INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

# *Project-Team IPARLA*

# *Computer Graphics and 3D Interaction for Mobile Users*

*Futurs*

THEME COG

Activity Report

2007

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# 2. Overall Objectives

## 2.1. Introduction

Mobility is the major (r)evolution for current interactive systems. Therefore, one of the biggest challenges for interactive 3D graphics is now to evolve to a mobile context. The main goal of the IPARLA project is to contribute to this evolution.

During the last decade, a large range of consumer electronics devices have been developed, that allow the user to benefit from computing resources in mobile settings. The last generations of cell phones, personal digital assistants, or even portable game devices, combine embedded programmable CPUs (and more recently GPUs) with several flavors of wireless communication capabilities. Such *Mobile and Connected Devices* (MCDs) offer the opportunity to develop a wide variety of end-user software applications over client/server infrastructures.

MCDs induce specific constraints for the incoming data flow (e.g. limited CPU/GPU for real-time computing and small screens) as well as for outgoing data flow (e.g. limited input devices). These technological constraints naturally decrease the cognitive immersion of the user, which affects the performance and the adhesion to the end-user applications. In the IPARLA project, we want to address this issue by jointly developing techno-centered and human-centered techniques for interactive mobile 3D applications.

Although MCDs are an important part of our project, we focus more on the mobility of the user and the involved applications (including the data) than on the device itself. In other words, we do not aim exclusively on the development of applications for MCD, but rather to design flexible solutions that allow easy conversions for the user and the applications between a mobile context and a fixed context. For example, we want to design concepts that enable us to use the same application on a MCD, on a standard PC or in a virtual reality center as illustrated by the image at the end of this text.

In order to reach this goal, our development is strongly oriented to produce **scalable, multi-resolution** solutions that are able to **stream** and deal with **large amounts of data** in a **client-server** context. These five keywords recall the main approaches we have selected to reach our objectives.

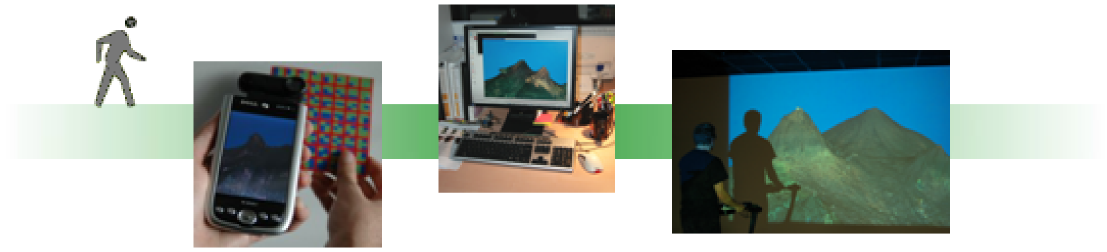


*Figure 1. Visualization and Interaction with 3D Content for Mobile Users.*

## 2.2. Highlights of the year

- In order to extend its scientific scope, IPARLA has been hosting two more permanent colleagues since september 2007. The first one is a specialist of expressive rendering which is a particularly well adapted method to visualize objects on small mobile devices. The second one is an expert in vision and 3D models reconstruction which is a very interesting way to improve Interaction modalities.
- After a first step of creation, IPARLA now wants to improve external relationships, especially with foreign institutions. For instance, we started discussions with Chinese colleagues in 2005 and this collaboration has been selected by Inria to build an Associated Team linking the State Key lab of CAD and Computer Graphics (Hangzhou) and Bunraku (Rennes) to IPARLA.
- We were asked to organize ACM VRST in Bordeaux next year. This conference, co-sponsored by SIGGRAPH and SIGCHI, is a major symposium in the scope of Virtual Reality. It comes for the first time to France.

# 3. Scientific Foundations

## 3.1. Geometric Modeling and Acquisition

In computer graphics, we are primarily concerned with the surfaces of geometric objects since the surfaces are what we actually see, animate, and physically process. Since Iparla project aims to develop mobile solutions, that is, solutions that can be adapted to the different modeling contexts and modeling platforms. We will thus consider multiresolution representations (like subdivision surfaces) and multi-representation (hybrid point-based/ implicit surface - meshes, hybrid 3D and 2D structures, ...).

In recent years, multiresolution modeling has proved to be valuable in 3D geometric surface modeling and computer graphics. It deals with the generation, representation, visualization, and manipulation of surfaces at various levels of detail or accuracy in a single model. Applications include fast rendering, level of detail editing, collision detection, scientific visualization, as well as compression and progressive transmission. In the context of mobility, the requirement of multiresolution is even essential due the enormous differences of hardware capacities. Multiresolution is also the link between geometric modeling and rendering, providing for instance an appropriate level of detail for a given viewpoint in order to ensure real-time rendering.

In the context of mobility, the users are directly in front of the real world. In Iparla project, we have thus to consider the problem of 3D data acquisition, with 3D scanners of any other devices like the embedded camera of mobile devices. A challenging task is to handle the modeling and rendering of the large amount of data in real-time. Several of our algorithms are designed to work "out-of-core" to process large acquired data (e.g. gigantic point clouds from 3D scanners). When real-time is reached, geometry acquisition can be used for interaction.

Modeling and acquisition can hardly be considered without taking into account the rendering part, and for a mobile usage, without taking into account the user, center of any mobile application. Cognition and Interaction have to be considered during the development of new modeling approaches.

## 3.2. Appearance, 3D Data Rendering and Visualization

One of the main goals of the Iparla project is the interactive visualization of complex 3D data on heterogeneous platforms. For example, a very rich and realistic visualization stream including shadows and a complete set of light effects is required when a user has to "feel" parts of a virtual world. Realistic rendering is also required when it comes to augmented reality applications. Keeping the coherence between the virtual world and some virtual objects as well as between real objects and the virtual world is a challenging research domain: appearance has to be sufficiently rich, illumination has to be sufficiently plausible. For the MCD, these technologies can be used for example for virtual visits, virtual presentations or, more generally, when the MCD is used as an interface to the real world.

On the other hand, in order to easily focus on what is really important to visualize, a more legible rendering is more appropriate. As a consequence, expressive rendering (non-photorealistic rendering - NPR) techniques have recently become popular in the computer graphics community. We believe that these techniques are helpful for depiction because they only represent perceptually salient properties of the depicted scenes and thus permit to avoid extraneous details that sometimes make images unnecessarily confusing. However, designing efficient expressive rendering systems involves being able to choose the appropriate style to represent the appropriate salient property. In particular, it requires to gain insights in the perceptual processes that occur in observing an image depending on a given task. We thus consider perceptual and cognitive issues to be inherently a part of the research on Expressive Rendering.

Despite the progress of MCDs, these client devices which are designed for mobility will always have less computing and storage capacity compared to the server. Consequently, we have to think about distributed approaches by re-investigating the entire pipeline, from storage, over transmission, to visualization. We have to define the correct representation for the data, for transmission and streaming. Moreover, we have to define how to visualize the data when received, both for realistic rendering and Expressive Rendering. We think that Expressive Rendering reduces the amount of information to transmit by focusing on what is really important.

## 3.3. 3D User interfaces

The Iparla project aims at improving the development of 3D interactive applications for the mobile user. Consequently, as we have seen above, an essential part of this project consists in adapting the classical 3D graphics pipeline to the mobile context. However, we think that the development of modeling and rendering techniques cannot go without the development of adapted user interfaces. Indeed, the interest of mobile applications where complex data can be visualized in real-time is limited when the interaction with the data is difficult.
We believe that human factors have to be taken into account in the early stage of development. Indeed, the choice of the user interface can influence the modeling and rendering techniques to use. For example, an object-oriented construction of the scene has to be preferred when the main user task of a given application consists in selecting individual objects. In the Iparla project, we want to control the entire process, from the creation of the 3D environments to the interaction with these environments. Each of the components of this process have to be strongly linked and should not be considered independently.
When dealing with mobile devices, the classical user interfaces that have been developed for desktop workstations are not the most appropriate. For example, the lack of keyboards has led to the development of intuitive writing interfaces. The classical side-menus cannot be used for the control of the application without occluding a large amount of the screen and, consequently, without occluding a large part of the data to be visualized. Last but not least, the lack of pointing devices with cell-phones makes the manipulation of the data very difficult. In the Iparla project, we develop interaction techniques that are adapted to the user, to the task, and to the characteristics of mobile devices, for efficient interaction with 3D datasets.
For the success of mobile applications, the efficiency of the interaction techniques is primordial. From previous work in the scope of VR and general Human Computer Interfaces (HCI), we investigate mobile HCI techniques. In particular, our work is based on the following foundations:

- Collaboration. In many cases, the user does not interact alone. Consequently, the issues coming with collaborative work are taken into account.
- Bi-manual interaction. It has been shown that the use of both hands can be more efficient than the use of one single hand.
- Multi-degree of freedom (dof) interaction. It is necessary to adapt the structure of the interface to the structure of the task. Consequently, interaction with 3D data generally requires interfaces with more than 2-dof.
- Gesture recognition. Non-intrusive and easy-to-learn interaction can be obtained from natural gesture recognition.
- Video-based interaction. Modern mobile devices are equipped with embedded cameras. The video stream analysis can be used as input for the development of interaction techniques.

The interaction techniques are developed in concordance with the user and the task. They are evaluated via experiments. Hence, the user performance can be qualitatively and quantitatively measured, which indicates whether a new technique is more or less efficient than another one.

# 4. Application Domains

## 4.1. Application Domains

**Keywords:** *augmented reality*, *interaction*, *modeling*, *multimedia*, *remote applications*, *telecommunications*, *virtual environment*, *visualization*.

We think that is out of the scope of this report to establish an exhaustive list of application domains that could benefit from mobile 3D interactive technologies. Consequently, we only present some key applications here.

**Assisted navigation.** Mobile and connected devices equipped with GPS are currently used as digital assistants for navigation. Such systems can help car drivers for route planning. They also can assist pedestrians or bike users when exploring cities, or when hiking in countryside. Existing solutions are mainly based on 2D or 2.5D visualization of data, which are generally stored on CD-ROMs or memory-sticks. Our project aims to provide 3D navigation tools where the data can be accessed from an up-to-date database stored on distant servers. Hence, for example, a hiker visualizes on its mobile device a 3D representation of the surrounding landscape that embeds information such as the way to follow, or the direction to the next mountain hut.

