



INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team EVASION

*Virtual environments for animation and
image synthesis of natural objects*

Grenoble - Rhône-Alpes

Theme : INTERACTION AND VISUALIZATION

Activity
R *eport*

2009

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2. Overall Objectives

2.1. Introduction

The EVASION project addresses the modeling, animation, visualization and rendering of natural scenes and phenomena. In addition to the high impact of this research on audiovisual applications (3D feature films, special effects, video games), the rising demand for efficient visual simulations in areas such as environment and medicine is also addressed. We thus study objects from the animal, mineral and vegetal realms, all being possibly integrated into a complex natural scene. We constantly seek a balance between efficiency and visual realism. This balance depends on the application (e.g., the design of immersive simulators requires real-time, while the synthesis of high-quality images may be the primary goal in other applications).

From its creation, EVASION mostly tackled the modeling, animation, visualization and rendering of isolated natural objects or phenomena. A very challenging long term goal, that may be not reachable within the next few years but towards which we should tend, would be to simulate full, complex natural scenes combining many elements of different nature. This would enable us to test our algorithms on real-size data and to achieve new applications such as the interactive exploration of a complex, heterogeneous data set from simulation, or of a visually credible natural scene. Being able to animate this scene during exploration and to interact with the simulation taking place would be very interesting. The three objectives below set up several milestones towards this long term goal.

2.2. Creation of digital content

Natural scenes present a multitude of similar details, which are never identical and obey specific physical and space repartition laws. Modeling these scenes is thus particularly difficult: it would take years for a designer, and is not easy to do either with a computer. Moreover, interfaces enabling intuitive and fast user control should be provided. Lastly, explicitly storing the information for every detail in a landscape is obviously not possible: procedural models for generating data on the fly, controlled by mid or high-level parameters, thus have to be developed. Our first objective for the next few years is therefore to develop novel methods for specifying a natural scene. This includes modeling the geometry of individual elements, their local appearance, positioning them within a full scene and controlling motion parameters. More precisely, we will investigate:

- New representations and deformation techniques for intuitive shape modeling.
- The exploitation of sketching, annotation and analysis of real-data from video, 3D scanners and other devices for the synthesis and animation of natural scenes.
- The procedural synthesis of geometry, motion and local appearance (texture, shaders) using existing knowledge, user input and/or statistical data.

2.3. Animating nature

Most natural scenes are in motion. However, many of the animated phenomena that we can observe in nature have never been realistically, yet efficiently simulated in Computer Graphics. Our approach for tackling this problem is to increase and deepen our collaborations with scientist from other disciplines. From our past experiences, we believe that such interdisciplinary collaborations are very beneficial for both parties: they provide us with a better understanding of the phenomena to model and help us to get some input data and to experiment with the most recent models. On the other hand, our partners get interactive virtual prototypes that help them testing different hypothesis and enable a visual appreciation of their results. In particular, our aims are to:

- Improve interactive animation techniques for all kinds of physical models.
- Develop models for new individual phenomena.
- Work on the interaction between phenomena of different nature, such as forest and wind, sand and water, erosion (wind, water and landscape) or even eco-systems (soil, water, plants and animals).

2.4. Efficient visualization of very large scenes

Being able to handle massive data sets has been a strategic objective for French Computer Science for the last few years. In our research field, this leads us to investigate both the scientific visualization of very large data sets (which helps exploring and understanding the data provided, for instance, by our scientific partners from other research fields), and the real-time, realistic rendering of large size natural scenes, seeking for the interactive exploration and possible immersion in such scenes as a long term goal. More precisely, our objectives are to develop:

- Novel methods for the interactive visualization of complex, hybrid massive data sets, possibly embedding 1D and 2D structures within volumetric data which may represent scalar, vector or tensor fields.
- Perception based criteria for switching between levels of detail or between the representations of different nature we use in multi-models.
- Real-time techniques enabling us to achieve the rendering of full, natural scenes by exploring new, non-polygonal representations and relying on the programmable graphics hardware whereas possible.

2.5. Highlights of the year

Selected highlights:

- Marie-Paule Cani was nominated *chevalier de l'ordre national du mérite* by the French government in October 2009, to acknowledge her carrier.
- Maxime Tournier and co-authors received the third best paper award at the Eurographics conference for their work on motion compression using principle geodesics analysis [13].
- Adeline Pihuit and co-authors received the best paper award at the AFIG conference for their work on implicit reconstruction of 3D surfaces from 2D slices [29].

3. Scientific Foundations

3.1. Methodology

The synthesis of natural scenes has been studied long after that of manufacturing environments in Computer Graphics, due to the difficulty in handling the high complexity of natural objects and phenomena. This complexity can express itself either in the number of elements (e.g., a prairie, hair), in the complexity of the shapes (e.g., some vegetal or animal organisms) and of their deformations (a cloud of smoke), from motions (e.g., a running animal, a stream), or from the local appearance of the objects (a lava flow). To tackle this challenge:

- we exploit *a priori* knowledge from other sciences as much as possible, in addition to inputs from the real world such as images and videos;
- we take a transversal approach with respect to the classical decomposition of Computer Graphics into Modeling, Rendering and Animation: we instead study the modeling, animation and visualization of a phenomenon in a combined manner;
- we reduce computation time by developing alternative representations to traditional geometric models and finite element simulations: hierarchies of simple coupled models instead of a single complex model; multi-resolution models and algorithms; adaptive levels of detail;
- we take care to keep the user in the loop (by developing interactive techniques whereas possible) and to provide him/her with intuitive control;
- we validate our results through the comparison with the real phenomena, based on perceptual criteria.

3.2. Research strategies

Our research strategy is twofold:

- **Development of fundamental tools**, i.e., of new models and algorithms satisfying the conditions above. Indeed, we believe that there are enough similarities between natural objects to factorize our efforts by the design of these generic tools. For instance, whatever their nature, natural objects are subject to physical laws that constrain their motion and deformation, and sometimes their shape (which results from the combined actions of growth and aging processes). This leads us to conduct research in adapted geometric representations, physically-based animation, collision detection and phenomenological algorithms to simulate growth or aging. Secondly, the high number of details, sometimes similar at different resolutions, which can be found in natural objects, leads us to the design of specific adaptive or multi-resolution models and algorithms. Lastly, being able to efficiently display very complex models and data-sets is required in most of our applications, which leads us to contribute to the visualization domain.
- **Validation of these models by their application to specific natural scenes**. We cover scenes from the animal realm (animals in motion and parts of the human body, from internal organs dedicated to medical applications to skin, faces and hair needed for character animation), the vegetal realm (complex vegetal shapes, specific material such as tree barks, animated prairies, meadows and forests) and the mineral realm (mud-flows, avalanches, streams, smoke, cloud).

4. Application Domains

4.1. Introduction

The fundamental tools we develop and their applications to specific natural scenes are opportunities to enhance our work through collaborations with both industrial partners and scientists from other disciplines (the current collaborations are listed in Section 7 and 8). This section briefly reviews our main application domains.

4.2. Audiovisual applications: Special effects and video games

The main industrial applications of the new representation, animation and rendering techniques we develop, in addition to many of the specific models we propose for natural objects, are in the audiovisual domain: a large part of our work is used in joint projects with the special effects industry and/or with video games companies.

