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Project-Team IPARLA

Computer Graphics and 3D Interaction for Mobile Users

Bordeaux - Sud-Ouest

THEME COG

Activity Report

2008

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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.

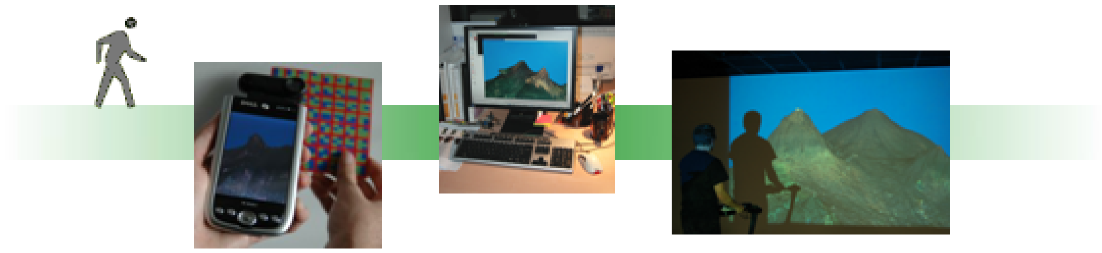


Figure 1. Visualization and Interaction with 3D Content for Mobile Users.

2.2. Highlights of the year

- Hachet et al.'s received a best paper award at the IEEE Symposium on 3D User Interfaces for their paper "Naviget for Easy 3D Camera Positioning from 2D Inputs".
- Our work in the field of expressive rendering received this year a significant international visibility with the publication of the "Diffusion Curves" and "Apparent relief" techniques at the ACM SIGGRAPH and NPAR conferences respectively.
- IPARLA organized ACM VRST in Bordeaux with Pascal Guitton as symposium co-chair and Martin Hachet as program co-chair. This conference, co-sponsored by SIGGRAPH and SIGCHI, is a major symposium in the scope of Virtual Reality. It was held in France for the first time.

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 rendering. 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, at the 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 legible rendering is more appropriate. As a consequence, expressive rendering (or 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 properties. In particular, it requires to gain insights into 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 stages 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 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.

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 it 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 refuge.

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. Elkano

Keywords: *3D visualization*, *client-server*, *framework*, *level-of-details*, *remote-rendering*, *streaming*.

Participants: Joachim Pouderoux [correspondant], Mariam Amyra, Fabrice Decle, Mickael Raynaud, Xavier Granier.

Web: http://iparla.labri.fr/software/elkano/

Elkano is a scenegraph oriented real-time 3D framework which is used to develop 3D applications, rendering and interaction techniques. Elkano is a cross platform C++ library and a set of client/server applications for Linux, Win32 and Windows Mobile. Elkano is fully scriptable through the Lua scripting language. It also 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 PCs in a virtual reality center.

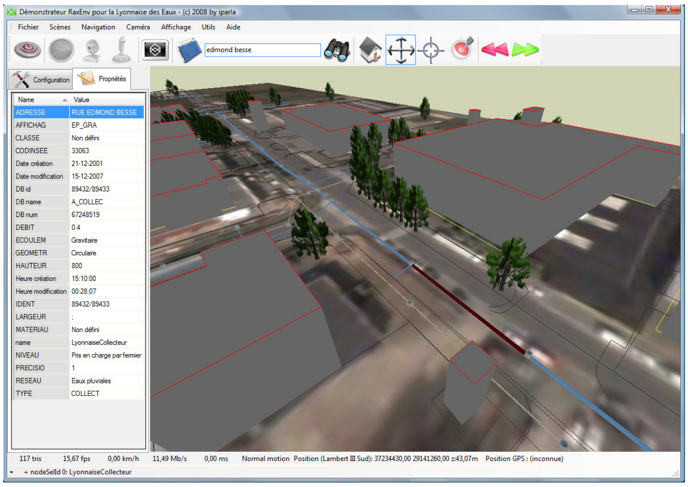


Figure 2. Real-time visualization of the underground water network of Bordeaux. An Elkano-based application developed for the ANR RaxEnv project.

Through the VRML97, X3D, Ogre scene 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) are supported. Objects animation, physical engine, light sources management, shadows and GPU buffer objects support were recently introduced.

Elkano is used in many work and projects of Iparla: NatSim, RaxEnv, Partage, Dahlia, etc.

5.2. Osiris

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

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

Web: http://iparla.labri.fr/software/osiris/

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. Visualization 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).

5.3. CEMO

Keywords: *Sketch-based modeling*.

Participants: Xavier Granier, Zhang Zhongxin [Zheijang University].

Cemo is a framework for sketch-based 3D modeling. First issued from the work of Dr Zhang Zhongxin from the State Key Lab of CAD&CG (Zheijang University - Hangzhou - China), it is now a common development platform for research in 3D modeling through sketching. This research is part of the Bird Associated team (Bunraku - IPARLA - State Key Lab of CAD&CG).

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

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

Participant: Joachim Pouderoux [correspondant].

Web: http://www.autodem.com/

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 2.800 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.

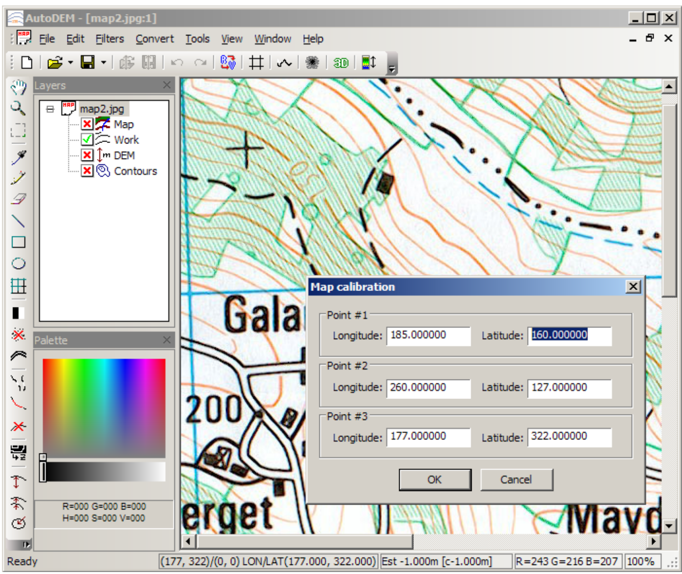


Figure 3. AutoDEM graphical user interface.