**Augmented reality.** The majority of today's mobile devices is equipped with embedded cameras. Consequently, the use of these setups for augmented reality allows to imagine a wide variety of useful applications in our everyday life. For example, in the domain of cultural heritage, some extra information coming from distant servers can enhance the images coming from the cameras of the mobile devices. More precisely, for example the interest of merging synthetic reconstructions of partially destroyed buildings with the images of the real buildings can easily be understood. The same approach can be useful for many domains such as tourism, maintenance, and so on.

**Crisis management and distant assistance.** Mobile and immersive technologies can be mixed. In particular, we want to enhance interaction between mobile users that are surrounded by the real environment and distant "control centers" where high quality visualizations are provided. On the one hand, information such as GPS positions and video streams can be received by control centers from all the mobile units. On the other hand, control centers that have a global knowledge of the situation can send helpful information to the mobile users, such as 3D models of pertinent objects. The interest of such an approach can easily be understood for many applications in the scope of crisis management or distant assistance.

**Entertainment.** Entertainment and especially video games are key applications directly related with our project as well. Some mobile devices have been designed for entertainment, and video games have been specifically developed for such setups. The results of our research in the scope of rendering or interaction can directly contribute to the development of the entertainment industry. Moreover, we are investigating new approaches for entertainment, in particular concerning the continuum between different platforms. For example, we can imagine a user to start a game at home with a PC/console, and to continue later the same game with MCD in public transportation.

# 5. Software

## 5.1. GLUT|ES - The OpenGL|ES Utility Toolkit

**Keywords:** *GLUT*, *OpenGL|ES*, *PocketPC*.

**Participant:** Joachim Pouderoux [correspondant].

GLUT|ES is an OpenSource translation of the well known OpenGL Utility Toolkit (GLUT) which is a window system independent toolkit for the development of OpenGL applications. GLUT|ES is an implementation of GLUT for WinCE and Win32 systems based on OpenGL|ES that itself is based on the OpenSource freeglut implementation. Most of GLUT API v.3 features are present: window creation, callbacks, menus, timers, etc. Only the functions that cannot exist with OpenGL|ES or that are not pertinent have not been ported (like overlays, joysticks on PocketPC, etc.). An example is given in Figure 2.

GLUT|ES homepage, which is hosted on SourceForge.net since 2006, has been visited by more than 20.000 people all around the world and downloaded more than 6.000 times. GLUT|ES has been cited by OpenGL and OpenGL|ES in their respective homepages and by their community, like in the ZeusCMD tutorials or in a 3D-Test.com interview.

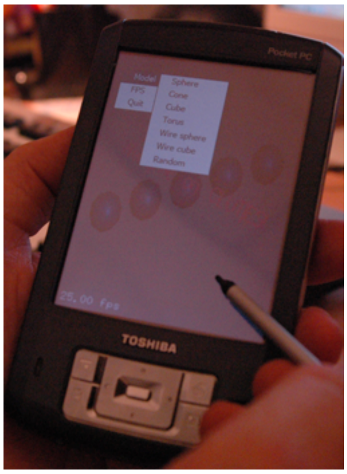



*Figure 2. A sample application based on GLUT|ES running on a Smartphone and a PocketPC.*

## 5.2. AutoDEM - A software to create digital terrains from scanned topographic maps

**Keywords:** *DEM*, *GIS*, *contours*, *interpolation*, *map processing*.

**Participant:** Joachim Pouderoux [correspondant].

AutoDEM is a Geographical Information System (GIS) software for the creation of Digital Elevation Models (DEM) from scanned topographic maps. Through different data layers (map, contours, DEM, etc.), AutoDEM provides many tools for topographic map analysis, contour line extraction and reconstruction, DEM interpolation and analysis. Most of the worldwide file formats used in the GIS domain are supported, making AutoDEM a credible software in the GIS community.

AutoDEM development started in 2003. Since the first freeware public version released in August 2004, nearly 10.000 people visited the webpage and we counted about 2.500 downloads. Through an open forum and emails, we established the contact with architects, researchers and many amateurs. Figure 3 shows a screenshot of the software.

## 5.3. Elkano

**Keywords:** *3D visualization*, *client-server*, *framework*, *streaming*.

**Participants:** Mickaël Raynaud [correspondant], Joachim Pouderoux.

Based on the Magellan framework developed by Jean Eudes MARVIE during his PhD thesis (2004, IRISA SIAMES Project), we have developed Elkano, our own scene-graph oriented system. Elkano is a cross platform C++ library and a set of client/server applications for Linux, Win32 and Windows Mobile. Elkano provides schemes for remote visualization of large 3D virtual environments and tools to design adaptive and progressive nodes. The applications designed with Elkano are made to work on such heterogeneous platforms from a handheld device in a mobility context to a cluster of PC in a virtual reality center.

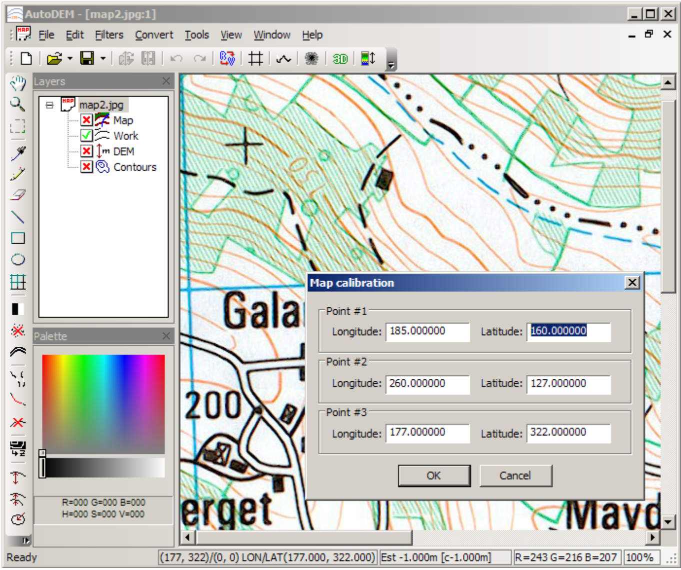



*Figure 3. AutoDEM graphical user interface.*


*Figure 4. Adaptive rendering of the same terrain on a PocketPC and on a virtual reality center using Elkano.*

Through the VRML97 and X3D formats, one can easily develop new optimized nodes with streaming capabilities to get the best performance on heterogeneous platforms. We also developed modules to support multi-screen rendering through a homogeneous cluster of devices (PCs or MCDs), OpenGL shaders and streamed level of details of lines in the context of NPR rendering. Geo-referenced models (like earth terrains, see figure 4) are supported. Objects animation and light sources support have also been recently introduced.

## 5.4. Osiris

**Keywords:** *Geometry processing*, *large models*, *meshes*, *point-sampled surfaces*, *real-time rendering*, *scanned models*.

**Participants:** Tamy Boubekeur [correspondant], Vincent Lebret-Soler.

Osiris provides various surface processing tools and visualization methods for 3D surfaces, either represented by point clouds or polygonal meshes which may be very large. It features two main types of simplification algorithms. The first one is a hierarchical partitioning (with Octree and VS-Tree). The second one is a collection of out-of-core techniques that make use of grid-based algorithms, spatial finalization and VS-Trees. The software also provides mesh processing techniques for rendering subdivision surfaces or for estimating normals for instance. Other algorithms rely on point-based methods, like percentage-rendering or Moving Least Squares. Visualisation can be point-based too. Finally, some other useful tools like surface reconstruction and raytracing are provided.

The future work on this software may lead to a more industrial tool (with multi-os support for example).

## 5.5. Seraphin

**Keywords:** *Interaction*, *Sketch-based modeling*.

**Participants:** Florian Levet [correspondant], Xavier Granier.

While 3D sketching is an intuitive way to easily create a wide range of 3D objects, their editing possibilities and interactions have still to be extended in order to take into account all the reconstruction steps, which infer a 3D surface from 2D sketches, and the resulting hybrid 2D/3D representation. Currently, the editing operations are strongly based on the paradigm introduced in Teddy, which defines 3D modifications based on 2D sketches drawn in a single view and projected in 3D.

To go a step further, we are developing *Seraphin*, a 3D sketching interface that defines new editing operations based on the intuitive use of different 2D or 3D views and sketches. It aims to give a better feedback of the modeling process thanks to multiple and coherent views during each operation. To achieve this goal, we have developed a new model generation that is robust, keep the topology of the sketched silhouettes and perform a better sampling of the final 3D objects. Based on this representation and the multiple views, we have designed an intuitive tool that leads to new editing possibilities and perspectives for 3D sketching.

Currently, *Seraphin* uses four different views (one in 3D and the other three in 2D): the **3D view** where the 3D models are shown and where users can interact with them, the **skeleton view** (in 2D) that shows the shape skeleton, the **profile view** (in 2D) where users sketch new profile curves to be applied on the models and the **allProfileView** which keeps track of the already defined profiles. Figure 5 shows a snapshot of *Seraphin*. Compared to classic 3D sketching systems, the use of multiple views enables *Seraphin* to define new interaction possibilities and to facilitate existing ones.

## 5.6. ArcheoTUI

**Keywords:** *Tangible User Interfaces for the Virtual Reassembly of Fractured Archeological Objects*.

**Participants:** Patrick Reuter [correspondant], Nicolas Sorraing.

We designed the ArcheoTUI software for the Virtual Reassembly of Fractured Archeological Objects. ArcheoTUI is designed to easily change assembly hypotheses, beyond classical undo/redo, by using a scene graph. The software connects to the database of the broken fragments that are organized in an SQL database.

