPU implementation, while preserving high-quality rendering.

This work has been published as a technical report [35]. An application of this work to mesh painting will be published in the book *GPU Gems 2*, to appear in March 2005. Finally, this work has been submitted for publication

6.6.2. *Semantic analysis of non coherent geometry*

Aurélien Martinet has started his PhD in 2003 working on the automatic extraction of semantic information from non coherent geometry. This thema aims at answering a recurrent need in computer graphics: most researchers work with 3D scene data into which they need high level information such as which groups of polygons form connex shapes, human regognisable objects, or even which groups of polygons look like each other (Also known as *instancing information*). Unfortunately such high level information is most of the time not present in 3D geometry files, either because it was lost during format conversions, or because it was not defined the same way by the designer of the model. The question to be solved by Aurelien is thus how to automatically retrieve some high level (also named *semantic*) information from a *polygon soup*, *i.e* a list of polygons without any information about how these polygons are related to each other. Figure 11 shows preliminary results of automatically retrieving instancing information [28].

7. Contracts and Grants with Industry

7.1. Noveltis

Participants: Cyril Soler [contact], Francois sillion.

Noveltis is a company established in Toulouse (France) and its main activity is to perform studies of applicability and to provide usable solutions to clients in various scientific application domains such as atmospheric physics and chemistry, oceanography, land surfaces and astrophysics. The technology itself is obtained through consolidation and promotion of scientific work as a tool for analysing and managing environmental problems. Noveltis is developing a partnership with INRIA for using the PlantRad software

[7] http://artis.imag.fr/Members/Raphael.Grasset/AR/

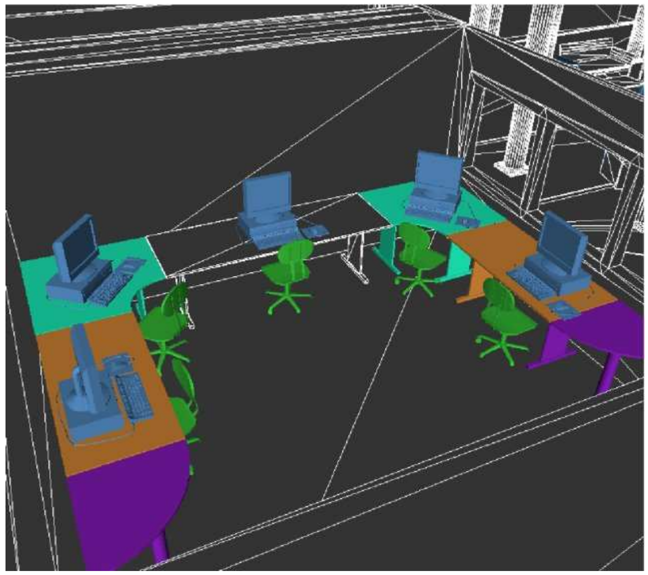


Figure 11. Automatic retrieval of instancing information from a polygon soup: all groups of polygons forming chairs have been detected as similar, despite their different position and orientation in the scene.

developed by ARTIS into a framework for simulating embeded sensors on satellites. In this context PlantRad serves for the computation of the reflectance of mixed forest and urban regions of the earth surface. This collaborative work has lead to a publication [25].

8. Other Grants and Activities

8.1. National grants

8.1.1. Grants supporting the CYBER research project

The project CYBER-I was supported by the "ACI Jeunes Chercheurs" of the Department of the Research (2001-2003). The continuation of this project is CYBER-II which is supported by the "ACI Masse de Données" of the Department of the Research (2003-2006). In this second step, we will improve the realism by augmenting the number of cameras (approximatively 20), by using a grid of PC and by visualizing the augmented scenes at very high resolutions, using a multi-projector setup.

8.1.2. Research Ministry grant: SHOW

SHOW is a collaborative research action funded under the French Ministry of Research "Mass of Data" program, a program for projects for processing, managing anv visualizing very large datasets.

SHOW joins together four INRIA projects: Reves of INRIA Sophia, ISA of LORIA and Iparla of UR-Futurs (in Bordeaux). We are working on very large datasets, and we extract their structure for edition and interactive display.

The ARTIS project is working on very large datasets that represents an architectural model, including walls, windows, doors, furnitures, and small objects. The model is unstructured, as it often happens in industrial applications, usually as the consequence of applying an automatic translator on the 3D data.