5.5. MRF - Mallia Rendering Framework

Keywords: *GPU*, *Rendering*, *framework*, *global illumination*, *ray-tracing*.

Participants: Romain Pacanowski [correspondant], Mickael Raynaud, Xavier Granier, Vincent Lebret-Soler.

The Mallia Rendering Framework (aka MRF) is a framework library for the development of rendering algorithms. MRF has been used to develop several high quality software rendering applications like a Ray Tracer (marat), a Path-Tracer (manioc, see Figure 4) and also hardware rendering applications using GPU. MRF is a cross platform C++ library for Linux and Win32.

Figure 4. A scene rendering with manioc, a path-tracer.

5.6. ArcheoTUI

Keywords: *Culture heritage*, *Reassembly of fractured archeological objects*, *Tangible user interfaces*.

Participant: Patrick Reuter [correspondant].

ArcheoTUI is a software for the virtual reassembly of fractured archeological objects via tangible interaction with foot pedal declutching. 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. In 2008, we enhanced the ArcheoTUI software to support the pushing of buttons on the props. Pressing a button on a prop has exactly the same effect like pressing down the corresponding foot pedal, that was already present in former version of the software.

5.7. Cutdget

Keywords: *Cutaway*, *Expressive Rendering*, *Sketch based Interaction*.

Participants: Sebastian Knoedel [correspondant], Martin Hachet.

Cutget is a system allowing the user to create appealing illustrative cutaway renderings. It uses simple sketch based interaction techniques combined with smart widgets and illustrative rendering techniques. Since CAD models are becoming more and more complex, there is a request for special visualization and interaction techniques that allow the user to discover the model in a simple way. To do so our system lets the user create individual cutaway views to expose hidden objects. In addition, the adjacent geometry is rendered in a transparent way to underline the affiliation to the object in focus. Moreover the silhouettes of the geometry that was removed by the cut will be emphasized to preserve the original context of the object.

5.8. ARK - Adaptive Refinement Kernel

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

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 substitute 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 the 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 functions, 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 strength 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.

5.9. GLUT|ES - The OpenGL|ES Utility Toolkit

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

Participant: Joachim Pouderoux [correspondant].

Web: http://glutes.sourceforge.net/

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 5.

GLUT|ES homepage, which is hosted on SourceForge.net since 2006, has been visited by more than 25.000 people all around the world and downloaded more than 7.000 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.

6. New Results

6.1. Modeling

6.1.1. Modeling and Interaction from Silhouettes

Participants: Jean-Sébastien Franco, Benoit Bossavit, Li Guan, Marc Pollefeys, Edmond Boyer, Benjamin Petit, Jean-Denis Lesage.

Figure 5. A sample application based on GLUT|ES running on a Smartphone and a PocketPC.

We provided several new developments and formulations to deal with the problem of fast modeling from silhouettes acquired from multiple calibrated videos, in indoor, outdoor, and occluded scenes. First, previous work on purely geometric silhouette-based modeling (EPVH software developed at INRIA Rhone-Alpes with Edmond Boyer) was consolidated, with a deeper analysis, algorithmic study and broad results in a PAMI publication [13] (see figure 6). The method has been applied and demonstrated in VRST 2008 for multi-platform real-time 3D telepresence (financed by the DALIA project grant, with Benoit Bossavit, Benjamin Petit, Jean-Denis Lesage, and Edmond Boyer). Second, several new techniques and application fields for Bayesian multi-silhouette fusion and modeling were explored during ongoing collaborations with Li Guan (UNC Chapel Hill) and Marc Pollefeys (ETH Zürich), using a probabilistic voxel occupancy grid as methodology and scene representation. In particular, we have shown that multiple people can be robustly tracked (with state-of-the-art results) and their shape probabilistically represented in the context of difficult outdoor scenes as well as mutual and static scene occlusions (CVPR 08 publication [21], see figure 6). In another work we show the well-suited nature of Bayesian occupancy grids for multi-modal image-based information integration, by providing a framework and results for the fusion of silhouette cues and depth images obtained from both regular and time-of-flight depth cameras (3DPVT 08 publication [20], see figure 7). Finally we have comprehensively compiled and consolidated previous work on Bayesian occupancy grids and occlusion reasoning in chapters of an accepted Elsevier book, "Multi-Camera Networks: Concepts and Applications".

6.1.2. Diffusion Curves

Participants: Alexandrina Orzan, Adrien Bousseau, Holger Winnemöller, Pascal Barla, Joëlle Thollot, David Salesin.

We developed a new vector-based primitive for creating smooth-shaded images, called the diffusion curve [16]. A diffusion curve partitions the space through which it is drawn, defining different colors on either side. These colors may vary smoothly along the curve. In addition, the sharpness of the color transition from one side of the curve to the other can be controlled. Given a set of diffusion curves, the final image is constructed by solving a Poisson equation whose constraints are specified by the set of gradients across all diffusion curves. Like all vector-based primitives, diffusion curves conveniently support a variety of operations, including geometry-based editing, keyframe animation, and ready stylization. Moreover, their representation is compact and inherently resolution-independent. We describe a GPU-based implementation for rendering images defined by a set of diffusion curves in realtime. We then demonstrate an interactive drawing system for allowing artists

(a) (b)

Figure 6. (a) Exact polyhedral visual hull modeling results for two complex multi-view datasets. (b) Result of tracking 2 people and modeling both their shape and the shape of a static occluder from 9 calibrated silhouettes sequences, in a difficult outdoor setup.