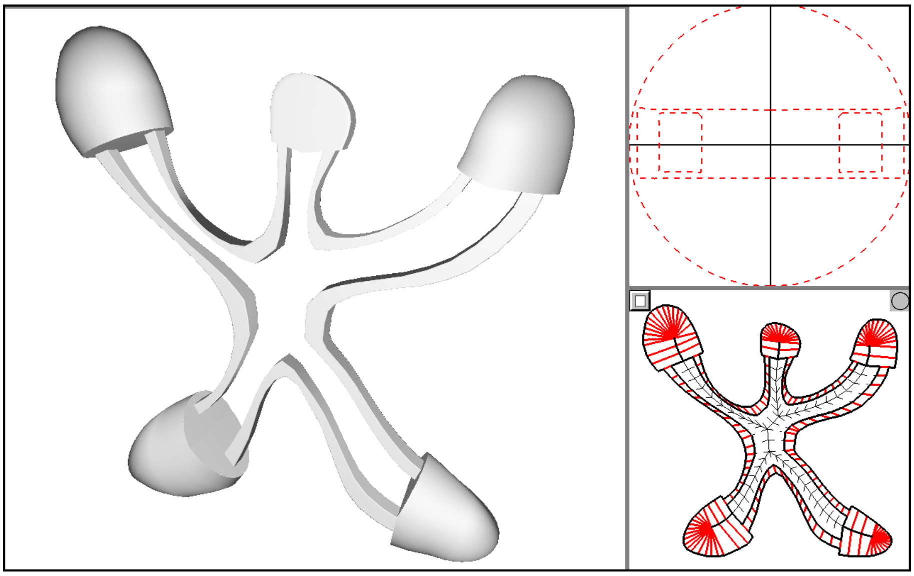


*Figure 5. Seraphin. This object was created with one silhouette sketch, two selections and two profile sketches.*

A screenshot during the usage of the ArcheoTUI software on a dual screen can be seen in Figure 6. On the right screen, in the assembly window, one fragment (or a partial assembly) corresponds to the props of the left hand, and another fragment (or partial assembly) corresponds to the right hand. At any time, the user can assemble the two objects by hitting the space bar, and undo the assembly by pressing the DEL key. When two objects are assembled, the resulting partial assembly is associated to the left prop, and the right prop is liberated, so that another fragment (or partial assembly) can be associated. Note that assembling and disassembling by the space/DEL keys is an intermediate solution, and we are currently planning to use either a third foot pedal, or buttons on the props.

On the left screen, there are drop-down menus for the import of new 3D fragments, and for loading and saving assembly hypothesis. Furthermore, there are 7 windows that can be resized according to the user's preferences:

The fragment library (1) allows the user to browse through the database, and a list of the results shows thumbnails of the corresponding 3D fragments. These fragments can be associated to the left or right prop by a context menu, or they can be dragged to the desktop.

The desktop (2) provides a space to render certain fragments or partial assemblies easily accessible.

The scene graph of the current assembly (3) illustrates the assembly hierarchy. By clicking on the nodes on the scene graph, the corresponding fragment (or partial assembly) is highlighted by its bounding box, and it can be taken out of the entire assembly by dragging it to the desktop or to the fragment library.

The status bar (4) provides visual feedback which foot pedals are currently hold down. Furthermore, the speed of the translation of the fragments can be adjusted using a slider.

The side view (5), top or bottom view (6), and rear view **(7)** help the user to better perceive the 3D space.

## 5.7. Adaptive Refinement Kernel

**Keywords:** *Mesh Refinement*, *Real-time Geometry Synthesis*, *Single Pass GPU Technique*, *Vertex Shader Technique*.

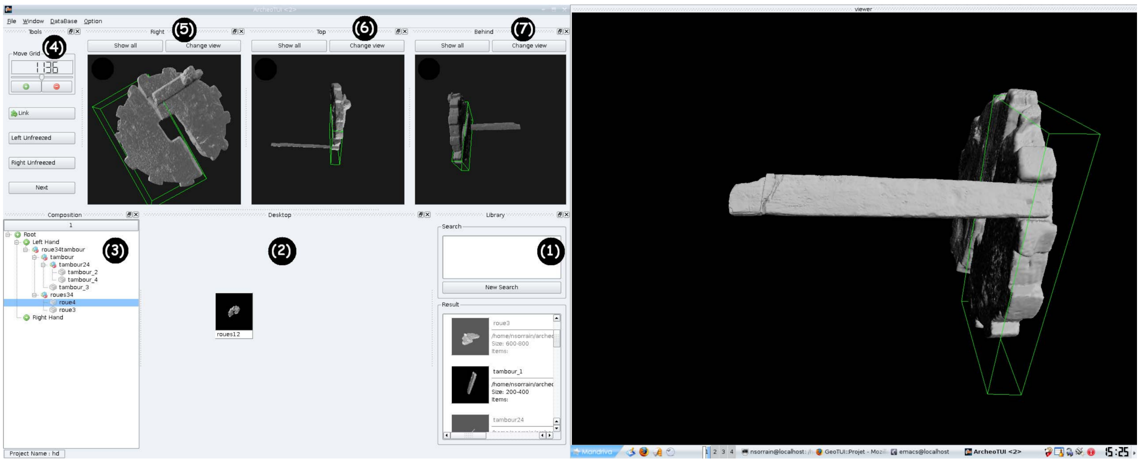


*Figure 6. ArcheoTUI. On the left: (1) the fragment library, (2) the desktop, (3) the scene graph of the current assembly, (4) the status bar, (5) the side view, (6) the top or bottom view, (7) the rear view. On the right: The assembly window.*

**Participant:** Tamy Boubekeur [correspondant].

ARK, for *Adaptive Refinement Kernel*, is a generic and flexible kernel for real-time mesh refinement. It is based on parametric instantiation of so-called *Adaptive Refinement Patterns*, which substitue a refined connectivity (encoded in a VBO) to a given coarse polygon. The adaptivity is driven with a depth-tagging methods, generic enough to handle arbitrary per-vertex refinement criteria. On GPU-side, a special Vertex Shader called Refinement Shader, performs a refinement mapping via barycentric coordinates, and applies a user-defined displacement, which can can be defined in several ways (spline patch, height map, procedural fonctions, etc). Using ARK, we have developed new mesh refinement methods, for either controlling surface singularities of Curved PN-Triangles, or approximating smooth surfaces such as subdivision surfaces with a set of low degree patches. One strenght of the ARK is its true graphics foundations: this is not a GPGPU technique involving multi-pass rendering, mesh-to-image conversion and fragment shading. This is a pure object-space technique, running in a single pass for arbitrary mesh topology, without conversion. In particular, it benefits from the recent unified architecture to balance more shader units for the geometry synthesis at vertex shader stage.

# 6. New Results

## 6.1. Modeling

### *6.1.1. Size-Insensitive Freeform Deformation*

**Participants:** Tamy Boubekeur, Olga Sorkine, Christophe Schlick.

Last year, we have addressed the problem of interactive editing of appearance for large models. This year, we complete this work by proposing a new system, SIMOD [24], for editing interactively the other fundamental properties of gigantic acquired geometries: their shape. We focus on one of the most powerful family of editing methods: Freeform Deformations.

Freeform deformation techniques are powerful and flexible tools for interactive 3D shape editing. However, while interactivity is the key constraint for the usability of such tools, it cannot be maintained when the complexity of either the 3D model or the applied deformation exceeds a given workstation-dependent threshold. In this system paper (see Figure 7), we solve this scalability problem by introducing a streaming system based on a sampling-reconstruction approach. First an efficient out-of-core adaptive simplification algorithm is performed in a pre-processing step, to quickly generate a simplified version of the model. The resulting model can then be submitted to arbitrary FFD tools, as its reduced size ensures interactive response. Second, a post-processing step performs a feature-preserving reconstruction of the deformation undergone by the simplified version, onto the original model. Both bracketing steps share streaming and point-based basis, making them fully scalable and compatible with point-clouds, non-manifold polygon soups and meshes. Our system also offers a generic out-of-core multi-scale layer to arbitrary FFD tools, since the two bracketing steps remain available for partial upsampling during the interactive session. As a result, arbitrarily large 3D models can be interactively edited with most FFD tools, opening the use and combination of advanced deformation metaphors to models ranging from million to billion samples (See Figure 8). Our system also offers to work on models that fit in memory but exceed the capabilities of a given FFD tool.

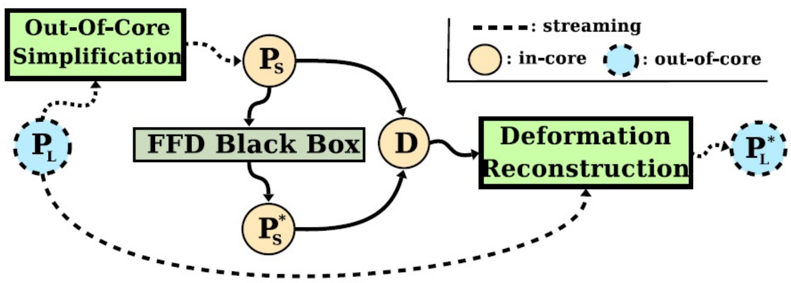



*Figure 7. The SIMOD system architecture is based on a sampling-reconstruction scheme.*

### 6.1.2. A Flexible Adaptive Real-Time Refinement Kernel for Meshes

**Participants:** Tamy Boubekeur, Christophe Schlick.

We present a flexible GPU kernel for adaptive on-the-fly refinement of meshes with arbitrary topology [15] (Figure 9). By simply reserving a small amount of GPU memory to store a set of adaptive refinement patterns, on-the-fly refinement is performed by the GPU, without any preprocessing nor additional topology data structure. The level of adaptive refinement can be controlled by specifying a per-vertex depth-tag, in addition to usual position, normal, color and texture coordinates. This depth-tag is used by the kernel to instanciate the correct refinement pattern. Finally, the refined patch produced for each triangle can be displaced by the vertex shader, using any kind of geometric refinement, such as Bezier patch smoothing, scalar valued displacement, procedural geometry synthesis or subdivision surfaces. This refinement engine does neither require multi-pass rendering nor any use of fragment processing nor special preprocess of the input mesh structure. It can be implemented on any GPU with vertex shading capabilities.

### 6.1.3. Approximation of Subdivision Surfaces for Interactive Applications

**Participants:** Tamy Boubekeur, Christophe Schlick.

We introduce QAS [21], an efficient quadratic approximation of subdivision surfaces which offers a very close appearance compared to the true subdivision surface but avoids recursion, providing at least one order of magnitude faster rendering (see Figures 10 and 11). QAS uses enriched polygons, equipped with edge vertices, and replaces them on-the-fly with low degree polynomials for interpolating positions and normals. By systematically projecting the vertices of the input coarse mesh at their limit position on the subdivision surface,

Figure 8. An example of interactive out-of-core shape editing.

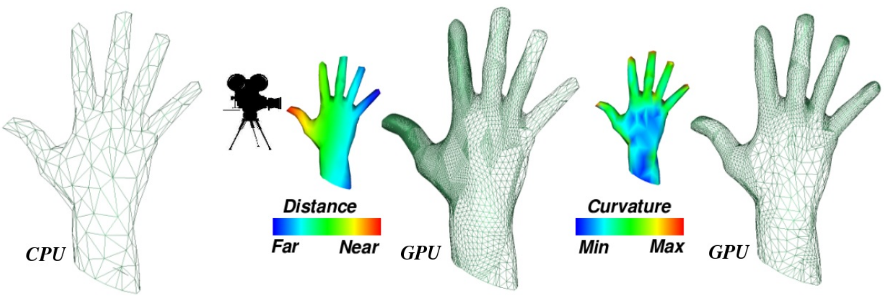



Figure 9. Generic tag-based adaptive refinement control.

the visual quality of the approximation is good enough for imposing only a single subdivision step, followed by our patch fitting, which allows real-time performances for million polygons output. Additionally, the parametric nature of the approximation offers an efficient adaptive sampling for rendering and displacement mapping. Last, the hexagonal support associated to each coarse triangle is adapted to geometry processors. QAS offers a convincing alternative to true subdivision surface rendering, while providing real-time rendering.