We are working on the automatic generation of a spatial and semantic structure out of this unstructured dataset, using geometrical tools and techniques from Computer Vision. The goal is to separate and identify in the database the walls, furniture and other objects. The other research projects will be using the generated structure for simulation, parameterization and visualization of the architectural dataset.

8.1.3. Region Rhône-Alpes investigation grant: DEREVE

The Region Rhone-Alpes is funding the Dereve research project. The project has been going on for three years in its first phase (Dereve, 1999-2002) and is now in its second phase (Dereve II, 2003-2006). The Dereve research project is grouping together the ARTIS and EVASION research teams of the GRAVIR research laboratory, the LIRIS research laboratory in Lyon and the ICA research laboratory in Grenoble. The goals of the Dereve project are to render large and animated virtual environments in real time, using either photorealistic rendering or non-photorealistic rendering.

In the Dereve project, we are also working in collaboration with the ARIA research laboratory of the Lyon school of Architecture, who is producing a 3D model of the "Ideal City" by the famous Lyon architect, Tony Garnier. As the city has never been built, the architects are seeing fit to have a non-photorealistic rendering of the city, to underline its virtual status.

8.2. Association with MIT CSAIL graphics group

INRIA's office of international relations has set up in 2001 a program for "associated teams" that bring together an INRIA project-team and a foreign research team, providing a form of institutional recognition to stable scientific collaborations involving several researchers on each side.

An "associated team" was created in for the 2003-2005 period between ARTIS and the MIT graphics group (CSAIL Lab) on the subject of *Flexible Rendering*. After one year of existence, this association has already proven to be extremely positive: several research actions (described above in the results sections) have been performed jointly with MIT researchers, notably the work on simplified representation based on billboard clouds, and the development of a programmable system for stylized rendering.

The associated team has helped this collaboration on a practical level by providing funding for researcher exchanges. The two teams know each other very well and frequent visits and conference calls make actual cooperation a reality (for instance publications [13][15][14][33] are co-signed by researchers from the two groups). 2003 saw four visits of MIT researchers at ARTIS, and six visits of ARTIS researchers at MIT. Furthermore, Hector Briceño was hired by ARTIS as a post doc after graduating from MIT, and Xavier Décoret was hired as research scientist (CR2) after his post-doc at MIT.

8.3. International grants

8.3.1. RealReflect

The european RealReflect project (http://realreflect.org/) is a part of the IST-2001-34744 program (http://www.cordis.lu/ist/). This is a research and developement project planned over three years. The goals of the RealReflect project are the development new simulation and visualization methods in the context of Virtual Prototyping (VR), the new techniques, standards and interfaces for data exchange developed in this project being an engine for economic development.

On the technical level the RealReflect project combines aspects of data acquisition for materials and ligth sources, light simulation, and realistic and physically correct visualization in VR-displays. Academic partners of the project are:

- VUT (Vienna University of Technology, Institute of Computer Graphics and Algorithms, Austria);
- UBO (University of Bonn, Institut fur Informatik II, Germany);
- MPI (Max Planck Institut, Computer Graphics Group, Germany);
- UTIA (Czech Academy of Sciences, Institute of Information Theory and Automation, Czech);
- INRIA (Institut National de Recherche en Informatique et Automatique, ARTIS project, France).

Industrial partners are:

- DC (Daimler Chrysler, automotive industry, Germany);
- ICIDO (integration in VR-systems, Germany);
- FAURECIA (supplier for car interiors in Europe, France);
- VRA (VR-Architecs, architecs, Austria).

The role of the ARTIS team in this project are (1) to transfer its scientific knowledge in the domain of simulation of the light equilibrium in complex environments and (2) to develop new methods for obtaining a realistic solution in accordance with the physical data. While the first year of work has led to a first version of the rendering kernel of the High Quality Renderer (HQR) software (C++), the second year has been devoted to developing the necessary modules for handling bidirectional texture functions, using IESNA standard light sources, and computing surface light fields.

8.3.2. Eurodoc grants

The Region Rhône-Alpes has established a grant program to help PhD students in starting actual international cooperation during their PhD years. The following actions have been supported by the program:

8.3.2.1. Hong Kong University of Science and Technology

Sylvain Paris has visited Long Quan at Hong Kong University of Science and Technology (HKUST) twice in 2003: in February-March and in August-September. These visits have been supported by a grant from the Eurodoc program of Region Rhone-Alpes. This collaboration has been mainly centered on developing a new method for face relighting [29] and on formulating the surface-from-images technique [36][30]. During these visits Sylvain Paris has also participated in Gang Zeng PhD work about volumetric recontruction from images [32].