4.3. Medical applications: Virtual organs and surgery simulators

Some of the geometric representations we develop, and their efficient physically-based animations, are particularly useful in medical applications involving the modeling and simulation of virtual organs and their use in either surgery planning or interactive pedagogical surgery simulators. All of our applications in this area are developed jointly with medical partners, which is essential both for the specification of the needs and for the validation of results.

4.4. Environmental applications and simulation of natural risks

Some of our work in the design and rendering of large natural scenes (mud flows, rock flows, glaciers, avalanches, streams, forests, all simulated on a controllable terrain data) lead us to very interesting collaborations with scientists of other disciplines. These disciplines range from biology and environment to geology and mechanics. In particular, we are involved in inter-disciplinary collaborations in the domains of impact studies and simulation of natural risks, where visual communication using realistic rendering is essential for enhancing simulation results.

4.5. Applications to industrial design and interactive modeling software

Some of the new geometrical representations and deformation techniques we develop lead us to design novel interactive modeling systems. This includes for instance applications of implicit surfaces, multiresolution subdivision surfaces, space deformations and physically-based clay models. Some of this work is exploited in contacts and collaborations with the industrial design industry.

4.6. Applications to scientific data visualisation

Lastly, the new tools we develop in the visualisation domain (multiresolution representations, efficient display for huge data-sets) are exploited in several industrial collaborations involving the energy and drug industries. These applications are dedicated either to the visualisation of simulation results or to the visualisation of huge geometric datasets (an entire power plant, for instance).

5. Software

5.1. Introduction

Although software development is not among our main objectives, the various projects we are conducting lead us to conduct regular activities in the area, either with specific projects or through the development of general libraries.

5.2. Sofa

Participants: Michaël Adam, Guillaume Bousquet, Florent Falipou, François Faure, Lenka Jeřábková.

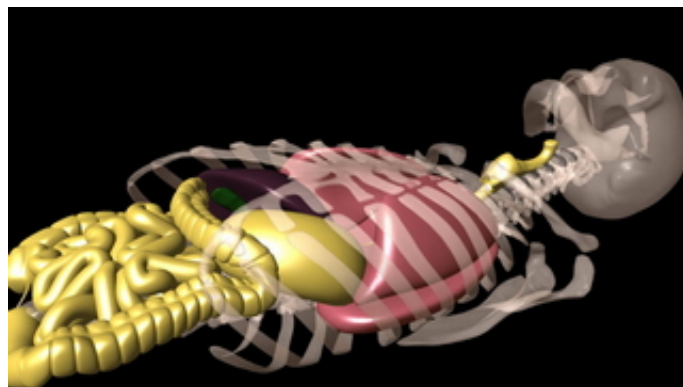


Figure 1. Physically based simulation of an abdominal cavity using SOFA.

SOFA is a C++ library primarily targeted at medical simulation research. Based on an advanced software architecture, it allows to (1) create complex and evolving simulations by combining new algorithms with algorithms already included in SOFA; (2) modify most parameters of the simulation – deformable behavior, surface representation, solver, constraints, collision algorithm, etc. – by simply editing an XML file; (3) build complex models from simpler ones using a scene-graph description; (4) efficiently simulate the dynamics of interacting objects using abstract equation solvers; and (5) reuse and easily compare a variety of available methods (see Figure 1).

A tutorial on SOFA has been given at the IEEE Virtual Reality Conference, La Fayette, February 2009. It has been used as software platform for several publications of the team [10], [23], [20], [11].

SOFA has been chosen as implementation platforms for the European project Passport for Liver Surgery, the national projects ANR Vulcain, BQR Fissure, our participation in ANR RepDyn,

5.3. MobiNet

Participant: Franck Hétroy.

The MobiNet software allows for the creation of simple applications such as video games, virtual physics experiments or pedagogical math illustrations. It relies on an intuitive graphical interface and language which allows the user to program a set of mobile objects (possibly through a network). It is available in public domain for Linux, Windows and MacOS at <http://mobinet.inrialpes.fr>. It originated from 4 members of EVASION and ARTIS. The main aim of MobiNet is to allow young students at high school level with no programming skills to experiment, with the notions they learn in math and physics, by modeling and simulating simple practical problems, and even simple video games. This platform has been massively used during the Grenoble INP "engineer weeks" since 2002: 150 senior high school pupils per year, doing a 3 hour practice. This work is partly funded by Grenoble INP. Various contacts are currently developed in the educational world.

5.4. Proland

Participants: Eric Bruneton, Antoine Begault, Adyl Kenouche, Guillaume Piolat.

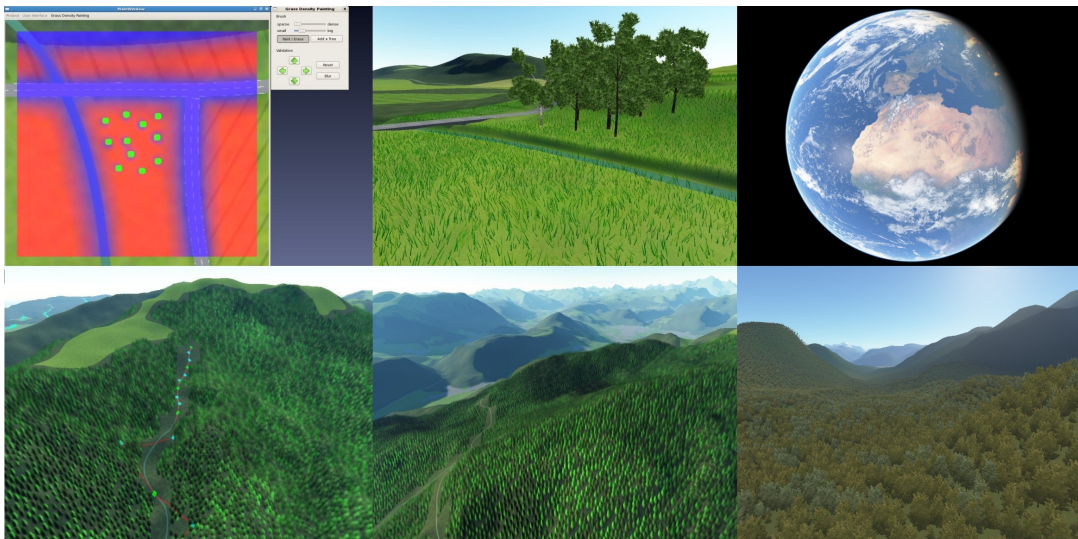


Figure 2. Proland software

Proland (for *procedural landscape*) is a software platform originally developed for the NatSim project. It has also been developed using fundings from the GVTR project, and it is the basis for our participation in the MarketSimGame project (see Section 7.4). The goal of this platform is the real-time rendering and editing of large landscapes. The second version started last year integrated a terrain renderer, billboard cloud forests, and atmospheric effects. This year Antoine Begault ported in this new version our work on vector based terrain rendering and editing, as well as the work on the real-time animation of large scale rivers. We also integrated our work on ocean rendering (see Section 6.3.3). All features can work with planet-sized terrains, for all viewpoints from ground to space. Proland versions have been deposited to APP (Deposit numbers IDDN.FR.001.390029.000.S.C.2008.000.31500 and IDDN.FR.001.390030.000.S.P.2008.000.31500). A licence of this software has been sold to RSA Cosmos, a company developing digital planetariums.

5.5. Azalic Studio

Participants: Adrien Bernhardt, Marie-Paule Cani, Olivier Palombi, Adeline Pihuit.