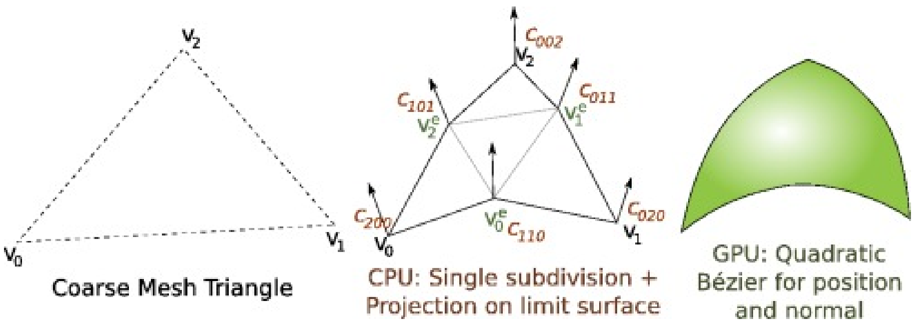



*Figure 10. Quandratic Patches for Approximating Subdivision Surfaces at low cost.*

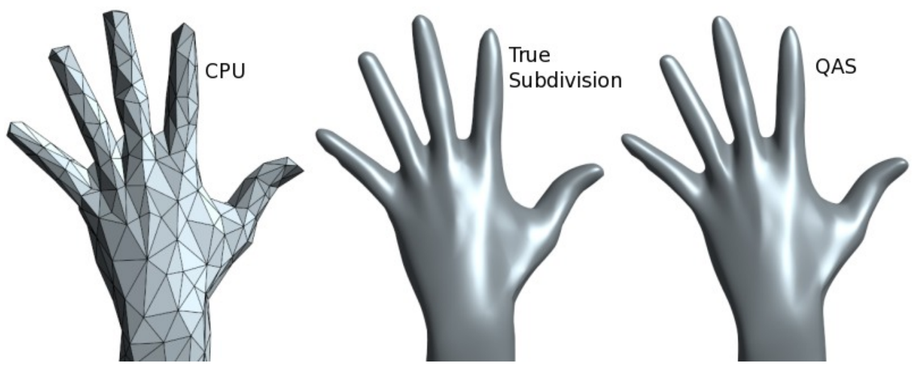



*Figure 11. Example of QAS realt-time geometry synthesis at more than 500 FPS (right), starting from 546 triangles at application (left). The visual quality is hardly distinguishable from the true recursive subdivision evaluation (middle).*

### 6.1.4. On the Fly Quantization for Large Data Transmission

**Participants:** Julien Hadim, Tamy Boubekeur, Mickaël Raynaud, Xavier Granier, Christophe Schlick.

We have developped an improved client-server system that increases the availability of 3D data in the context of 3D broadcasting (see Figure 12). We can transmit meshes and point clouds compressed on-the-fly. The data related to the appearance (colors and normals) are quantized on-demand in order to reduce the required bandwith. We reduce the size of the data without reducing the geometric complexity. Our friendly GPU quantization appearance algorithm allows us to use the GPU to quantize data and reduce the CPU load on the server-side. We have shown with our system that the time of transmission for quantized data including times of quantization/dequantization is better than the time to transmit original data. The appearance of 3D data is compressed without visible deterioration during visualisation.

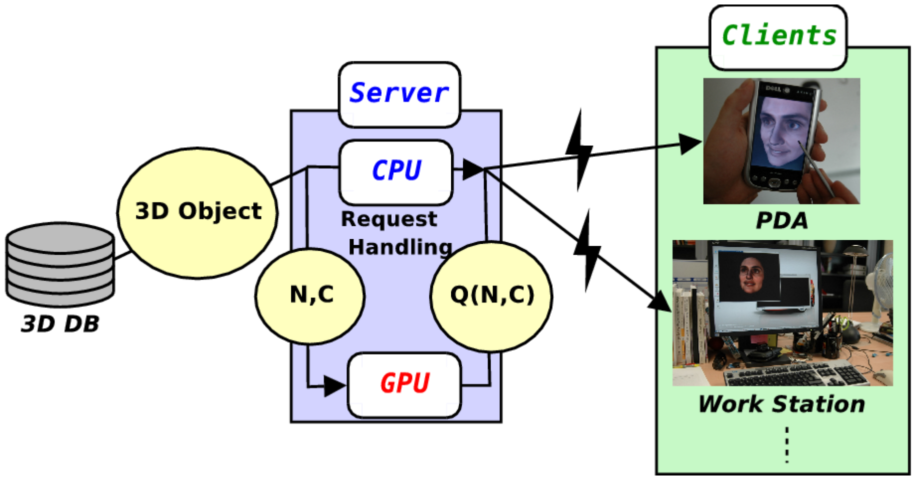



*Figure 12. A client/server 3D broadcasting application, with on-demand quantization to reduce bandwidth. The on-demand quantization workload is delayed to the GPU on the server side.*

### 6.1.5. On-the-fly Appearance Quantization on GPU for 3D Broadcasting

**Participants:** Julien Hadim, Tamy Boubekeur, Mickaël Raynaud, Xavier Granier, Christophe Schlick.

This research work presents an improved client-server system that increases the availability of remote 3D data [27]. In order to reduce the required bandwidth, the data related to the appearance (color and normal) involved in the rendering of meshes and point clouds is quantized on-the-fly during the transmission to the final client, without reducing the geometric complexity. Our new quantization technique for the appearance that can be implemented on the GPU, strongly reduces the CPU load on the server-side and the transmission time is largely decreased.

### 6.1.6. Using particle systems in order to sample and add details to implicit surfaces

**Participants:** Florian Levet, Xavier Granier, Christophe Schlick.

Particle systems are a powerful way to sample implicit surfaces since they generate almost evenly distributed samples over the surface, thanks to a global minimization of an energy criterion. Nonetheless, due to the computational cost of the relaxation process, the sampling process becomes rather expensive when the number of samples exceeds a few thousands. We have developed [18] a technique that only relies on a pure geometry processing which enables us to rapidly generate the set of final particles (e.g., half a second to generate 5,000 particles for an analytic implicit surface) with near-optimal positions. Because of its characteristics, the technique does not need the usual split-and-death criterion anymore and only about ten relaxation steps are necessary to get a high quality sampling. Either uniform or non-uniform sampling can be performed with our technique (see Figure 13).

Thanks to the extremely regular distribution of uniform particle systems, we have developed a very efficient technique [32] that uses these particle systems in order to rapidly generate a triangular mesh over an implicit surface, where each triangle is almost equilateral. The major advantage of such a triangulation is that it minimizes the deformations between the mesh and the underlying implicit surface. We exploit this property by using few triangular texture samples mapped in a non-periodic fashion as presented by Neyret and Cani. The result is a pattern-based texturing method that maps homogeneous non-periodic textures to arbitrary implicit surfaces, with almost no deformation. Some examples of this technique are shown in Figure 14.

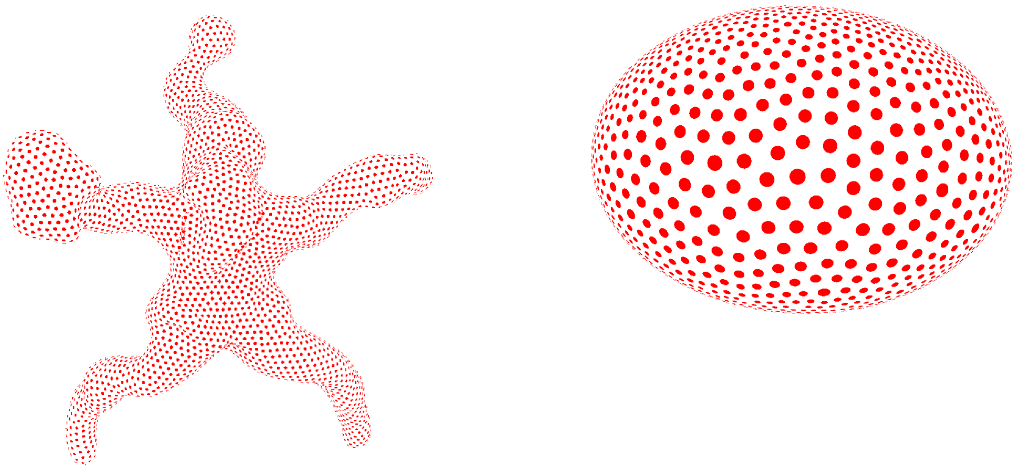


*Figure 13. Sampled models with either uniform (a) or non-uniform (b) particles.*

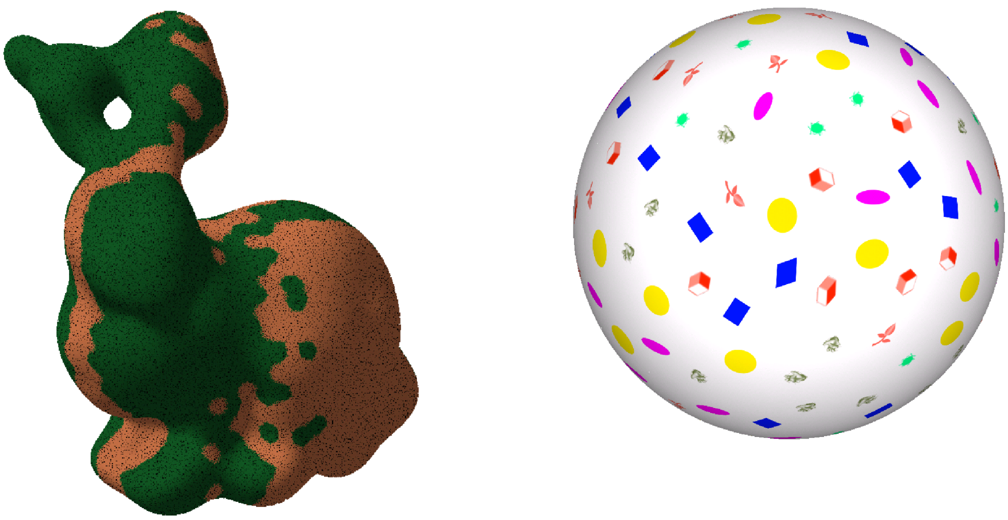


*Figure 14. Pattern-based texturing of two different models.*

## 6.2. 3D Data Rendering and Visualization

### *6.2.1. Topographic map analysis and recognition*

**Participants:** Joachim Pouderoux, Pascal Guitton, Jean-Christophe Gonzato.

Topographic maps are a common support for geographical information because they have the particularity to portray the relief through a set of contour lines (see figure 15). This topographic feature can be very useful in many context but the automatic extraction of this information is not an easy task, especially because the map contains many other layers which overlay the contours. In particular, we have proposed [12] different techniques to reconstruct digital elevation models from topographic maps.