Figure 7. Result of modeling a multi-person scene from the silhouettes obtained from 3 calibrated views and a calibrated depth camera.

to create artworks using diffusion curves, either by drawing the curves in a freehand style (see Figure 8), or by tracing existing imagery. The system is simple and intuitive: we show results created by artists after just a few minutes of instruction. Furthermore, we describe a completely automatic conversion process for taking an image and turning it into a set of diffusion curves that closely approximate the original image content.

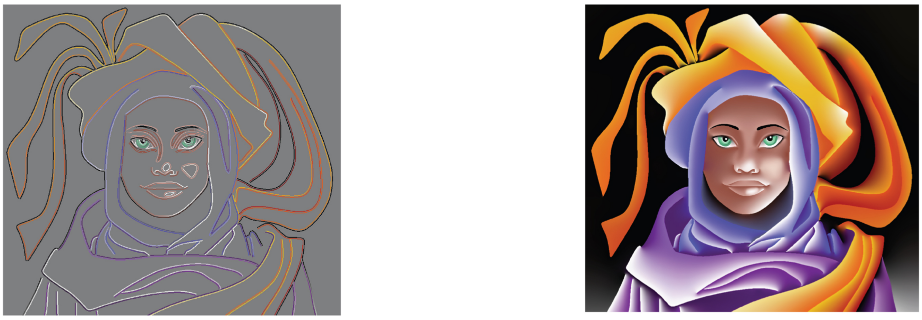


Figure 8. Diffusion curves (left), and the corresponding color image (right). Note the complex shading on the folds and blur on the face..

6.1.3. Sketch and Paint-based Interface for Highlight Modeling

Participants: Romain Pacanowski, Xavier Granier, Christophe Schlick.

In computer graphics, highlights capture much of the appearance of light reflection off a surface. They are generally limited to pre-defined models (e.g., Phong, Blinn) or to measured data. We are working on new tools and a corresponding BRDF model to provide computer graphics artists a more expressive approach to design highlights. A first solution [26] has been presented, based on intuitive sketching and painting techniques, and a GPU-compatible representation for interactive changes. The next steps would lead to the development of a simple control for plausible BRDFs.

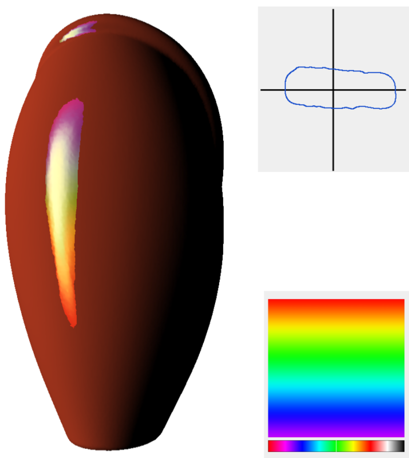


Figure 9.

6.1.4. 2D Shape Interpolation

Participants: William Baxter, Pascal Barla, Ken Anjyo.

Rigid Shape Interpolation Using Normal Equations. We developed a new compact formulation of rigid shape interpolation in terms of normal equations, and proposed several enhancements to previous techniques, with a focus on 2D shape animation [17]. Specifically, we proposed 1) a way to improve mesh independence, making the interpolation result less influenced by variations in tessellation, 2) a faster way to make the interpolation symmetric, and 3) simple modifications to enable controllable interpolation (see Figure 10). Finally we also identified 4) a failure mode related to large rotations that is easily triggered in practical use, and we present a solution for this as well.

Compatible Embedding for 2D Shape Animation. We developed new algorithms for the compatible embedding of 2D shapes [11]. Such embeddings offer a convenient way to interpolate shapes having complex, detailed features. Compared to existing techniques, our approach requires less user input, is faster, more robust, and simpler to implement, making it ideal for interactive use in practical applications. Our novel approach consists of three parts. First, our boundary matching algorithm locates salient features using the perceptually-motivated principles of scale-space and uses these as automatic correspondences to guide an elastic curve matching algorithm. Second, we simplify boundaries while maintaining their parametric correspondence and the embedding of the original shapes. Finally, we extend the mapping to shapes' interiors via a new compatible triangulation algorithm. The combination of our algorithms allowed us to demonstrate 2D shape interpolation with instant feedback. The proposed algorithms exhibit a combination of simplicity, speed, and accuracy that has not been achieved in previous work (see Figure 11).

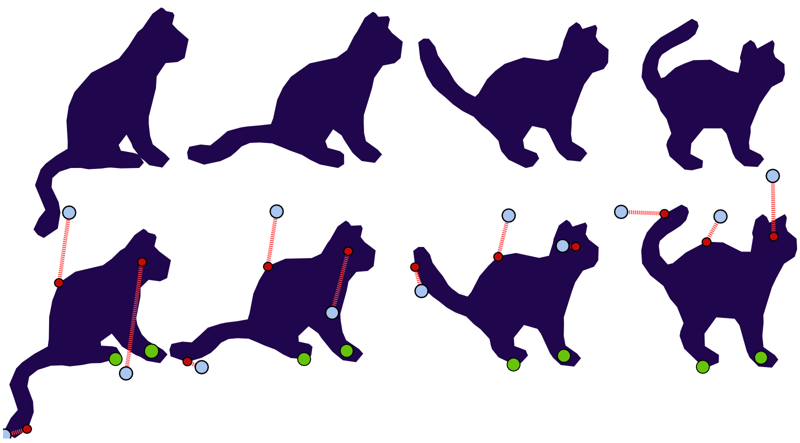


Figure 10. Previous rigid interpolation techniques were black-boxes. No means of influencing the resulting interpolation was available. The original sequence (top) was modified using a combination of the hard (green) and soft (blue) constraints, resulting in the bottom sequence.

6.1.5. Multi-Layer Level of Detail for Character Animation

Participants: Yann Savoye, Alexandre Meyer.