Figure 3. Azalic Studio: a free-form shape modeling tool for non-experts, based on a 2D painting metaphor.

Azalic Studio is a software dedicated to free form shape Modeling through Interactive Sketching and Sculpting gestures. The goal is to provide a very intuitive way to create 3D shapes, as easy to use for the general public as roughly sketching a shape or modeling it with a piece of clay. Our first prototype, called Matisse, was developed in 2007-2008, in the framework of a research contract with the company Axiatec 7.2. It enables to create a 3D shape by smoothly blending different components, which are progressively painted at different scales and from different viewing angles. See Figure 6. Our prototype is written in C++ as an extension of the Ogre open-source library. It relies on our research on free-form sketch-based modeling using geometric skeletons and convolution surfaces 6.1.4, and on our recent contribution on local implicit blending 6.1.3. Future extensions will include the combination of sketching with modeling gestures related to clay sculpting, such as deforming a shape through pulling, pushing, bending or twisting gestures 6.1.2.

5.6. MyCorporisFabrica

Participants: Guillaume Bousquet, François Faure, Sahar Hassan, Olivier Palombi, Lionel Reveret.

MyCorporisFabrica (MyCF) is a new anatomical database, based on the reference anatomical ontology FMA (the Foundational Model of Anatomy) with the possibility to coherently integrate 3D geometrical data, as well as biomechanical parameters. The purpose of this extension is to allow the user to intuitively create a patient-specific 3D representation from a formal description of anatomical entities and also to automatically export this description to test a physical simulation. The main contribution of MyCF consists in the formalization of a comprehensive database structure implemented in MySQL, linking canonical description of anatomical entities with reality-grounded instances of such description in terms of geometrical data and physical attributes. The principle of ontology modeling inherited from FMA is maintained in order to guarantee a close consistency between the two databases. MyCorporisFabrica has been presented this year in the Workshop on Physiological Human [11].

6. New Results

6.1. Representing, creating and processing geometry

Participants: Adrien Bernhardt, Dobrina Boltcheva, Georges-Pierre Bonneau, Marie-Paule Cani, Jean-Rémy Chardonnet, Sahar Hassan, Franck Hétyroy, Jean-Claude Léon, Olivier Palombi, Adeline Pihuit, Damien Rohmer.

6.1.1. Multiresolution geometric modeling with constraints

Participant: Georges-Pierre Bonneau.

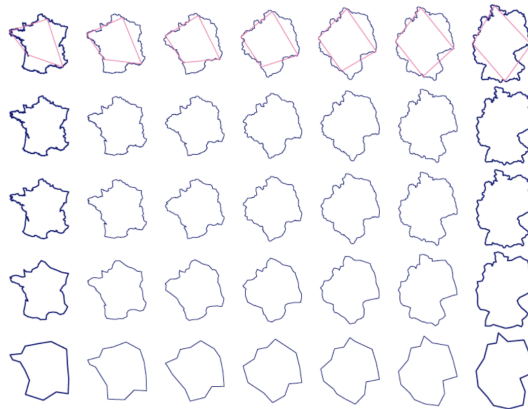


Figure 4. Multiresolution Morphing between France and Germany, at 5 levels of resolution.

This work is done in collaboration with Stefanie Hahmann from LJK. The purpose of this research is to allow complex nonlinear geometric constraints in a multiresolution geometric modeling. This year we have worked on a multiresolution *morphing* algorithm using "as-rigid-as-possible" shape interpolation combined with an angle-length based multiresolution decomposition of simple 2D piecewise curves. This novel multiresolution representation is defined intrinsically and has the advantage that the details' orientation follows any deformation naturally. The multiresolution *morphing* algorithm consists of transforming separately the coarse and detail coefficients of the multiresolution decomposition. The results are illustrated in Figure 4. This work has been published in [18].

6.1.2. Hand-on interaction for Virtual Sculpture

Participants: Marie-Paule Cani, Jean-Rémy Chardonnet, Jean-Claude Léon, Damien Rohmer.

The different deformation models we developed in the past few years open the problem of providing intuitive interaction tools for specifying the desired deformation in real-time. Our recent work therefore focused on developing new interfaces for interacting with the model to deform.

After experimenting a soft ball connected to a phantom device, serving as a proxy for the model to deform, we developed an interface similar to a mouse, called the *hand-navigator*, enabling to control simultaneously all the degrees of freedom of a virtual hand. This device, which provides some passive haptic feedback, needs no calibration and enables interrupting the tasks anytime, is patented by INRIA. It extends a standard pace-navigator using petals that support sensors for the fingers, to control the opening and closure gestures of the virtual hand as well as its position and orientation.

This year, thanks to a pre-industrialization project funded by the incubator GRAVIT (see Section 7.1), we extended the first prototype by testing new captors and new shapes for the device. We also interfaced it with a constant volume skinning method (see Section 6.1.5) and demonstrated it at Grenoble Innivation Fair and in various conferences [30], [19].

Note that this work is also part of our contribution to the PPF "Multimodal interaction" (see Section 8.3.3).

6.1.3. Implicit Modeling

Participants: Adrien Bernhardt, Marie-Paule Cani, Olivier Palombi, Adeline Pihuit.

Implicit surfaces are a very good representation for smooth, organic-like, free-form shapes. In addition to being able to represent objects of arbitrary topological genus, they have the ability to be constructed by successively blending different components, which eases interactive modelling tasks. Lead by our needs of an adequate surface representation for sketch-based modelling (see 6.1.4), re-started this year some fundamental research on implicit modelling, leading to three new contributions:

Firstly, we designed a method for reconstructing 3D implicit surfaces from 2D regions painted in parallel planes. This method, applied to the reconstruction of anatomic shapes, first uses convolution surfaces to reconstruct a field function whose iso-surface fits a single contour, and then uses a combination of interpolation and extrapolation for computing field values outside the planes, leading to a full 3D reconstruction of the shape. Adeline Pihuit received the best student paper award at the French computer graphics conference (AFIG) for this work [29]. See Figure 5.

This method has been used to reconstruct the shape of the precerebellar linear nucleus in the mouse. This neuroanatomical study has been successfully completed in collaboration with the laboratory of Pr. Paxinos in Sydney (POWMRI, UNSW, Australia) [7].

Secondly, we collaborated with a researcher in formal computation to improve and extend the analytical methods for computing closed form solutions for convolution surfaces [35].

Lastly, we revisited implicit blending, to enable implicit surfaces to blend in regions where they intersect, but to be able to come as close to each other as desired without blending in other regions. See Figure 6. This work has been accepted for publication at Eurographics in 2010.

6.1.4. Sketch-Based Modeling

Participants: Adrien Bernhardt, Marie-Paule Cani, Jean-Claude Léon, Olivier Palombi, Adeline Pihuit.