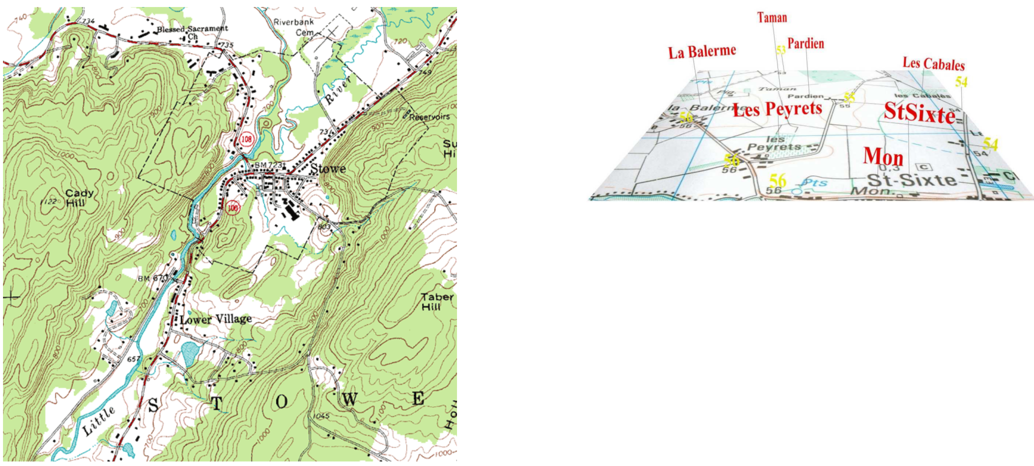



*Figure 15. Left: Extract of a color topographic map. Right: Automatically extracted toponyms on a topographic map.*

In [34] we proposed an automatic approach to reconstruct gaps in contour lines. Our novel parameter-less reconstruction scheme is based on the interpolation of the gradient orientation field from the available pieces of thinned contours (see figure 16a). A weight is then affected to each pair of end-points according the force needed by its potential reconstructed curve to cross the field. The computation of the optimal global solution is obtained by solving a perfect matching problem. We finally use the orientation flow to fill the gaps with a smooth curve that respects the tangents at the end-points (see figure 16b).

Still in the field of document analysis of this kind of document, we proposed in [33] an automatic approach to extract and recognize toponyms. Our technique is based on image segmentation and connected component processing. Different filtering stages ensure the consistency of plausible characters and strings. Detected text areas are used to feed an OCR software and the recognized words are analyzed and corrected. The main advantage of our technique is that no assumption is made about the character font, size or orientation. Experimental results obtained are encouraging in term of recognition efficiency.

### *6.2.2. Volumetric Lighting Representation*

**Participants:** Romain Pacanowski, Xavier Granier, Pierre Poulin, Christophe Schlick.

We are working on a volumetric representation to capture and edit indirect illumination. A 3D grid of irradiance vectors is first constructed via particle tracing or path-tracing. The indirect illumination within a voxel is interpolated from its associated irradiance vectors. This volumetric and vectorial representation is

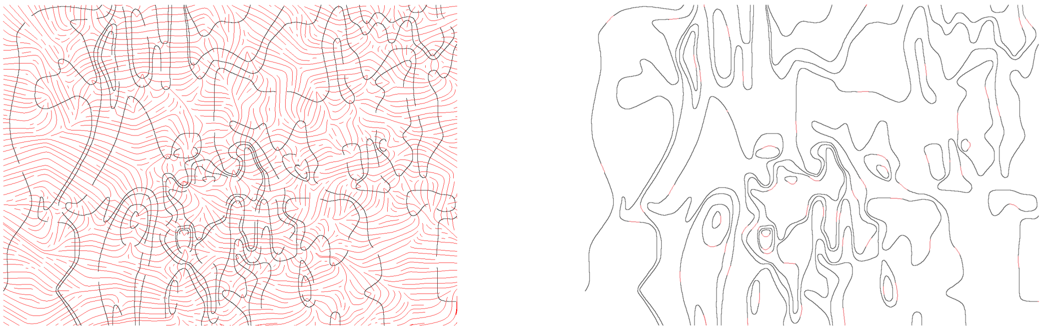


*Figure 16. Left: contour lines and the streamlines of their interpolated orientation field. Right: smoothly reconstructed contour lines.*

more independent of the local variations of geometric and photometric properties of a scene, and captures low-varying diffusely inter-reflected lighting. This properties are therefore well suited for higher-quality caching schemes compared to state of the art solutions as demonstrated by our results. An example of the quality obtained when using our structure as a cache is given in Figure 17. Furthermore, its low-cost evaluation and compactness allow to adapt easily this structure to programmable hardware for real-time display of indirect illumination. We are also working on an adaptive version of our grid that allows the transmission of indirect lighting for mobile device. We expect our adaptive grid to improve our previous results and we are planing to use it for complex objects like trees or plants.

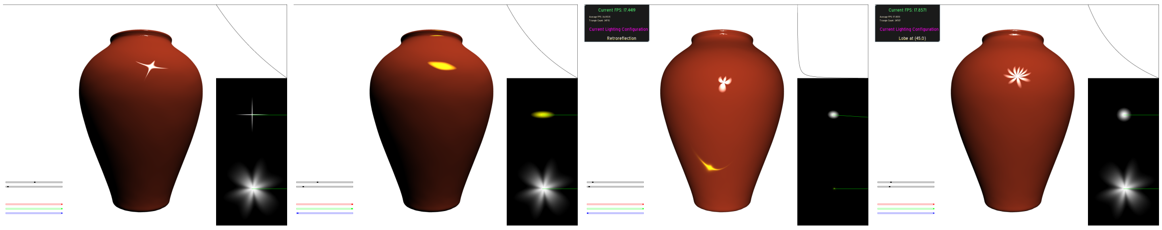
*Figure 17. Capture and editing of indirect illumination effects for the creation of a virtual museum*

### *6.2.3. Tools for editing Lighting Effects*

**Participants:** Romain Pacanowski, Xavier Granier, Pierre Poulin, Christophe Schlick.

**Indirect Lighting Edition:** We are planing to use our volumetric lighting grid to let the user edit the indirect lighting of a scene without full recomputation of the global illumination solution. We will also propose a tool to propagate the local modifications, made by the user, to the rest of the scene. The length and the direction of the propagation will be user defined and controllable.

**BRDF Edition:** We are working on a new approach for the generation of visually plausible BRDFs. This approach is based on an interactive creation and edition of BRDF lobes, mostly responsible for the appearance of surface highlights. The lobe definition is built on a new parameterization, based on the mirror direction of the incoming light. Through a set of simple and intuitive parameters, the user can modify the lobes' behavior. Figure 18 show preliminary results.



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

*Figure 18. Some possible highlights created with our BRDF system.*

## 6.3. 3D User interfaces

### *6.3.1. 3D Panorama Service on Mobile Device for Hiking*

**Participants:** Martin Hachet, Joachim Pouderoux, Sebastian Knödel, Pascal Guitton.

We present a prototype for an interactive 3D panorama service [25]. Such a service can be considered as the core of a digital assistant for mobile users like hikers and tourists. In particular, our service is based on geographical web services and non-photorealistic rendering of 3D terrains. Our aim is not provide full 3D models, we rather show a prerendered panorama scene that fits with the real surroundings. The result is a light X3D scene which can be viewed with any X3D compliant browsers on mobile devices, as presented in Figure 19.


*Figure 19. The mobile 3D hiking assistant.*

### *6.3.2. Enhancing the mapping between Real and Virtual World on Mobile Devices through efficient Rendering*

**Participants:** Sebastian Knödel, Martin Hachet, Pascal Guitton.

To create convincing mixed reality applications it is important that the user is able to combine easily information from the real and the virtual world [28]. To obtain a proper mapping, the applied rendering techniques must satisfy the special requirements of mobile devices and support an appropriate perception of the displayed data by the user. Hence the usability of relevant photorealistic and non-photorealistic rendering techniques must be evaluated in that particular context. The current challenge is to identify certain rendering techniques that help the user to map the real surroundings with the virtual scene and, consequently, allow intuitive interaction within the presented data. The general concept is presented in Figure 20.

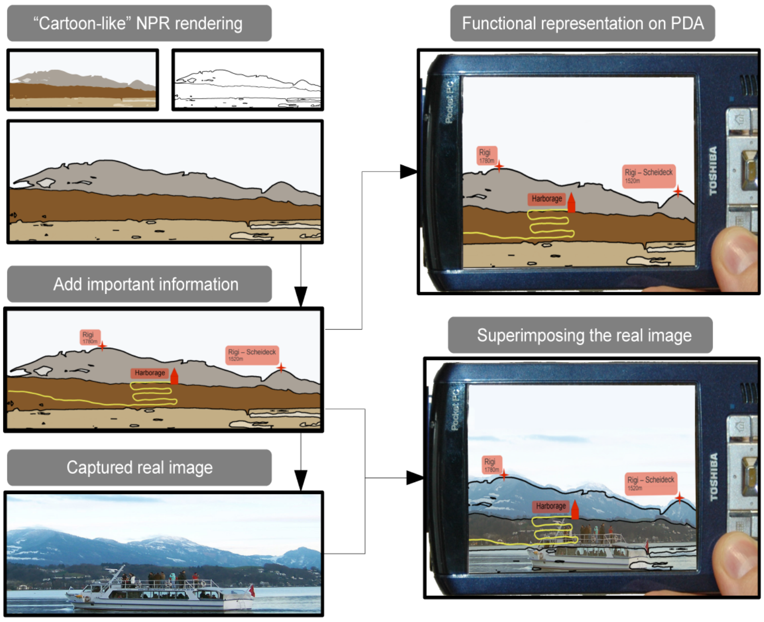



*Figure 20. Initially the data is rendered with "cartoon-like" NPR rendering techniques. Then further information is added and displayed on the mobile device. Finally the virtual data is combined with the real captured image.*

### *6.3.3. Sketch-based Route Planning with Mobile Devices in immersive Virtual Environments*

**Participants:** Sebastian Knödel, Martin Hachet, Pascal Guitton.

We present a novel sketch-based route planning technique [29], that supports the collaborative work of a group of people navigating through a virtual environments using mobile devices. With our new approach, route planning tasks, like creating camera animation paths, can be generated very efficiently, while working on large screens with complex data. Our interaction technique lets the user explore the distributed environment in a two stage process. During the first stage, the user draws the preferred navigation path directly onto a touch sensitive mobile device, that presents the data as a "World in Miniature". Afterward, during a second stage, the user can define areas of interest by performing additional sketches, like drawing points, lines or circles, to easily define the camera orientation during the animation. The resulting sketches are shown in Figure 22. Based on the sketched input, the system creates automatically the optimal animation path and camera orientation, so that disturbing occlusions are avoided and all areas of interest are in view. This system supports the collaborative work of groups of people in an immersive virtual environment with large virtual models, as presented in Figure 21.