Real-time animation of human-like characters has been an active research area in computer graphics. Nowadays, more and more applications need to render various realistic scenes with human motion in crowds for interactive virtual environments. Animation and level of detail are well explored fields but little has been done to generate level of detail automatically for dynamic articulated meshes. We developed an approach [29] based on the combination of three interesting layers for run-time level of detail in character crowd animation: the

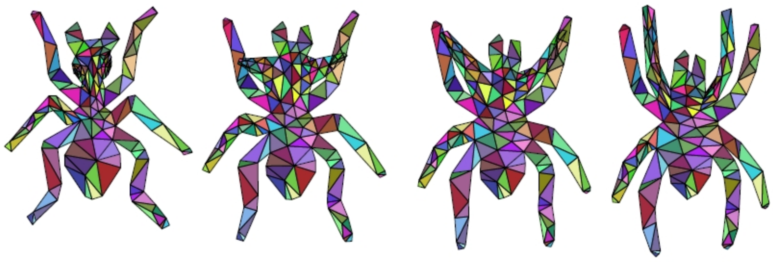


Figure 11. Thanks to our new algorithms, compatible triangulation can be carried out even on highly different shapes requiring extreme stretching. Here, turning an ant into a spider requires letting legs grow out of its head, and yet the triangulation does not exhibit any foldover. Moreover, matching both shapes required the specification of only 5 manual boundary correspondences, and no interior correspondence; And the initial tessellation (before) refinement required only 3 additional internal vertices.

skeleton, the mesh and the motion. We build a Multiresolution Skeletal Graph to simplify the skeleton topology progressively. In contrast to previous works, we used a Dual-Graph Based Simplification for articulated meshes, where the triangle decimation is driven by triangle compactness, to build a dynamic, continuous, progressive and selective mesh level of detail. We also presented Power Skinning to ensure the stability of Linear Smooth Skinning, during the simplification, with an efficient multi-weight update rule.

6.1.6. A Flexible Adaptive Real-Time Refinement Kernel for Meshes

Participants: Tamy Boubekeur, Christophe Schlick.

We developed a flexible GPU kernel for adaptive on-the-fly refinement of meshes with arbitrary topology [12] (Figure 12). 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 instantiate 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.

6.1.7. Virtual objects on real ocean

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

In 2006, we started a research project aiming at the insertion of virtual objects floating on a real ocean video. This work has been amplified in 2007, with the collaboration of Benoit Crespin (Xlim, University of Limoges). In [19], we presented a quasi-automatic algorithm to detect wave crests in order to reconstruct automatically virtual surface of waves. This algorithm is easily manageable by a non-expert user. 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 for different mobile uses.

6.2. 3D Data Rendering and Visualization

6.2.1. Apparent Relief

Participants: Romain Vergne, Pascal Barla, Xavier Granier, Christophe Schlick.

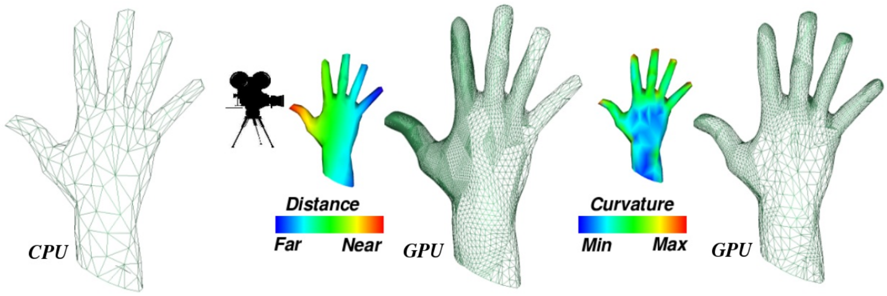


Figure 12. Generic tag-based adaptive refinement control.

Shape depiction in non-photorealistic rendering of 3D objects has mainly been concerned with the extraction of contour lines, which are generally detected by tracking the discontinuities of a given set of shape features varying on the surface and/or the picture plane. In this work, we investigated another approach: the depiction of shape through shading [30]. This technique is often used in scientific illustration, comics, cartoon animation and various other artwork. A common method consists in indirectly adapting light positions to reveal shape features; but it quickly becomes impractical when the complexity of the object augments. In contrast, our approach is to directly extract a set of shape cues that are easily manipulated by a user and re-introduced during shading. The main problem raised by such an approach is that shape cues must be identified in a continuous way in image space, as opposed to line-based techniques. Our solution is a novel view-dependent shape descriptor called Apparent Relief, which carries pertinent continuous shape cues for every pixel of an image (see Figure 13-left). It consists of a combination of object- and image-space attributes. Such an approach provides appealing properties: it is simple to manipulate by a user, may be applied to a vast range of styles (see Figure 13, middle and right), and naturally brings levels-of-detail functionalities. It is also simple to implement, and works in real-time on modern graphics hardware.

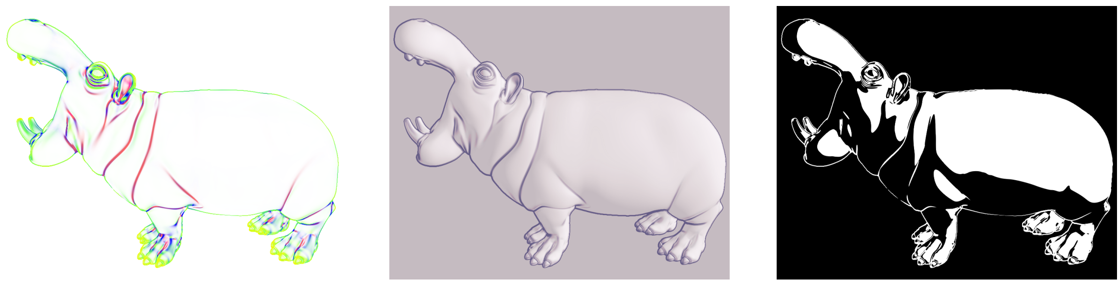


Figure 13. Starting from a 3D model, we extract our view-dependent shape descriptor (left). We then manipulate shading based on continuous shape cues selected using the descriptor, and create various styles such as cartoon shading (middle), and minimal shading (right).

6.2.2. New parameterizations for Bidirectional Texture Functions

Participants: Jérôme Baril, Julien Hadim, Xavier Granier, Christophe Schlick.