3D modeling from a sketch is a fast and intuitive way of creating digital content. We are exploring this technique from two different view-points:

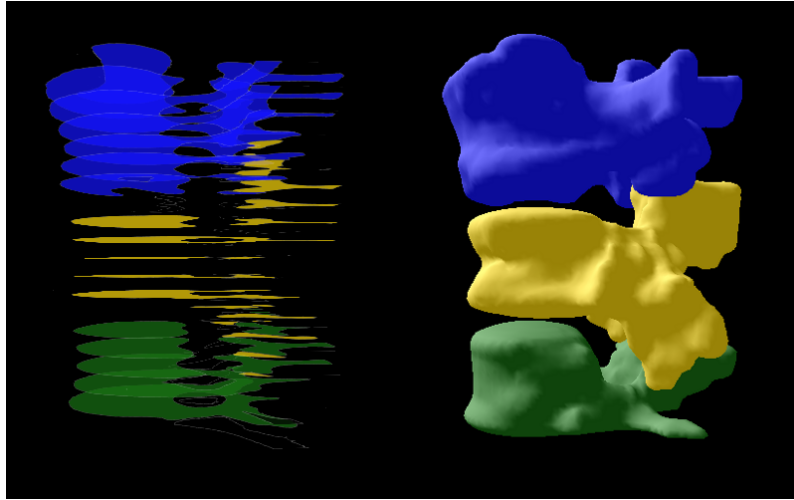


Figure 5. Mixed interpolation and extrapolation for the implicit reconstruction of vertebra from 2D regions sketched in parallel planes.

A first class of methods directly infer free-form shapes in 3D from arbitrary progressive sketches, without any a priori knowledge on the objects being represented. Our work relies on implicit, convolution surfaces for doing so: the user paints a 2D projection of the shape. A skeleton (or medial axis), taking the form of a set of branching curves, is reconstructed from this 2D region. It is converted into a close form convolution surface whose radius varies along the skeleton. The resulting 3D shape can be extended by sketching over it from a different viewpoint, while the blending operator used adapts its action so that blending remains local and no detail is blurred during the process (see figure 6). This work was supported by a direct industrial contract with Axiattec (see Section 7.2), leading to the development of the Azalic studio software (see Section 5.5).

Another research direction in sketch-based modelling is to create a complex shape from a single sketch, using some a priori knowledge on the object being drawn for inferring the missing 3D information. This idea was exploited for the sketch-based modeling of trees [15], in collaboration with the INRIA project-team Virtual Plants (see Figure 7). This work in the same spirit is currently conducted within Adeline Pihuit's PhD thesis, co-supervised by Olivier Palombi and Marie-Paule Cani, and focusing on the use of sketch-based interfaces for the interactive teaching of anatomy. We are also investigating the design of realistic terrains from a single sketch, within the PhD thesis of Adrien Bernhardt.

6.1.5. Geometrical methods for skinning character animations

Participants: Marie-Paule Cani, Franck Hétroy, Damien Rohmer.

Skinning, which consists in computing how vertices of a character mesh (representing its skin) are moved during a deformation w.r.t. the skeleton bones, is currently the most tedious part in the skeleton-based character animation process. We propose [21] new geometrical tools to enhance current methods. First, we developed a new skinning framework inspired from the mathematical concept of atlas of charts: we segment a 3D model of a character into overlapping parts, each of them being anatomically meaningful (e.g., a region for each arm, leg, etc., with overlaps around joints), then during deformation the position of each vertex in an overlapping area is updated thanks to the movement of neighboring bones. This work was done in collaboration with Boris Thibert from the MGMI team of the LJK, Cédric Gérot from the GIPSA-Lab in Grenoble, and Lin Lu from the University of Hong Kong.

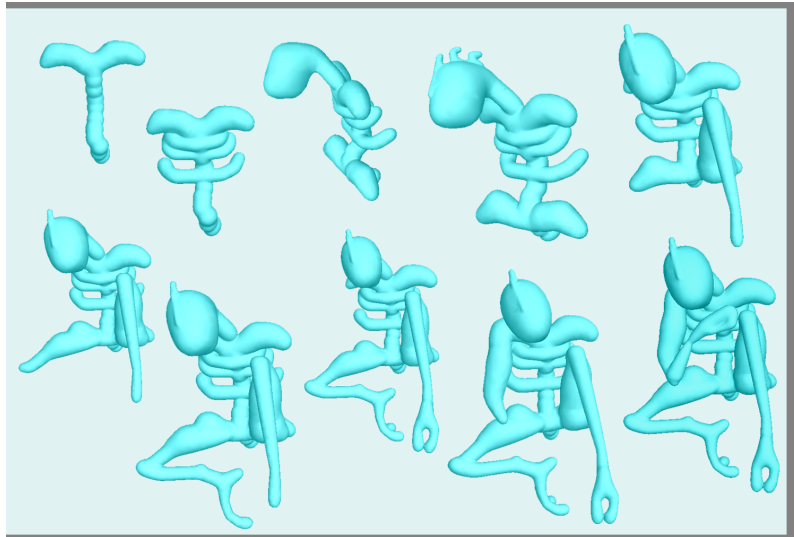


Figure 6. Interactive modelling using Azalic Studio, our sketch-based modelling software: the different shape component are successively created using implicit surfaces and locally blended to the shape.

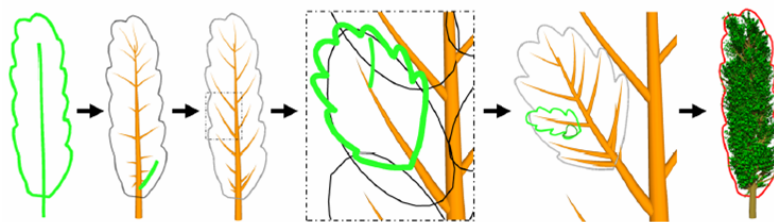


Figure 7. Tree designed in less than 2mn using a multi-resolution sketching system which incorporates some a priori knowledge from botany.

Secondly, we developed, in collaboration with Stefanie Hahmann from the MGMI team of the LJK, a post-correction method for preserving volume in the standard smooth-skinning pipeline [25]. As usual, the character is defined by a skin mesh at some rest pose and an animation skeleton. At each animation step, skin deformations are first computed using standard SSD. Our method corrects the result using a set of local deformations which model the fold-over-free, constant volume behaviour of soft tissues. This is done within an exact geometrical computation in three passes. This new method has the benefits to allow the specification of a profile curve through which the user controls the shape of the deformation. See figure 8.



Figure 8. Constant volume skinning with shape control.

6.1.6. *Ontology-based mesh segmentation*

Participants: Sahar Hassan, Franck Hétroy, Olivier Palombi.

Patient-specific 3D virtual models of anatomical organs are becoming more and more useful in medicine, for instance for diagnosis or follow-up care purposes. These models are usually created from 2D scan OR MRI images. However, small or thin geometrical features, such as ligaments, are sometimes not visible on these images. We propose to use an anatomical ontology, called MyCorporisFabrica [11] and developed in the team (see Section 5.6), to add missing parts to reconstructed virtual organs. This ontology describes definitions of and relationships between organs: e.g., femur is part of the leg. The first step towards the full achievement of this process is to segment virtual models, often represented by 2D meshes, into meaningful parts. In our case, “meaningful” means “related to the ontology”: each part should refer to an organ defined in the ontology. The general outline to create this segmentation has been proposed this year [27]: first, we approximate organ’s shapes by geometric primitives, then we segment a given organ mesh by optimizing objective functions which are related to these primitives.

6.1.7. *Topological classification of non-manifold singularities*

Participants: Dobrina Boltcheva, Franck Hétroy, Jean-Claude Léon.