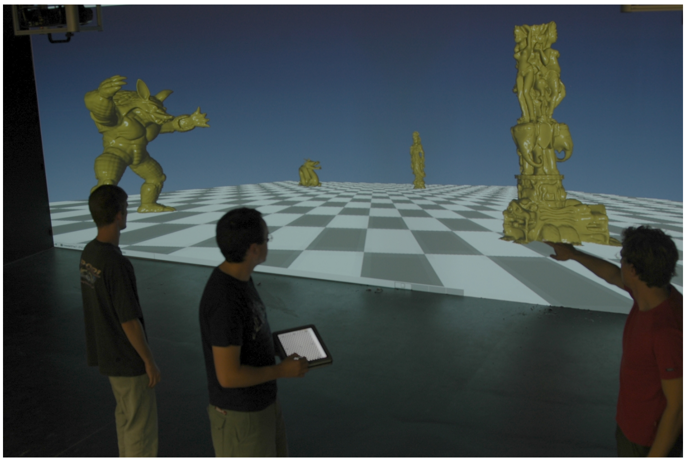


*Figure 21. Exploring a virtual scene in collaboration with a group of people.*

*Figure 22. From left to right: Sketching an animation through a virtual museum, around a terrain model and in city scene.*

#### *6.3.4. Elastic control with mobile devices*

**Participants:** Martin Hachet, Alexander Kulik.

The isotonic pen interface of handheld devices is very suitable for many interaction tasks (eg. pointing, drawing). However, this interface is not appropriate for rate controlled techniques, as required for other tasks such as navigation in 3D environments. In collaboration with Alexander Kulik from Bauhaus Universität Weimar, we investigate the influence of elastic feedback to enhance user performance in rate controlled interaction tasks.

#### *6.3.5. 3D interaction for music*

**Participants:** Martin Hachet, Florent Berthaut, Myriam Desainte-Catherine.

We are investigating the use of interactive 3D environments for controlling music. The classical digital music interfaces are generally based on the WIMP paradigm. We think that 3D environments can enrich interaction between users and music. We have developed a framework that allows links between interactive 3D graphics and music composition. This work is led in collaboration with Myriam Desainte-Catherine and Florent Berthaut who are numerical sound specialists [20].

### 6.3.6. Jump and Refine

**Participants:** Martin Hachet, Joachim Pouderoux, Florence Tyndiuk, Pascal Guitton.

Standard mobile phones input devices such as directional keys and discrete thumb-joysticks are dedicated to the current discrete phone GUIs (eg. scroll lists and small icons arrays). Today, new mobile applications are arising and require adapted interfaces. In particular, the development of 3D applications will be favored if users can efficiently interact by pointing on any part of the screen. We proposed a new interaction technique called ”Jump and Refine” for selection tasks on mobile phones. This technique is based on two levels of cursor displacement in order to reduce the number of keystrokes. The first level allows fast movements into an underlying grid. The second one can be used for accurate positioning into the selected area (see Figure 23). A user study allows us to show that using a first coarse *jump* level decreases the selection completion times. The study also shows that the technique is widely accepted by the users. [26]

We focus on 3D interaction techniques that are only based on some keystrokes. Indeed, key-based interaction is widespread on mobile devices such as cell phones. Discrete keys are even sometimes the only available input device. With only some keystrokes, 3D interaction tasks become hard to perform. Consequently, a challenge is to develop efficient user interfaces in order to favor 3D interaction on mobile devices.


*Figure 23. ”Jump and Refine” for selection on mobile phones.*

### 6.3.7. Multi-view sketch-based freeform modeling

**Participants:** Florian Levet, Xavier Granier, Christophe Schlick.

For the generation of freeform models, sketching interfaces have raised an increasing interest due to their intuitive approach. It is now possible to infer a 3D model directly from a sketched curved. Unfortunately, a limit of current systems is the poor quality of the skeleton automatically extracted from this silhouette, leading to low quality meshes for the resulting objects.

In [30], we have presented new solutions that improve the surface generation for sketch-based modeling systems. The first one is a new solution for the skeleton extraction from a silhouette curve. This skeleton, computed thanks to a 2D variational implicit surface that approximates the silhouette curve, is smoother than previous algorithms (see Figure 24). The second one is a new approach for inferring the 3D volume based on this skeleton and the computation of a good set of radial edges. Its main goal is to provide a better quality mesh without inherent artefacts that occur on mesh-based freefrom modeling.

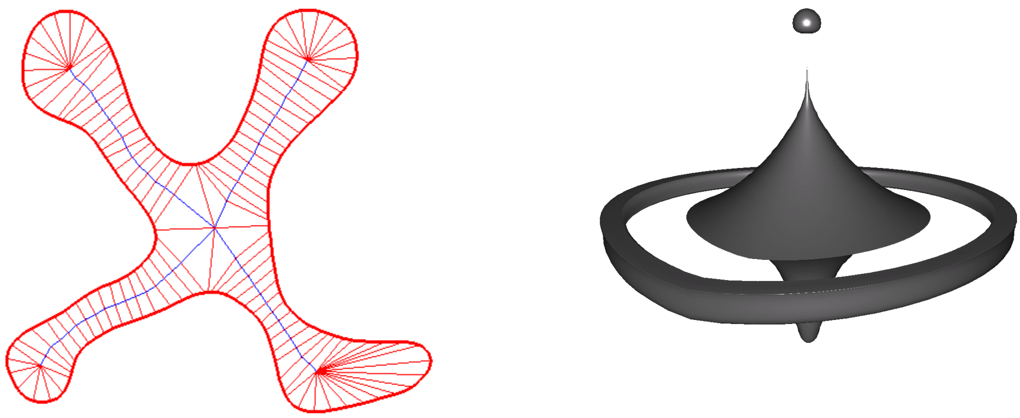


*Figure 24. A smooth skeleton extracted with our technique (left). Since it is combined with a better sampling of the silhouette, our system creates models with better quality meshes (right).*

But while, as said before, 3D sketching is an intuitive way to easily create a wide range of 3D objects, their editing possibilities and interactions have still to be extended in order to take into account all the reconstruction steps, which infer a 3D surface from 2D sketches, and the resulting hybrid 2D/3D representation. Currently, the editing operations are strongly based on the paradigm introduced in Teddy, which defines 3D modifications based on 2D sketches projected in 3D.

In [31], we presented a 3D sketching interface that defined new editing operations based on the intuitive use of different 2D or 3D views and sketches. Its aim was to give a better feedback of the modeling process thanks to multiple and coherent views during each operation (see Figure 25). Thus, each view is specialized on a component of the modeling process (like the skeleton, the profile, etc.), and is based on specific sketching interactions. With this approach, users could improve their understanding of the modeling process and perform a larger range of modeling operations.

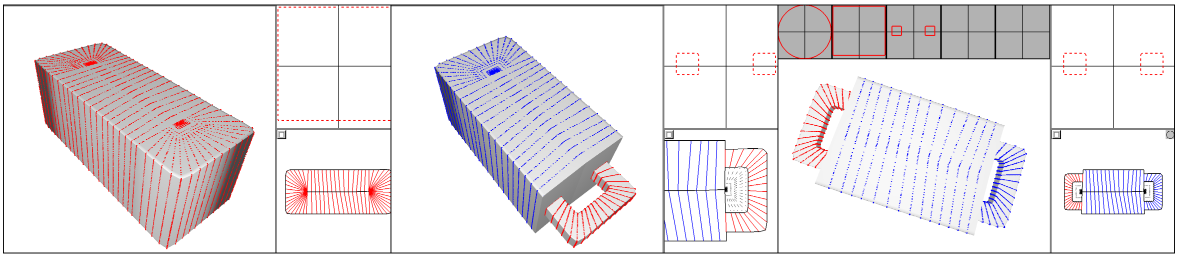
### *6.3.8. 2D Gesture based Interaction and Navigation*

**Participants:** Martin Hachet, Pascal Guitton, Fabrice Decle, Sebastian Knödel.

We propose to investigate general principles for easy interaction and navigation in Virtual Environments using mobile and immersive projection technologies. The technique is based on simple 2D gestures, which allow easy navigation in 3D virtual environments. It provides a good feedback and control for fast and easy interactive camera positioning. Consequently, it is well suited for a wide variety of modern visualization systems, from small handheld devices to large interactive displays. Figure 26 shows an example with a PDA.

### *6.3.9. Tangible User Interfaces for the Virtual Reassembly of Fractured Archeological Objects*

**Participants:** Patrick Reuter, Tamy Boubekeur, Martin Hachet, Pascal Guitton, Xavier Granier, Nicolas Sorraing.



(a) (b) (c)

*Figure 25. Possible interactions with our system. (a) The user sketches a silhouette curve and then a square profile curve that is applied on the radial edges. (b) He then selects a subset of these edges and applies a genus-1 profile on it. We can see that the 3D model is modified as well as the skeleton/silhouette of the skeleton view. (c) Finally, he selects the other side of the object and uses the allProfile view to apply the last profile he has sketched to the current selection.*

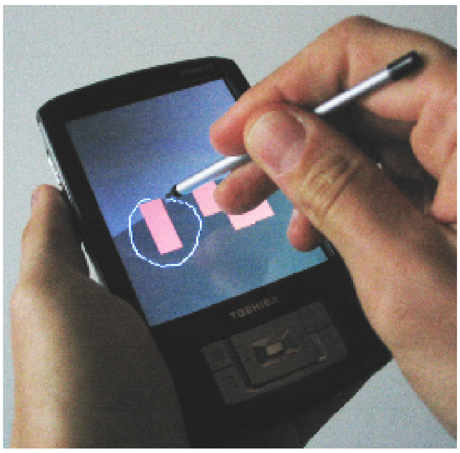


*Figure 26. Navigation within 3D Virtual Environments with different technologies*

We continue our collaboration with the archeologists from the University Bordeaux 3 - Ausonius/Archeopôle (http://www-ausonius.u-bordeaux3.fr/ and the ESTIA Engineering School.