Obtaining highly-realistic materials in computer graphics is computationally and memory demanding. Currently, the most accurate techniques are based on Bidirectional Texture Functions (BTFs), an image-based approximation of appearance. Extremely realistic images may be obtained with BTFs but the price to pay is to handle a huge amount of data. We are working on a new compressions schemes called *Polynomial Wavelet Trees for Bidirectional Texture Functions* [34] that separate directional and spatial variations by projecting the spatial BTF domain (i.e., the light-dependent textures) onto a wavelet basis and to approximate these light-dependent wavelet coefficients with a polynomial function.

With the data size, the other main challenge arises from the fact that a BTF embeds many different optical phenomena generated by the underlying meso-geometry (parallax effects, masking, shadow casting, inter-reflections, etc.) that can only be correctly handled by using appropriate approaches. We are working on a new representation for the BTF that isolates parallax effects from other effects stored in the BTF. All the developed techniques are well-suited for real-time rendering on GPUs.

6.2.3. Lighting structure for global illumination on complex geometries

Participants: Romain Pacanowski, Mickael Raynaud, Xavier Granier, Patrick Reuter, Christophe Schlick.

Computing and storing the lighting due to inter-reflections on very detailed 3D objects is tied to the complexity of the geometric definition. We are working on the development on new vectorial representations, and associated pre-processing and on-line rendering techniques, that can decorrelate the geometry from the indirect lighting. This decorrelation and the consequent geometric robustness has been validated for the streaming of complex illuminated geometries [27] and for hybrid representation of 3D objects, based on simplified mesh and normal mapping for preserving the original details [28]. For better efficiency, some work still needs to be done to reach faster precomputation and more accurate representation with the development of a new direction basis.

6.3. 3D User interfaces

6.3.1. Naviget

Participants: Martin Hachet, Fabrice Decle, Sebastian Knoedel, Pascal Guitton.

http://www.labri.fr/perso/hachet/publications/navidget.html

Navidget is a new interaction technique for camera positioning in 3D environments (Figure 14). This technique derives from the Point-of-Interest (POI) approaches where the endpoint of a trajectory is selected for smooth camera motions. Unlike the existing POI techniques, Navidget does not attempt to automatically estimate where and how the user wants to move. Instead, it provides good feedback and control for fast and easy interactive camera positioning. Navidget can also be useful for distant inspection when used with a preview window. This new 3D User interface is totally based on 2D inputs. As a result, it is appropriate for a wide variety of visualization systems, from small handheld devices to large interactive displays. A user study on TabletPC shows that the usability of Navidget is very good for both expert and novice users. This new technique is more appropriate than the conventional 3D viewer interfaces for some camera positioning tasks in 3D environments [22].

An extended version of our preliminary publication has been published in [14]. In this extended paper, we show that, in addition to camera positioning tasks, the Navidget approach can benefit to the user for further tasks such as collaborative work and animation.

Finally, in [24], we show how the Navidget approach can be used in immersive virtual environments (VE). By moving a virtual ray, the immersed users select destinations in the VE. This allows them to navigate in the VEs easily.

With Navidget, we have shown that the same user interface can be used from mobile devices to immersive virtual environments. Such approaches, which enhance the mobility of users, are at the heart of the motivations of the Iparla project-team.

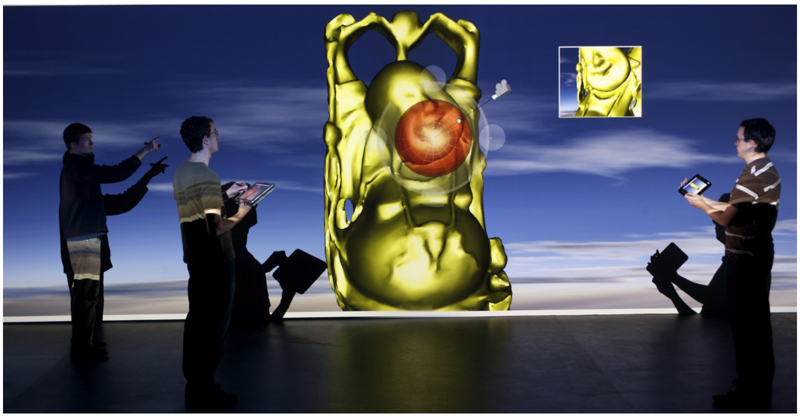


Figure 14. Navidget for 3D camera positioning from handheld devices to large screens.

6.3.2. 3D Elastic Control for Mobile Devices

Participants: Martin Hachet, Joachim Pouderoux, Pascal Guitton.

To increase the input space of mobile devices, we developed a proof-of-concept 3D elastic controller that easily adapts to mobile devices. This embedded device improves the completion of high-level interaction tasks such as visualization of large documents and navigation in 3D environments (Figure 15). It also opens new directions for tomorrow's mobile applications [15].

6.3.3. 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 have investigated the influence of elastic feedback to enhance user performance in rate controlled interaction tasks (Figure 15). We conducted an experiment, which proves evidence that elastic feedback, given to input movements with the pen, provides better control for 3D travel tasks [23].

6.3.4. ArcheoTUI - Tangible user interfaces for the Virtual Reassembly of Fractured Archeological Objects

Participants: Patrick Reuter, Loïc Espinasse, Nadine Couture, Guillaume Rivière.

We extended the ArcheoTUI system that was designed for the virtual reassembly of fractured archeological objects.

We enhanced the ArcheoTUI system by putting buttons on the props. Pressing a button on a prop has exactly the same effect like pressing down the corresponding foot pedal. Since the Polhemus Liberty system used in ArcheoTUI does not provide buttons on the props, we rigged up a regular mouse device by soldering on two cables in order to use the left and right mouse buttons on the props (see Figure 17).

We conducted an additional user study in order to evaluate the user performance of the foot pedal declutching mechanism compared to the button declutching mechanism. This second user study revealed that the movement of the hands is more similar to real-world assembly scenarios when using the foot pedals, and that the users can keep on concentrating on the actual assembly task.