In computer graphics, as in many other cases (CAD, civil engineering, ...), idealized virtual representations of real models are used. For instance in case of a complex big building, a single wall will be seen as a planar surface, instead of a thin volume. However, most processing algorithms suppose these data to be globally coherent: surfacic meshes are for instance supposed to be 2-manifolds. Together with colleagues from the university of Genova in Italy, we aim at classifying non-manifold singularities of used idealized models (we restrict to simplicial complexes), in order to exhibit global topological properties that can then be used to enhance or modify current processing algorithms. A first step towards this goal has been achieved this year, with a first classification proposal [22], [28]. Two examples of non-manifold singularities are shown on figure 9.

6.1.8. *Mesh repair*

Participant: Franck Hétroy.

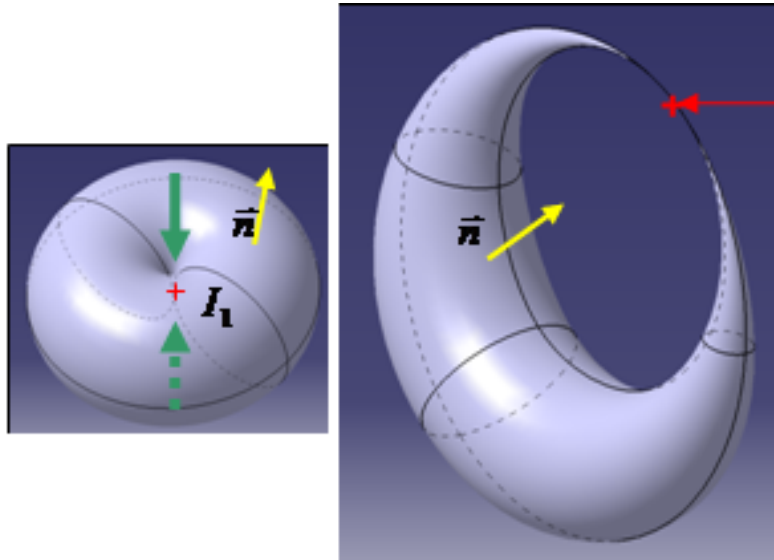


Figure 9. Two shapes with non-manifold singularities: pinched sphere (left) and squeezed torus (right).

This work is done in collaboration with Carlos Andujar, Pere Brunet and Alvar Vinacua from Universitat Politècnica de Barcelona, Spain. The purpose is to propose an efficient method to create 2-manifold meshes from real data, obtained as soups of polygons with combinatorial, geometrical and topological noise. We propose to use a voxel structure called a discrete membrane and morphological operators to compute possible topologies, between which the user chooses. It has been submitted to publication.

6.2. Animating nature

Participants: Romain Arcila, Guillaume Bousquet, Eric Bruneton, Marie-Paule Cani, Julien Diener, Estelle Duveau, François Faure, Benjamin Gilles, Everton Hermann, Franck Hétry, Olivier Palombi, Cécile Picard, Lionel Reveret, Maxime Tournier, Xiaomao Wu.

6.2.1. Robust finite elements for deformable solids

Participants: François Faure, Guillaume Bousquet.

We have presented at SIGGRAPH 2009 a new approach for the embedding of linear elastic deformable models [10]. Our technique results in significant improvements in the efficient physically based simulation of highly detailed objects. First, our embedding takes into account topological details, that is, disconnected parts that fall into the same coarse element are simulated independently, as illustrated in Figure 10. Second, we account for the varying material properties by computing stiffness and interpolation functions for coarse elements which accurately approximate the behaviour of the embedded material. Finally, we also take into account empty space in the coarse embeddings, which provides a better simulation of the boundary. The result is a straightforward approach to simulating complex deformable models with the ease and speed associated with a coarse regular embedding, and with a quality of detail that would only be possible at much finer resolution.

We have also collaborated with the University of Geneva on finite elements which are both numerically efficient and physically accurate, using an extended St-Venant-Kirchhoff model [14]. We have applied it to simulate the anisotropic, non-linear behavior of cloth, as illustrated in Figure 11.

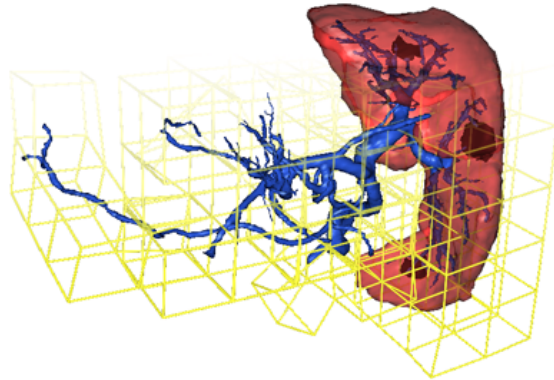


Figure 10. A model of a liver with attached vascular system simulated with coarse resolution hexahedra. Our technique models the behaviour of the soft liver tissue, stiffer veins, and much stiffer tumors by taking into account a distribution of materials and the presence of empty regions in the embedding. The complex topological branching of the vascular system is preserved by superimposing elements.

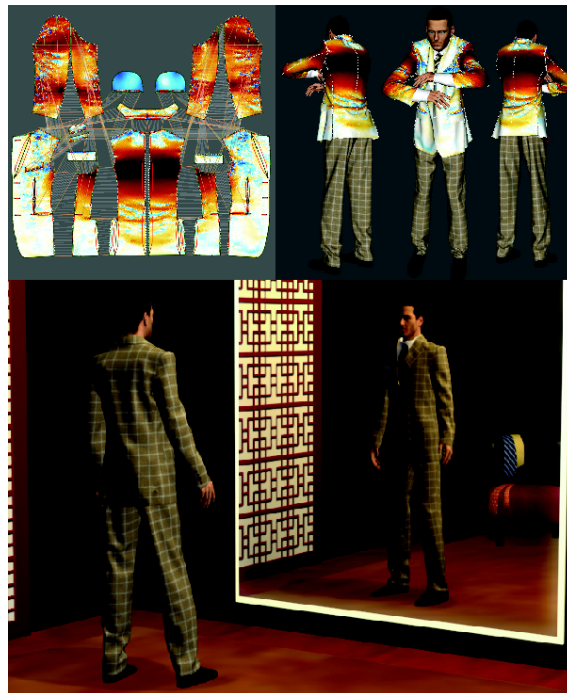


Figure 11. Virtual prototyping applications require an accurate representation of cloth material behavior for evaluating precisely the stretch forces (color scale) on the garment along particular postures of the character (top). An efficient simulation model is also required for the dynamic simulation of high-resolution complex garments involving several layers of cloth.

6.2.2. High-Performance Simulation of Complex Models

Participants: François Faure, Everton Hermann.

Everton Hermann is a Brazilian Ph.D. student funded by a Cordi grant and co-tutored by François Faure in EVASION and Bruno Raffin in MOAIS. We have proposed a parallelization of interactive physical simulations [20]. Our approach relies on a task parallelism where the code is instrumented to mark tasks and shared data between tasks, as well as parallel loops even if they have dynamics conditions. Prior to running a simulation step, we extract a task dependency graph that is partitioned to define the task distribution between processors. This approach has a low impact on physics algorithms as parallelism is mainly extracted from the coordination code. It makes it non parallel programmer friendly, using domain decomposition or task-based parallelism, as illustrated in Figure 12.