8.3.2.2. MIT

Stéphane Grabli has been visiting Frédo Durand at MIT for four months in 2003, from May 15 to September 15. This visit was supported by a grant from the Eurodoc program of Region Rhone-Alpes. During this collaboration, Frédo Durand and Stéphane Grabli have introduced a model for Style modeling in computer generated Line-Drawings and implemented this model within a flexible programmable system [33].

8.3.2.3. UIUC

In July 2004, Samuel Hornus visited prof. John C. Hart associate professor at University of Illinois, Urbana Champaign, with a grant from a collaboration between CNRS and UIUC. We worked on the "Practical visibility project" (NSF grant CCR-0219594). More precisely, we tried to highlight the usability of the 3D visibility complex in some problems such as the continuous maintenance of the visibility polyhedron of a moving observer, or the description of an efficient data-structure for image-based rendering. Also, some work has been done on an efficient algorithm for rendering hard-shadows.

9. Dissemination

9.1. Scientific diffusion and Education

The proper diffusion of scientific results is an important part of their value. Since most of this diffusion is done using the web, a new bibliography server has been developed to ease this diffusion[8]. A search engine browses all the publications: download is made easy, and all associated documents (images, videos, abstract, bibTex...) are also available. This kind of local bibliographic tool is not widely spread in the academic community, and we tried to make our system easy to distribute, so that it can be shared.

Most of the members of the team (faculty members as well as Ph. D. students) give courses. This educational effort is also present in the distribution of libraries such as libQGLViewer, which have a real pedagogical

[8] http://artis.imag.fr/Publications

interest since they simplify and explain the creation of computer graphics images. The project is also involved in the animation of the “fete de la science” (scientific vulgarization event), and is often consulted for its scientific expertise.

9.2. Code on the Web

9.2.1. Freestyle

Freestyle is a software for Non-Photorealistic Line Drawing rendering from 3D scenes. It is designed as a programmable interface to allow maximum control over the style of the final drawing: the user "programs" how the silhouettes and other feature lines from the 3D model should be turned into stylized strokes using a set of programmable operators dedicated to style description. This programmable approach, inspired by the shading languages available in photorealistic renderers such as Pixar’s RenderMan, overcomes the limitations of integrated software with access to a limited number of parameters and permits the design of an infinite variety of rich and complex styles. The system currently focuses on pure line drawing as a first step. The style description language is Python augmented with our set of operators. Freestyle was developed in the framework of a research project dedicated to the study of stylized line drawing rendering from 3D scenes. This research has lead to two publications ([17][16]). This software is distributed under the terms of the GPL License.

9.3. Collaborations

9.3.1. Technical University of Wien

Raphaël Grasset originally had the opportunity to do a two months internship in September 2002 at the Interactive Media System Group, Vienna University of Technology (Austria). Inscribed on in PhD Subject (Augmented Reality Tabletop Collaboration Environment), this collaboration with Dieter Schmalstieg guided him to extend his reflexion on the metaphors for interacting with the real world. More precisely, he mainly introduced the new concept of ’Interactive Mediated Reality’[9]: developping new interfaces for modifying in real-time the perception of our real world. One of an application area is the architectural sketching process, where a user can interactively modify the appearance of a building mockup. After a initial prototype [20], the first user experiments have demonstrated the interest of this concept [18]. He is still working on this topic where he now focus on proposing mobile setup but also provided algorithms for NPR rendering of the real world.

9.4. Eurographics 2004

Jean-Dominique Gascuel was co-chair of the 25th *EuroGraphics 2004 Conference*, that was held in September, at Grenoble. This international annual conference was in France for the fourth time only. This is one of the topmost important events for the Computer Graphics research all over the world.

We kept the standard Eurographics format (with 2 days of tutorials, 3 days of scientific program (4 session in parallel at the pick), and satellite workshops the week-end before). We made a special effort to involve the Game and Media industry, by organising a 4 sessions track tailored with representatives of the SME associations and of the Rhône-Alpes Media agency.

The whole ARTIS project was involved by the conference organization, as well as two dozens of volunteer students, from all over the world. This edition was a great success (more than 500 registered participants) and exploded all predictions and past records.

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