Cultural objects of archeological findings are often broken and fractured into a large amount of fragments, and the archeologists are confronted to 3D puzzles when reassembling the fractured objects. Scanning the fragments and reassembling the corresponding 3D objects virtually is an elegant (and sometimes the only) solution. During the assembly, an efficient user interaction for the complex task to orientate or position two 3D objects relative to each other is essential. Even though fully automatic assembly methods based on pairwise matching exist, they fail when some fragments are flawed or missing. Consequently, an efficient user interaction is always required, in addition to automatic techniques.

We are studying tangible user interfaces for the efficient assembly of the 3D scanned fragments of fractured archeological objects. The key idea of the ArcheoTUI system is to use props as physical representation and control for the scanned virtual fragments. For an illustration, consider the 6 items of the set-up of the ArcheoTUI system in Figure 27. In each hand, the user manipulates a prop (items 1 and 2). The props can be freely positioned and oriented in space. For each prop, there is a corresponding foot pedal (items 3 and 4). Only when the corresponding foot pedal is pressed down, the translations and rotations are directly mapped to the corresponding virtual fragment on the display (items 5 and 6). Consequently, the user gets a sort of passive haptic feedback when manipulating the props. Once the foot pedal is released, the movement of the corresponding prop is dissociated from the virtual fragment. Hence, the position and orientation of the virtual fragment is fixed, and the hands of the user can be repositioned. This is especially useful when the user feels uncomfortable about his arm positions, or when the physical props collide with each other. Thanks to this declutching mechanism, the user can also be switched while the virtual fragments stay in position, and thus another user can propose new assembly hypothesis.

We designed the ArcheoTUI software (see Figure 6) in a direct collaboration with the archeologists. Archeo-TUI is designed to easily change assembly hypotheses, beyond classical undo/redo, by using a scene graph. We conducted a user study on site at the workplace of the archeologists. This user study revealed that the interface, and especially the foot pedal, was accepted, and that all the users managed to solve simple assembly tasks. A case study of one of their fractured archeological findings prooves the efficiency of our new tangible interface.

### *6.3.10. Augmented Reality on Mobile Devices*

**Participants:** Emilie Lalagüe, Jean-Christophe Gonzato.

During year 2007, a new research theme, augmented reality on mobility, has been created in the team. To start it efficiently, we have done a complete state of the art of this domain including work on mobile devices. This work permits to point out new research axes to explore. The document, issued during a master student training period, is a starting guide for our staff. The AR domain will be one of the major axis developped at the end of 2007 with the arriving of new collegues (Jean-Sebastien Franco).

### *6.3.11. Laser Interactor*

**Participants:** Emilie Lalagüe, Jean-Christophe Gonzato, Jean-Sebastien Franco.

In 2007, we developed a library which is able to catch efficiently a laser beam with an embedded camera om a mobile device in order to interacts with applications and to replace stylus. The laser beam could be a line or a cross. With the cross laser beam, our library retrieves its position and orientation in order to have 3 degrees of freedom. This way, we can manipulate easily on mobile devices high-resolution maps or 3D objects. With the line laser beam, our library retrieves only 2 degress of freedom. We have tested it to fly over a pseudo-infinite terrain using the laser device as a real plane flying over the terrain. Actually, we are in the phase of testing our library on standard population to proove the real utility of this type of library. The difficulty consists in finding the less cost-computing algorithm in order to be a transparent interactor of the application.

### *6.3.12. Virutal objects on real ocean*

**Participants:** Jean-Christophe Gonzato, Benoit Crespin [XLIM, University of Limoges)].

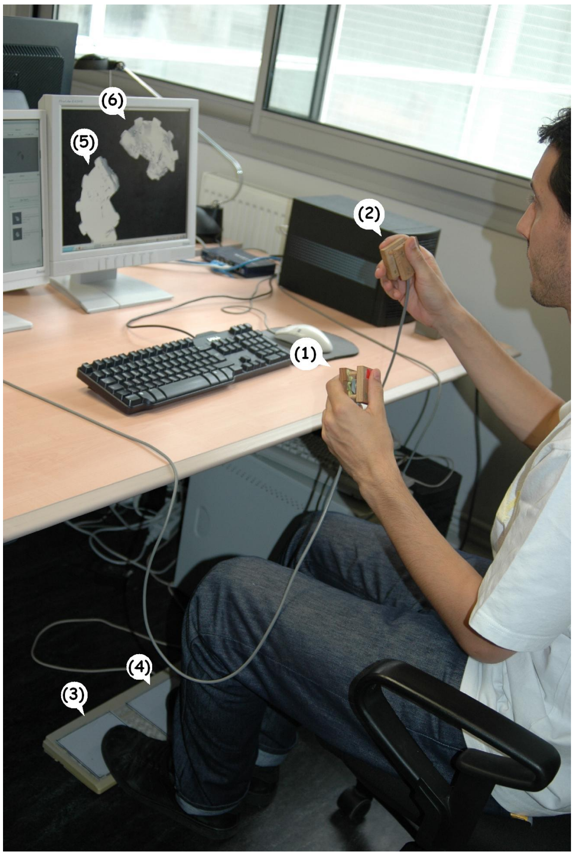



*Figure 27. Our prototype for assembling fractured objects with electromagnetic trackers. The props (items 1 and 2), the corresponding foot pedal (items 3 and 4), and the virtual fragments on the display (items 5 and 6).*

In 2006, we started a master research project (with Thomas Arcila - master student) which aim to insert virtual objects floating on a real ocean video. We restart this work in 2007 with Benoit Crespin (Xlim, University of Limoges). The first step of the work was to find a peudo-automatic algorithm to detect wave crests in order to reconstruct automatically virtual surface of waves. Our first results are quite good but our method needs to be enhanced to perform it on various type of real photo or films of ocean surfaces.

# 7. Contracts and Grants with Industry

## 7.1. France Télécom R&D

**Participants:** Audrey Legeai, Xavier Granier, Pascal Guitton, Gwenola Thomas.

**Title:** Non-photorealistic rendering dedicated to facial animation and city walkthrough.
**Dates:** 2006-2007
**Overview:** We aim at exploring Non-Photorealistic solutions for two kinds of application : "3D cities" and "virtual humans". This study includes three steps: (i) **Feature lines extraction** we propose a stroke-based representation of the objects based on their nature and the templates they are made of (3D cities or faces). This representation has to be minimal in order to save memory and ease transmission. (ii) **Feature lines structuration**. The set of feature lines is structured hierarchically to produce levels of details. (iii) **Validation**. The stroke based representations of cities and faces are efficient if recognition is possible whatever the level of detail used. We have settled some first experiments to measure the quality of matching between the reality and an NPR abstraction.

## 7.2. France Télécom R&D

**Participants:** Jerome Baril, Tamy Boubekeur, Xavier Granier, Patrick Reuter, Christophe Schlick.

**Title:** Multi-scale techniques for scalable coding of 3D representations and attributes.
**Dates:** 2005-2008
**Overview:** The goal of this project is to develop new techniques for progressive representations of point-based surfaces and their appearence properties. These methods are based on wavelet decomposition, a well-known tool to compute a space/frequency representation of a signal. Our first steps deal with the compression and transmission of Bilateral Texture Functions. This research project is the theme of a CIFRE PhD, and its results are subject to a patent. Future work is focused on point-based surfaces and how to find a good wavelet decomposition for them.

## 7.3. Immersion

**Participants:** Martin Hachet, Pascal Guitton.

**Title:** The CAT.
**Dates:** From 2004
**Overview:**

The CAT is a 6 degrees of freedom input device that has been developed to favor interaction with virtual environments displayed on large screens (see the 2004 activity report). The success of this new interface lead us to work with a company, Immersion, for the commercialization of the product. The CAT will be presented at 2007 European Research and Innovation Exhibition for the 40th anniversary of INRIA.

The design of the CAT has been registred by Inria.
**Web:** http://www.immersion.fr

# 8. Other Grants and Activities

## 8.1. International grants

### *8.1.1. Associated Team: LIGHT*

"Lab for Interactive Graphics on Handheld and Tabletop displays"
**Grant:** INRIA-DREI
**Dates:** 2004-2007
**Partners:** IMAGER Lab - University of British Columbia - Vancouver - Canada
**Overview:** LIGHT stands for "Laboratory for Interactive Graphics on Handheld and Tabletop Displays". Our goal is to investigate the different possibilities for the acquisition, the rendering and the visualization of specific or adapted representation of mobile and connected devices. We want also to develop some new interaction techniques for such devices.
**Web:** http://iparla.labri.fr/collaborations/associate/RA2007.html

## 8.2. National grants

### *8.2.1. NatSim*

**Grant:** ARA "Masse de données" (Research National Agency)
**Dates:** 2005 - 2008
**Partners:** IRIT (Toulouse 2), EVASION (Inria Rhones-Alpes), AMAP (UMR Montpellier), LIAMA (Beijing)
**Overview:** This project deals with natural simulations (vegetal, watercourses, clouds). It aims to adapt this huge amount of heterogenous data in terms of data structures, techniques and algorithms, in a unified framework to both to the content and navigation context (from mobile phones to display walls). One seminar, in Bordeaux, was organized on march 2007 on the workpackage "Streaming" of the project NatSim (12 participants).

### *8.2.2. DALIA*

**Grant:** ARA "Masse de données" (Research National Agency)
**Dates:** 2007 - 2009
**Partners:** MOAIS and PERCEPTION (Inria Rhones-Alpes), University Orléans.
**Overview:** The Dalia project focuses on visualization, interactivity and collaboration in distributed and heterogeneous environments. The goal is to study 3D collaborative/interactive applications handling large data sets.