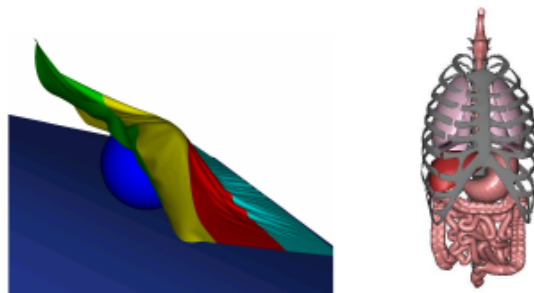


Figure 12. Two ways of parallelizing a complex scenes: domain decomposition (left) and task-based parallelism (right).

6.2.3. Sound synthesis

Participants: François Faure, Cécile Picard.

Cécile Picard, a PhD. student, was previously in Sophia-Antipolis tutored by Nicolas Tsingos and George Drettakis. She has been with us from July 2008 to July 2009, then moved back to Sophia-Antipolis to complete the writing of her Ph.D. dissertation with George Drettakis. We published a method for sound synthesis in game engines [24], where we bridge the gap between direct playback of audio recordings and physically-based synthesis by retargetting audio grains extracted from the recordings according to the output of a physics engine, as illustrated in Figure 13.

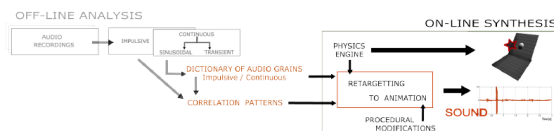


Figure 13. Overview of our approach combining off-line analysis of recorded sounds with interactive retargetting to motion.

We have also extended our grid-based approach for robust finite elements to physically based sound synthesis [23], as illustrated in Figure 14. The technique performs automatic voxelization of a surface model and automatic tuning of the parameters of hexahedral finite elements, based on the distribution of material in each cell. The voxelization is performed using a sparse regular grid embedding of the object, which easily permits the construction of plausible lower resolution approximations of the modal model.

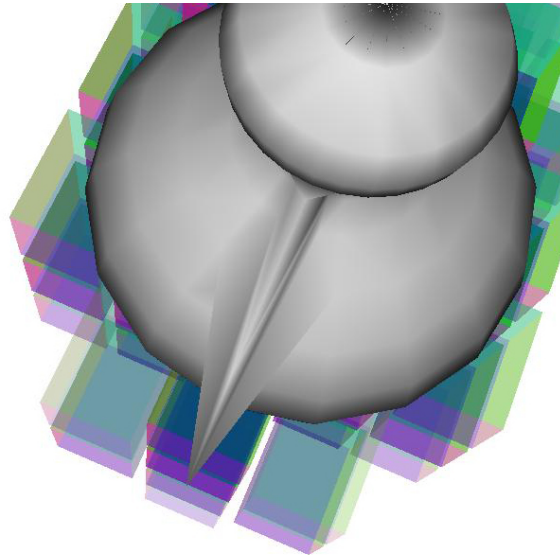


Figure 14. An example of a complex geometry that can be handled with our method. The thin blade causes problems with traditional tetrahedralization methods.

6.2.4. Real-time animation of liquids and river surfaces

Participant: Eric Bruneton.

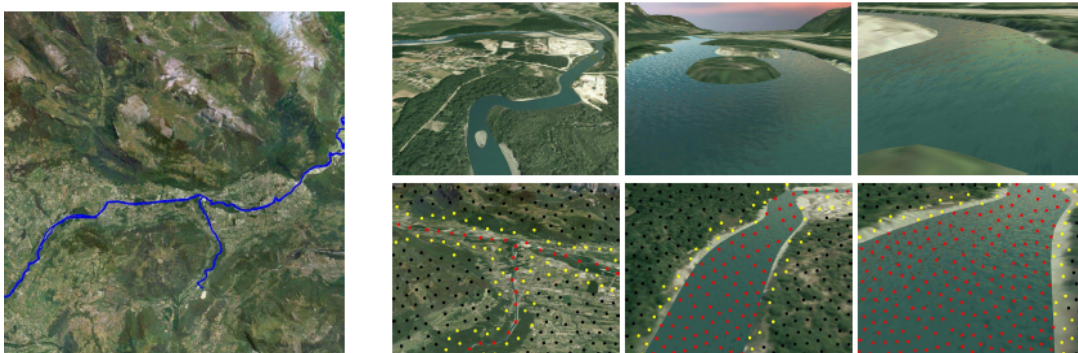


Figure 15. Our river animation and reconstruction model handles the real-time dynamic exploration from landscape-scale to close-scale. Advected particles obey a Poisson-disk distribution in screen space.

Last year, Qizhi Yu (a Marie Curie PhD student supervised by Fabrice Neyret and Eric Bruneton) developed a macroscopic model of rivers, allowing for the real-time visual simulation of a flow from close to far view on very large terrains (see Proland Project). A real-time editable vector description of river boundaries and obstacles is used to define a semi-analytic distance field which is used to derive a zero-derivative flow. A screen-space Poisson-disk distribution of river particles carrying wave textures is animated and continuously readapted, so as to be space-time continuous (see Figure 15). This work has been published this year at the Eurographics conference [17].

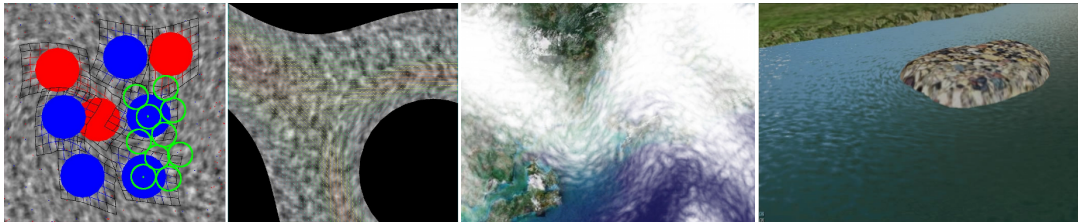


Figure 16. Our Lagrangian texture advection model allows local patches to be deformed and regenerated asynchronously. This yields a better conformance to the apparent flow and to the texture spectrum properties at the same time.

A research report has also been published this year [33], on a Lagrangian texture advection model developed last year by Qizhi Yu. Our particles are distributed according to animated Poisson-disk, and carry a local grid mesh which is distorted by advection and regenerated when a distortion metric is passed. This Lagrangian approach solves the problem of local-adaptive regeneration rate, provides a better spectrum and better motion illusion, and avoids the burden of blending several layers (see Figure 16).

6.2.5. Motion capture and animation of vertebrates

Participants: Estelle Duveau, Olivier Palombi, Lionel Reveret, Xiaomao Wu, Benjamin Gilles.

The ANR project Kameleon has driven several research topics towards the achievement of motion capture and animation of small vertebrates. Based on data collected at the synchrotron, Benjamin Gilles has developed a new method to quickly register new anatomical models of animals on CT and MRI scans to speed up the segmentation of the articulated bones. A paper will be published at Computer Graphics Forum journal. Estelle Duveau is continuing her PhD on motion capture from 3D surface flow. This PhD is co-advised by Lionel Reveret and U. Descartes, Paris 5. A new method based on physically-based motion capture has been developed. A clinical study is currently under investigation using techniques developed during the project. The CNES has selected this project to bring the study into micro gravity conditions using their zeroG airplane facility. A new set-up adapted to the airplane is starting to be built. The methodology has opened new projects: one is focusing on the modeling of walking birds and its potential to be morphed towards the anatomy of bipedal dinosaurs to simulate their locomotion. Another one is focusing on the parameterization of quadruped locomotion (see below).