Figure 15. (a) 3D elastic control on a PDA for exploration of virtual cities. (b) 3D elastic control device on a PDA.

6.3.5. GeoTUI - Improving Tangible Interaction for Geosciences

Participants: Patrick Reuter, Nadine Couture, Guillaume Rivière.

GeoTUI [18] is a system designed for geologists. It uses props as tangible user interfaces on a tabletop vision-projection system in order to select cutting planes on a geographical map of a subsoil model. Our GeoTUI system allows the geologists to manipulate in the same action and perception space since the movement of the physical artifacts is done on the tabletop and thus constrained to two dimensions. Consequently, it combines the advantages of the spontaneous conditions of user interaction that the geologists are commonly used to in their classical paper/pen/ruler environment with the advantages of the use of powerful geological simulation software. We conducted an extensive user study in the workplace of the geologists that clearly revealed that using a tangible interaction performs better than using classical mouse/keyboard and GUI for the cutting line selection task on a geographic subsoil map. Consequently, it increases the efficiency for the real-world trade task of hypothesis validation on a subsoil model. Moreover, this geological user case is complex enough to confirm the hypothesis that in space-multiplex conditions, specialized devices perform better than generic ones.

6.3.6. 3D Sketching for Large Displays

Participants: Xavier Granier, Hongxin Zhang, Julien Hadim.

Sketching, as an intuitive tool for creation and edition of 3D prototypes, is a topic of increasing interest. These approaches are based on the natural ability of humans to quickly draw in 2D some characteristic curves of 3D objects. Unfortunately, some 3D modeling operations - like positioning different components - and the modeling in front of large displays have still not reached the same ease of use in sketching systems. The main difficulty is to leverage the intuitive 2D gesture abilities of humans and lift them to 3D operations. We have developed a new approach [31], based on a virtual 3D paper sheet metaphor and the use of a 6 degrees of freedom (DOF) device, the CAT.

6.3.7. 3D interaction for music

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

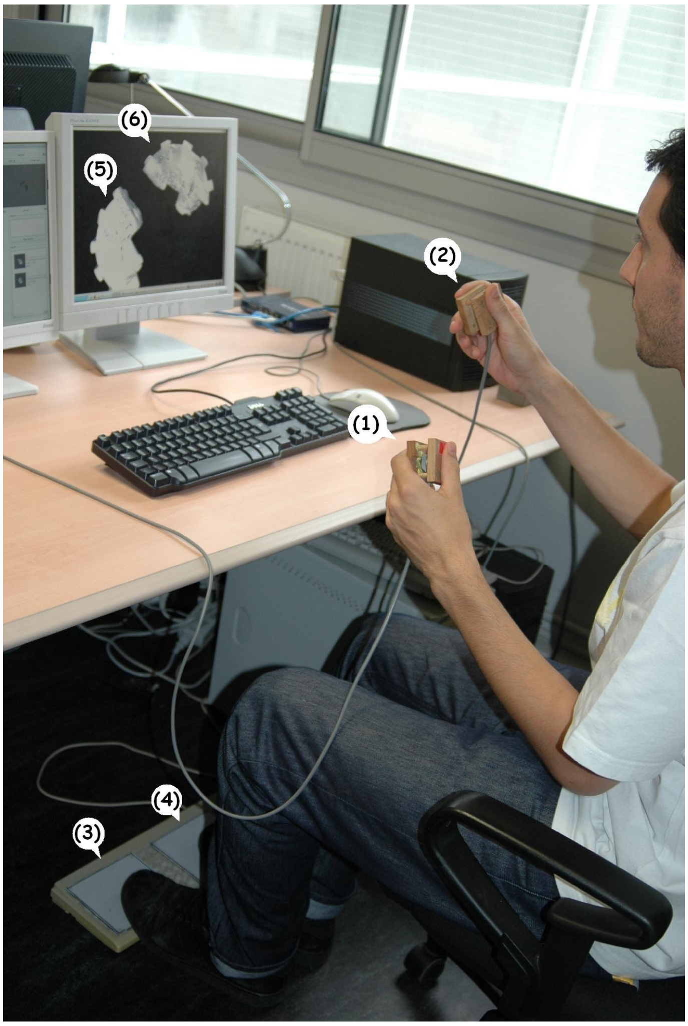
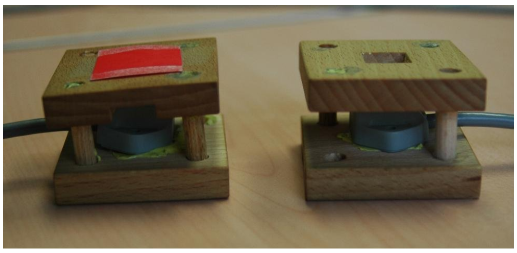
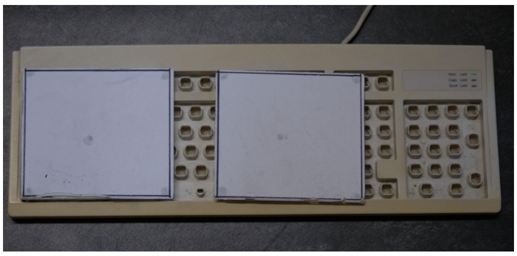


Figure 16. The ArcheoTUI user interface.



(a) The props.



(b) The foot pedals.

Figure 17. The props and the associated foot pedals.

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 [32].

6.3.8. Visualization and Interaction with Mobile Technology

Participants: Knoedel Sebastian, Hachet Martin, Pascal Guitton.

Our research in Mobile HCI concerns the exploration of new interaction and visualization techniques for 3D data on mobile devices as we present in [25]. Furthermore, we want to examine new forms of collaboration supporting groups of people, who interact together with diverse data using heterogeneous hardware, from small mobile devices to large projection screens. Hence, in our investigations we propose adapted visual representations and efficient interaction techniques that take in account the human factor, as well as technical terms of mobile technology.

6.3.9. Touch screens for 3D Manipulation

Participants: Fabrice Decle, Martin Hachet.