### *8.2.3. Part@ge*

**Grant:** RNTL (Research National Agency)
**Dates:** 2007 - 2009
**Partners:** CEA-LIST, Clarte, CNRS, ESIA, France-Telecom, Haption, INRIA, INSA Rennes, Renault SAS, Sogitec, Thales, Virtools.
**Overview:** This project deals with the human - system interaction with 3D Virtual Environments in a collaborative experiment. We are involved in both visualization and interaction topics for mobility settings.

### *8.2.4. Raxenv*

**Grant:** RNTL (Research National Agency)
**Dates:** 2007 - 2009
**Partners:** BRGM, Lyonaise des eaux, Université d'Evry, Archividéo.
**Overview:** This project aims at developing an Augmented Reality (see [36]) system for outdoor use. It is based on environmental sciences and techniques (geology, water distribution ...). We are involved in both visualization and interaction topics for mobility settings.

### 8.2.5. SOUL

**Grant:** Pôle de compétitivité AESE
**Dates:** 2007-2009
**Partners:** Thalès, BeTomorrow, Axyz.
**Overview:** This project deals with control of autonomous embedded systems. We are involved in the human - system interaction for 3D Virtual Environments.

### 8.2.6. Pôle de recherche en informatique

**Grant:** Conseil Régional d'Aquitaine
**Dates:** 2005-2007
**Partners:** Sound analysis and synthesis group (LaBRI)
**Overview:** We collaborate with the sound analysis and synthesis group of our lab for the development of interfaces aiming at enhancing interaction with sounds in virtual reality setups.

# 9. Dissemination

## 9.1. Participation to the Scientific Community

### 9.1.1. Symposium co-chair

ACM VRST 2008, the conference on Virtual Reality Software and Technology (Pascal Guitton).

### 9.1.2. Program co-chair

ACM VRST 2008, the conference on Virtual Reality Software and Technology (Martin Hachet). VRIC 2008, the Virtual Reality International Conference (Pascal Guitton).

### 9.1.3. Program committee

Iparla is involved in the program committee of:

- Eurographics 2008 (Martin Hachet, Christophe Schlick),
- IEEE symposium on 3D User Interfaces 2007 & 2008 (Martin Hachet),
- NPAR 2008 (Pascal Barla),
- Eurographics Symposium on Virtual Environments 2007 (Martin Hachet),
- Virtual Reality International Conference 2008 (Martin Hachet),
- ACM conference on Virtual Reality Software and Technology 2008 (Martin Hachet),
- UBIMOB 2008 (Pascal Guitton),
- IEEE International Conference on Shape Modeling and Applications 2008 (Christophe Schlick),
- IEEE/Eurographics Symposium on Point-Based Graphics 2007 (Christophe Schlick),
- Computer Graphics Forum 2007 (Christophe Schlick),
- Association Française d'Informatique Graphique conference (Jean-Christophe Gonzato).

### *9.1.4. Reviews*

The members of Iparla have also participated to the reviewing process for conferences and journals: Conférence francophone sur l'interaction homme-machine 2007 (IHM), Parallel computing 2007, Workshop in Information Security Theory and Practices 2007 (WISTP), IEEE Virtual Reality 2007 (VR), Graphics Interface 2007 (GI), International Conference on Computer Graphics and Interactive Techniques 2007 (Graphite, sponsored by ACM Siggraph), Conférence francophone sur l'interaction homme-machine 2007 (IHM), Siggraph 2007, Eurographics 2007 & 2008, Euromicro Conference on Parallel, Distributed and Network-based Processing 2008 (PDP), Eurographics Symposium on Rendering 2007 (EGSR), IET Conference on Visual Information Engineering 2007 (VIE), Computer Graphics Forum 2007 (CGF), IEEE Visualization 2007 (Vis), Graphics Interfaces 2007 (GI), Graphics Hardware 2007 (GH, sponsored by Eurographics and ACM Siggraph), International Journal on Advances of Computer Science for Geographic Information Systems 2007 (Geoinformatica)

### *9.1.5. Committees*

In 2007, the members of Iparla have been involved in the following responsibilities: "Chargé de mission" Research by training for INRIA (Pascal Guitton), Scientific committee of INRIA Futurs (Pascal Guitton), recruitment committee for temporary engineers (Pascal Guitton), Editorial committee member for Interstices (Pascal Guitton), Correspondant europe à Bordeaux (Xavier Granier), LaBRI-Hebdo chief editor (Xavier Granier), Jury CR2 à Lilles (Xavier Granier), LIGHT associated team correspondent (Xavier Granier).

### *9.1.6. Books*

The members of Iparla have participated to books editing:

**Informatique graphique et rendu**

- Couleur - Modèles locaux d'éclairement, Ombres portées, [Xavier Granier] [17]
- Rendu par Points, [Christophe Schlick, Patrick Reuter, Tamy Boubekeur ] [19]
- Rendu réaliste - Algorithmes pour l'éclairement global, [Xavier Granier] [16]
- Rendu expressif, [Pascal Barla] [13]

**GPU Gems 3**

- Generic Adaptive Mesh Refinement [Tamy Boubekeur, Christophe Schlick] [14]

## 9.2. Teaching

The members of our team are implied in teaching computer science at University Bordeaux 1, University Bordeaux 2, University Bordeaux 3, and ENSEIRB Engineering School. General computer science is concerned, as well as the following image related topics:

- Univ. Bx 1 - Master 2 - Image Synthesis (Pascal Guitton, Xavier Granier, Julien Hadim, Jean-Sebastien Franco, Romain Pacanowski)
- Univ. Bx 1 - Master 2 - Virtual Reality (Pascal Guitton, Martin Hachet, Jean-Sebastien Franco)
- Univ. Bx 1 - Master 1 - Computer graphics projects (Romain Pacanowski)
- Univ. Bx 1 - Licence 2 - Image and Sound (Romain Pacanowski)
- IUT Bx 1 - Computer Graphics (Romain Pacanowski)
- ENSEIRB - Computer Graphics (Pascal Guitton, Joachim Pouderoux, Romain Pacanowski)
- ESTIA - Master - Graphical User Interfaces (Patrick Reuter)
- 
- Univ. Bx 1 - Master1 - Advanced object-oriented programming (Jean-Sebastien Franco)

- Univ. Bx 1 - License 3 - Networks systems (Jean-Sebastien Franco)
- Univ. Bx 1 - License 1 - Introduction to computer science (Emilie Lalagüe, Sebastian Knödel, Fabrice Decle, Jean-Christophe Gonzato)
- Univ. Bx 1 - License 2 - Computing systems (Romain Pacanowski)
- Univ. Bx 1 - Master 2 - Industrial Computer Science (Jean-Christophe Gonzato)
- Univ. Bx 2 - Licence - Computer Science (Patrick Reuter, Christophe Schlick)
- Univ. de Pau et des Pays de l'Adour - Master - Graphical User Interfaces (Patrick Reuter)
- IUT Bx 1 - Algorithmics (Romain Vergne)
- IUT Bx 1 - Network systems (Romain Vergne)
- IUT Bx 1 - Office software (Jean-Christophe Gonzato)
- IUT Bx 1 - Databases (Jean-Christophe Gonzato)
- Univ. Bx 1, 2 & 4 - Master 1 - Programmation Objet (Christophe Schlick)
- Univ. Bx 1, 2 & 4,- Master 2 - Architecture et Conception Logicielle (Christophe Schlick)
- Univ. Bx 2 - Licence 1 Introduction à l'Informatique (Christophe Schlick)

## 9.3. Participation to Conferences and Seminars, Invitations

The project members have participated to a number of international workshops and conferences (cf bibliography).

They also have been invited to seminars and conferences:

- "Visualization and 3D Interaction for mobile users", Zheiyang University, Hangzhou (Chine), March 2007
- "Quelle interaction pour les applications médicales ?", Colloque Réalité virtuelle et Handicap, CHU Bordeaux, March 2007
- "Geometric Modeling : Generation of adapted data representations", Zhejiang University, Huangzhou (China), March 2007
- "Meshless noise-insensitive surface reconstruction of scanned 3D Objects" MathESTIA Workshop (Roundtable on meshless methods), ESTIA, Bidart (France), April 2007
- "Interaction en mobilité", IRIT, Toulouse (France), June 2007
- "La recherche en réalité virtuelle", Journée Réalité virtuelle, Archéopole Pessac, September 2007

# 10. Bibliography

## Major publications by the team in recent years

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[2] T. BOUBEKEUR, C. SCHLICK. *Interactive Out-Of-Core Texturing Using Point-Sampled Textures*, in "IEEE/Eurographics Point-Based Graphics 2006", August 2006, http://iparla.labri.fr/publications/2006/BS06a.

[3] T. BOUBEKEUR, C. SCHLICK. *Approximation of Subdivision Surfaces for Interactive Applications*, in "ACM Siggraph 2007 - Sketch Program", August 2007, http://iparla.labri.fr/publications/2007/BS07b.

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[10] P. REUTER, G. RIVIERE, N. COUTURE, N. SORRAING, L. ESPINASSE, R. VERGNIEUX. *ArcheoTUI - A Tangible User Interface for the Virtual Reassembly of Fractured Archeological Objects*, in "Proceedings of VAST 2007: The 8th International Symposium on Virtual Reality, Archaeology and Cultural Heritage", Eurographics, 2007, http://iparla.labri.fr/publications/2007/RRCSEV07.

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[12] J. POUDEROUX. *Création semi-automatique de modèles numériques de terrains - Visualisation et interaction sur terminaux mobiles communicants*, Ph. D. Thesis, Université Bordeaux I, jun 2007.

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[13] P. BARLA, J. THOLLOT, G. THOMAS. *Rendu expressif*, in "Informatique graphique et rendu - Rendu expressif", Hermes Publishing, 2007, http://iparla.labri.fr/publications/2007/BTT07.

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[15] T. BOUBEKEUR, C. SCHLICK. *A Flexible Kernel for Adaptive Mesh Refinement on GPU*, in "Computer Graphics Forum", vol. to appear, 2007.

[16] X. GRANIER, M. PAULIN, B. PÉROCHE. *Rendu réaliste : algorithmes pour l'éclairement global*, Hermes Publishing, 2007, http://iparla.labri.fr/publications/2007/GPP07a.

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### Publications in Conferences and Workshops

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[23] T. BOUBEKEUR, O. SORKINE, C. SCHLICK. *Scalable Freeform Deformation*, in "ACM Siggraph 2007 - Sketch Program", August 2007, http://iparla.labri.fr/publications/2007/BSS07.

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