6.2.6. Motion capture of animals in outdoor conditions

Participant: Lionel Reveret.

Projects have been started to develop methods adapted to the motion capture of animals in outdoor conditions. A pioneer study has been done for greyhound dogs. The goal is to set up a scientific campaign to perform motion capture in a wild life reserve in Africa. Another project has been launched to capture motion of penguins in Antarctica. Video data for marine turtles have been collected in Barbados, in collaboration with McGill University.

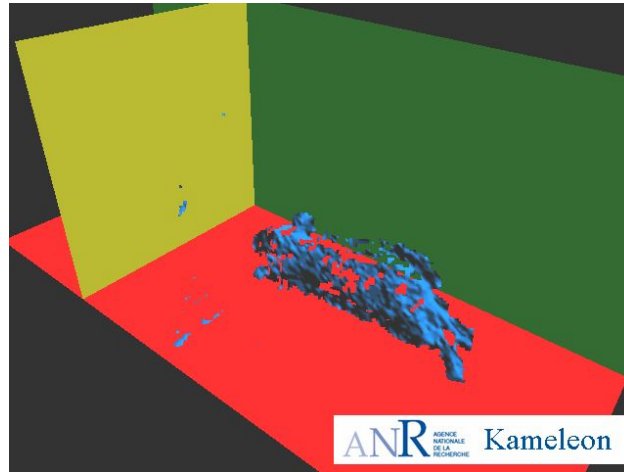


Figure 17. 3D surface tracking.

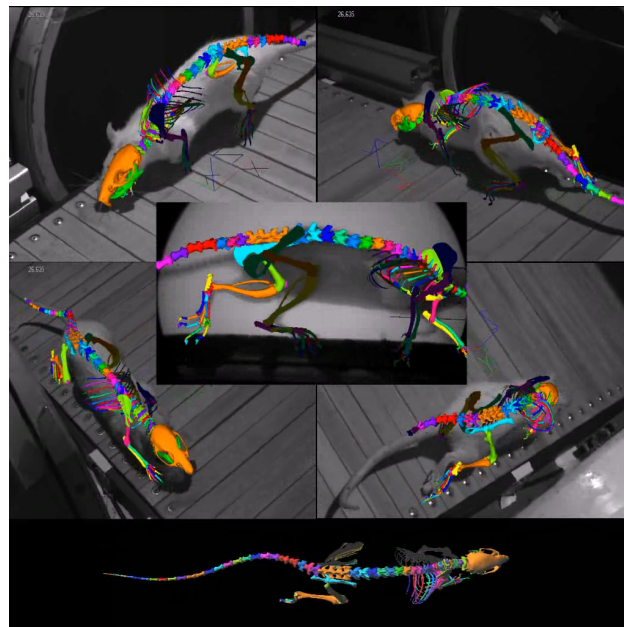


Figure 18. Motion capture and animation - walking condition.

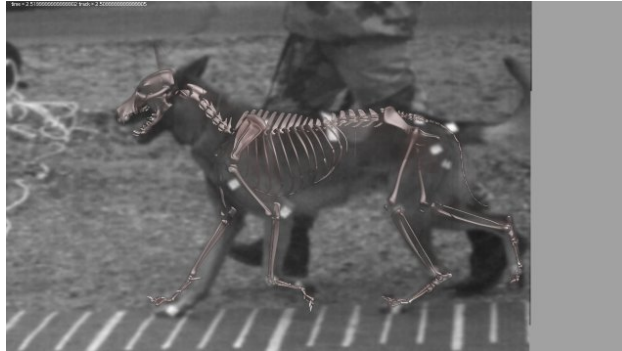


Figure 19. Motion capture and animation of a dog.

6.2.7. Character animation

Participants: Marie-Paule Cani, François Faure, Franck Hétroy, Lionel Reveret.

We have presented a general method to intuitively create a wide range of locomotion controllers for 3D legged characters [8]. The key of our approach is the assumption that efficient locomotion can exploit the natural vibration modes of the body, where these modes are related to morphological parameters such as the shape, size, mass, and joint stiffness. The vibration modes are computed for a mechanical model of any 3D character with rigid bones, elastic joints, and additional constraints as desired, as illustrated in Figure 20. A small number of vibration modes can be selected with respect to their relevance to locomotion patterns and combined into a compact controller driven by very few parameters. We show that these controllers can be used in dynamic simulations of simple creatures, and for kinematic animations of more complex creatures of a variety of shapes and sizes.

A state of the art has been published in the Computer Graphics Forum journal [12] about quadruped animation. It follows a publication as State of the Art Report, presented at Eurographics 2008. A research program is starting with the MNHN to derive a 3D animation controller of quadrupeds from theoretical results obtained at the Museum on the description of quadruped gaits.

6.2.8. Motion capture of trees under wind

Participants: Julien Diener, Lionel Reveret.

These works are carried on in the context of the ANR project Chene-Roseau. The goal is to validate measurement tool from video to evaluate the risk of breaking of fruit trees under strong wind. Several experiments have been done in collaboration with INRA at Clermont-Ferrand (UMR PIAF). In parallel, a work on modal analysis of tree structure and its application to real-time animation had been developed and has been published at EG09 [6].

6.2.9. Modeling motion capture data of human

Participants: Lionel Reveret, Maxime Tournier, Xiaomao Wu, Franck Hétroy.

Works on mathematical modeling of quaternionic signals arising from motion capture have been investigated within the context of the ARC project Fantastik. These works have led to two INRIA Research Report and one paper has been published at EG09 [13]. This paper has been awarded as one of the best three papers of the conference. Maxime Tournier has spent 6 months at the U. of McGill working with Paul Kry to integrate physical simulation into the statistical approach. A sparse statistical analysis of motion data has been investigated by Xiaomao Wu in collaboration with Maxime Tournier and Lionel Reveret. A paper has

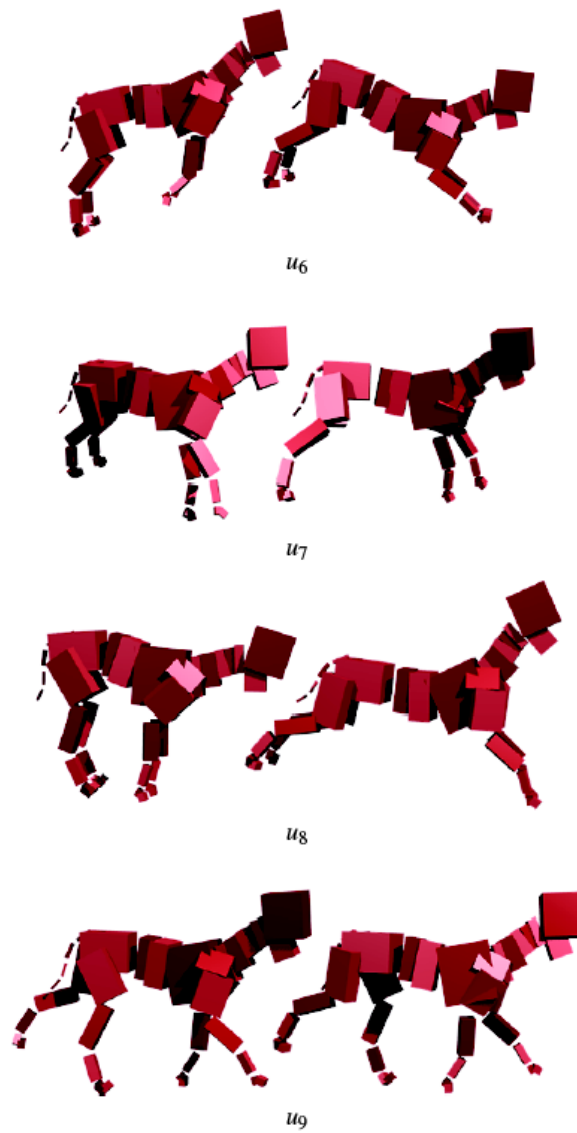


Figure 20. The first four non rigid vibration modes of a dog model with 80 degrees of freedom. These modes can be described as bounding, back twisting, stretching, and alternating legs, respectively.