Manipulation is a complex task in 3D applications. We are investigating how to use touch screens to achieve such a task. These devices benefit from several features that differ from the use of a mouse. The main benefit is that the finger is co-located with the cursor. We are studying how to use such features for manipulating 3D entities. In particular, we are studying the benefits of multi-touch devices for 3D manipulation.

7. Contracts and Grants with Industry

7.1. 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 appearance 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 Bidirectional 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.

7.2. SC2X

Participant: Fabrice Decle.

Title: Online 3D Visualisation and Simulation
Dates: 2008
Overview: SC2X is a French video games and simulation company. This contract consists in a *doctoral consultant*. Its general purpose is the creation of online 3D softwares. Rendering 3D contents on the web is still an issue, as there are several different engines available. Moreover, most of them require a manual and error prone installation, which can disturb some novice users. Therefore, we focused on the development of a 3D graphics engine based on the Abode Flex technology.

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 has been presented at 2007 European Research and Innovation Exhibition for the 40th anniversary of INRIA.

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

8. Other Grants and Activities

8.1. International grants

8.1.1. Associated Team: Bird

"Interactions entre les mondes Réels et Virtuels / Interactions between Real and Virtual Worlds"
Grant: INRIA-DREI
Dates: 2008-2011
Partners: Bunraku - IRISA - Rennes and State key Lab of CAD&CG - Zheijang University - Hangzhou - China
Overview: The main purpose of this collaboration is to provide new tools for managing the interaction between real and virtual worlds. We first want to ease the interaction between real users and virtual worlds during modeling and collaborative tasks. Concerning generation of virtual worlds, we will focus not on fully automatic solutions, but on semi-automatic ones that will take into account human decisions. This integration of the user is essential to provide intuitive processes and better immersion. Based on the different interfaces between virtual and real world (from a simple stylus to a set of cameras), we have to capture accurately the motions, the gestures, and to interpret the intentions of humans, in order to correctly integrate these actions and intentions.
Web: http://www.irisa.fr/prive/donikian/EA/

8.2. National grants

8.2.1. NatSim

Grant: ARA "Masse de données" (Research National Agency)
Dates: 2005 - 2008
Partners: IRIT (Toulouse 3), EVASION (Inria Rhones-Alpes), Virtual Plants (INRIA joined with CIRAD and INRA), LIAMA (Beijing)
Overview: This project deals with natural simulations (vegetation, watercourses, clouds). It aims to adapt this huge amount of heterogeneous 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). The final presentation of NatSim project was done at ANR on December 2008. This project permits to exchange expertise with other french labs and permits to create new collaborations. The main collaborations of IPARLA members into the NatSIM project took place into 4 workpackages : Edition and manipulation of big amount of data, Rendering, Animation and Streaming.

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 [39]) 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. Animaré

Grant: ANR Jeune Chercheur (Research National Agency)
Dates: 2009 - 2012
Partners: ARTIS (INRIA Rhone Alpes)
Overview: Expressive Rendering is a recent branch of Computer Graphics that offers promising novel styles, and is increasingly used in many application domains such as video games or movie production. At the present time, only expert artists are able to create compelling animations, and still, this is an extremely time-consuming process, with many constraints that strongly limit creativity. The reason is that current models are not sophisticated enough to provide intuitive manipulations and versatile styles. The motivation behind this project is to overcome these limitations both for 2D and 3D animation systems.

8.2.7. Pôle de recherche en informatique

Grant: Conseil Régional d'Aquitaine
Dates: 2008-2010
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. Conference organisation

- ACM VRST 2008, the conference on Virtual Reality Software and Technology, October 27-29 (http://vrst2008.labri.fr/). 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.
- AFRV 2008, the conference of the Association Française de Réalité Virtuelle, October 30-31 (http://afrv2008.labri.fr/).

9.1.2. Symposium co-chair

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

9.1.3. 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)

9.1.4. Program committee

Iparla is involved in the program committee of:

- Computer Graphics Forum 2008 (Christophe Schlick),
- Eurographics 2008 & 2009 (Martin Hachet, Christophe Schlick),
- Eurographics Sketch-Based Interfaces and Modeling Graphics (SBIM) 2008 (Xavier Granier),
- Graphics Interface (GI) 2008 & 2009 (Xavier Granier),
- IEEE International Conference on Shape Modeling and Applications 2008 & 2009 (Christophe Schlick),
- IEEE Symposium on 3D User Interfaces 2008 & 2009 (Martin Hachet),
- IEEE/Eurographics Symposium on Point-Based Graphics 2008 (Gael Guennebaud),
- NPAR 2008 & 2009 (Pascal Barla),
- UBIMOB 2008 & 2009 (Pascal Guitton),
- CAD/Graphics 2009 (Pascal Guitton),
- COLIBRI 2009 (Pascal Guitton)
- Virtual Reality International Conference 2008 (Martin Hachet),
- Best paper jury of the Association Française d'Informatique Graphique (AFIG) conference (Jean-Christophe Gonzato, Xavier Granier, Gaël Guennebaud).

9.1.5. Reviews

The members of Iparla have also participated to the reviewing process for conferences and journals:

- **Books:** book project for Morgan Kaufmann editor.
- **Journals:** Int. J. Human-Computer Studies, The Visual Computer, Pattern Analysis and Machine Intelligence (PAMI), Computer Vision and Image Understanding (CVIU), Signal Processing Letters, IEEE Computer Graphics & Applications, Recent Patents on Computer Science.
- **Conferences:** Siggraph 2008, Eurographics 2009, Siggraph Asia 2008, IEEE Visualization 2008, Eurographics Symposium on Rendering 2008 (EGSR), CHI 2009, Distributed and Network-based Processing 2008 (PDP), European Conference on Computer Vision (ECCV) 2008, Computer Vision and Pattern Recognition (CVPR) 2009, 3D Processing, Visualisation and Transmission (3DPVT) 2008, Graphics interface (GI) 2008.

9.1.6. Committees

In 2008, the members of Iparla have been involved in the following responsibilities:

- INRIA - Young Researchers Mission (Pascal Guitton)
- INRIA - COPIL Management member (Pascal Guitton)
- INRIA - New web project (Pascal Guitton)
- INRIA Bordeaux - commission for young researchers (Pascal Guitton)
- INRIA Bordeaux - commission for new building (Pascal Guitton)
- INRIA Bordeaux - local center committee (Pascal Guitton)
- INRIA Bordeaux - commission for technological development (Martin Hachet)
- INRIA Bordeaux - Administrative Staff Recruitment Committee (Pascal Guitton)
- INRIA Rennes - CR2 Recruitment Committee (Pascal Guitton)
- Interstices - Editorial committee member (Pascal Guitton)
- Fuscia - Editorial committee member (Pascal Guitton)
- AERES - Expert committee member of the LSIIT Strasbourg quadriennal evaluation (Christophe Schlick)
- Jury member of the 24hours of innovation, ESTIA, Bidart, France (Patrick Reuter)
- Co-treasurer and executive board member of the AFIG (Jean-Christophe Gonzato)
- Executive board member of the AFRV (Pascal Guitton)

9.1.7. Jury of PhD thesis

- T. Jehaes, Hasselt (Belgique) EDM February 22 - C. Dehais, Toulouse IRIT May 21 - S. Gerbaud, Rennes IRISA October 1st - M. Dodo, Toulouse IRIT November 6 - D. Van Der Haeghe, Grenoble LIG November 24 - S. Horna, Poitiers SIC November 27 - F. Lotte, Rennes IRISA December 4 - V. Vivanloc, Toulouse IRIT Decembre 18 - W. Abou Moussa, Toulouse IRIT 18 December - P. Qing, Lille LIFL December 19 (Pascal Guitton)
- Dominique Sobczyk, LIA Paris January 2008 - Emmanuelle Darles, XLIM Limoges October 2008 - Julien Lacoste, LIUPPA Pau December 2008 - V. Forest, Toulouse IRIT December 16 (Christophe Schlick)
- P. P. Estalella, University of Barcelona December 19 (Xavier Granier)

9.1.8. Jury of HDR

- D. Meneveaux, Poitiers SIC March 27 - J. Thollot, Grenoble LIG Novembre 24 (Pascal Guitton)

9.1.9. Expertises

The expertise of some members has been required for some projects:

- Projets recherche région Rhone-Alpes
- Dossier Jeune Entreprise innovante DRRT Pays de la Loire

9.1.10. Demos

- "3D User interfaces and computer graphics", Ville Européenne des Sciences, Paris 13-15 November 2008
- "Grimage: Remote 3D Interactions", Symposium on Virtual Reality Software and Technology (VRST), Bordeaux 27-29 October 2008
- "ArcheoTUI: Tangible interaction with foot pedal declutching for the virtual reassembly of fractured archeological objects", Symposium on Virtual Reality Software and Technology (VRST), Bordeaux 27-29 October 2008

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 graphics related topics:

- Univ. Bx 1 - Master 2 - Image Synthesis (Pascal Guitton, Xavier Granier, Julien Hadim, Jean-Sébastien Franco, Romain Pacanowski)
- Univ. Bx 1 - Master 2 - Virtual Reality (Pascal Guitton, Martin Hachet, Jean-Sébastien Franco)
- Univ. Bx 1 - Master 1 - Computer graphics projects (Romain Pacanowski)
- Univ. Bx 1 - License 3 - Introduction to Image Processing (Jean-Sébastien Franco)
- Univ. Bx 1 - Licence 2 - Image and Sound (Romain Pacanowski)
- IUT Bx 1 - Computer Graphics (Romain Vergne, Romain Pacanowski)
- Cognitive Science Engineering School - Virtual Reality (Martin Hachet)
- ESTIA - Master - Graphical User Interfaces (Patrick Reuter)
- ENSEIRB - Computer Graphics (Pascal Guitton, Romain Pacanowski)

Some members are also in charge of some fields of study:

- IUT Bx 1 - License 1 GACO (Jean-Christophe Gonzato)

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:

Conferences:

- "Dynamic ERIMA conference program - How to better manage parallel sessions", ERIMA 08 - European Symposium on Innovative Management Practices, Porto (Portugal), 5th November 2008 (Patrick Reuter)
- "ArcheoTUI - A Tangible User Interface for the Virtual Reassembly of Fractured Archeological Objects", ODENT Meeting - Interdisciplinary Workshop on 3D Paleo-Anthropology, Anatomy, Computer Science & Engineering, Museum of Toulouse, Toulouse (France), 20th July 2008 (Patrick Reuter)
- "Apparent Relief: a shape descriptor for stylized shading", ODENT Meeting - Interdisciplinary Workshop on 3D Paleo-Anthropology, Anatomy, Computer Science & Engineering, Museum of Toulouse, Toulouse (France), 20th July 2008 (Romain Vergne)

Seminars:

– “3D User Interfaces - from immersive environments to mobile devices”, INRIA Sophia Antipolis, March 2008 (Martin Hachet)
– “Informatique 3D et Archeologie - Une échange bidirectionnelle ? ”, Centre d’Etudes Alexandrines (CNRS USR 3134), Alexandrie (Egypt), 27th Octobre 2008 (Patrick Reuter)
– “Silhouette-based 3D Modeling for Interaction”, Zheijang University, Hangzhou (China), 27th August 2008 (Jean-Sébastien Franco)
– “Vision for modeling and 3D interaction”, Vision Show Invited Presentation (organized by I2S), Paris (France), 1st October 2008 (Jean-Sébastien Franco)
– “3D Computer Graphics for mobile users”, Seminar of the Beijing Normal University, Pékin, 10th July 2008 (Pascal Guitton)
– “3D Computer Graphics for mobile users”, Seminar of the North West University, Xian, 14th July 2008 (Pascal Guitton)
– “Des images de synthèse : pour quoi faire ?”, Journées Les nouvelles technologies de l’image au service du patrimoine, Bordeaux, 15th September 2008 (Pascal Guitton)
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