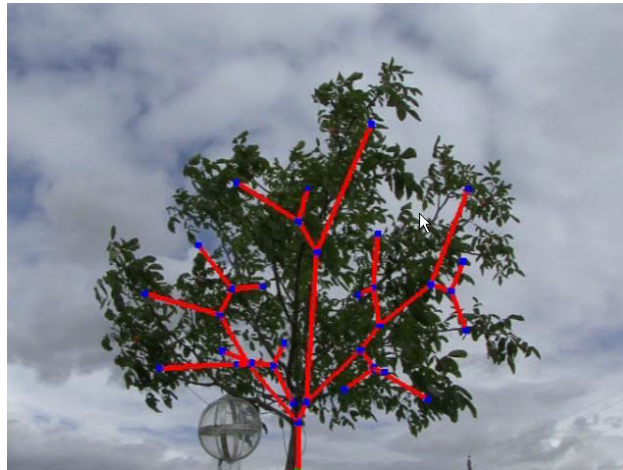


Figure 21. Motion capture of trees under wind.



Figure 22. Real-time animation of a thousands of trees using modal analysis.

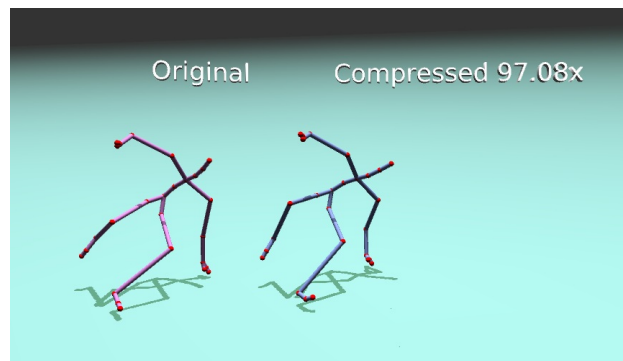


Figure 23. Modeling motion capture data of human.

been published at the IEEE Computer Graphics and Applications journal [16]. Finally, works have been done on expressive facial animation with the Psychology Department of the University of Geneva. A journal paper is currently under preparation.

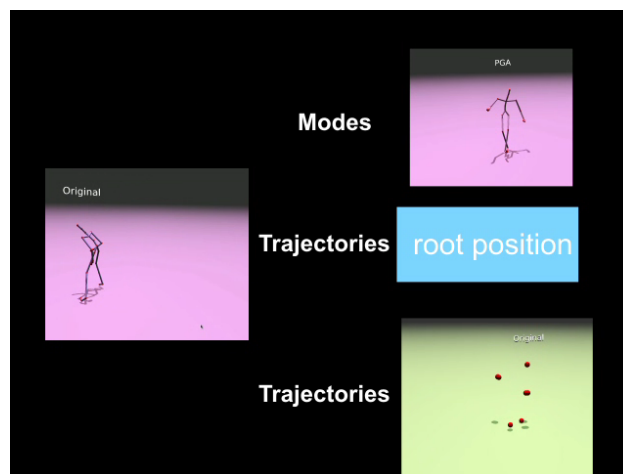


Figure 24. Motion compression using Principal Geodesic Analysis (PGA).

A project with Lionel Reveret and Franck Hétry has been started on learning and modeling climbing gestures. A first data collection has been done with a 2nd year Ensimag student, Simon Courtemanche, involved in this project both as a computer scientist and a competitor in rock climbing. Simon Courtemanche is continuing this work for his M2R in Computer Graphics. This work is extended as a collaboration with Edmond Boyer from the PERCEPTION team.

6.2.10. Processing animated meshes

Participants: Romain Arcila, Franck Hétry.



Figure 25. Modeling rock climbing gestures.

Mesh animations, or sequences of meshes, represent a huge amount of data, especially when acquired from scans or videos. In collaboration with the university of Lyon (LIRIS lab), we address the problem of partitioning these sequences, in order to later be able to compress them. We started this year by developing a formalism to describe possible mesh sequences and mesh sequence segmentations [26]. We then proposed a first motion-based segmentation algorithm, which clusters mesh vertices into static, rigid or homogeneously stretched components (see figure 26). This technique will be presented at the WSCG 2010 conference.



Figure 26. Segmentation of a horse mesh sequence.

6.3. Efficient visualization of very large scenes

Participants: Sébastien Barbier, Georges-Pierre Bonneau, Christian Boucheny, Eric Bruneton, Alexandre Coninx.

6.3.1. Visualisation of large numerical simulation data sets

Participants: Sébastien Barbier, Georges-Pierre Bonneau.

Sébastien Barbier has developed a set of GPU implemented algorithms that enable to dynamically extract a BiResolution mesh from any given tetrahedral mesh. A specific out-of-core simplification algorithm is performed in preprocessing. During exploration of the data, a single consistent mesh is extracted on-the-fly from a Volume-Of-Interest (VoI) and a coarse contextual mesh outside the VoI. Sébastien has defended his PhD thesis on October 26 2009 [1]. He is still working with the team until december 2009, and will be working at CEA in Bordeaux from January 2010. There he will work on Visualization with Fabien Vivodtzev, a former PhD student of Georges-Pierre Bonneau.

6.3.2. *Perceptive visualization*

Participants: Georges-Pierre Bonneau, Christian Boucheny, Alexandre Coninx.

This project is part of a collaboration with EdF R& D, and with LPPA (Laboratoire de Physiologie de la Perception et de l'Action, Collège de France). EdF runs massive numerical simulations in hydrodynamics, mechanics, thermodynamic, neutronic... Postprocess, and in particular visualization of the resulting avalanche of data is a bottleneck in the engineering pipeline. Contrary to the numerical simulation itself, this postprocessing is human-time consuming, with engineers spending several hours to explore the result of their simulation, trying to catch the knowledge hidden behind the numbers computed by the simulation. The focus of our collaboration with EdF and the College de France is to incorporate our knowledge of the human visual perception system in the development of more efficient visualization techniques. We also deal with the evaluation of existing visualization algorithms, based on perceptive criteria.

This year we have published a journal paper at ACM Transactions on Applied Perception [4], perceptive evaluation of volume rendering algorithms. Christian Boucheny has also defended his PhD thesis on February 13th [2]. Christian has been hired by EdF R&D, where he will continue to work on Visualization. We have started in January 2009 a new PhD thesis by Alexandre Coninx. Alexandre will focus his work on the Visualization of data with uncertainty.

6.3.3. *Real-time realistic ocean lighting*

Participant: Eric Bruneton.

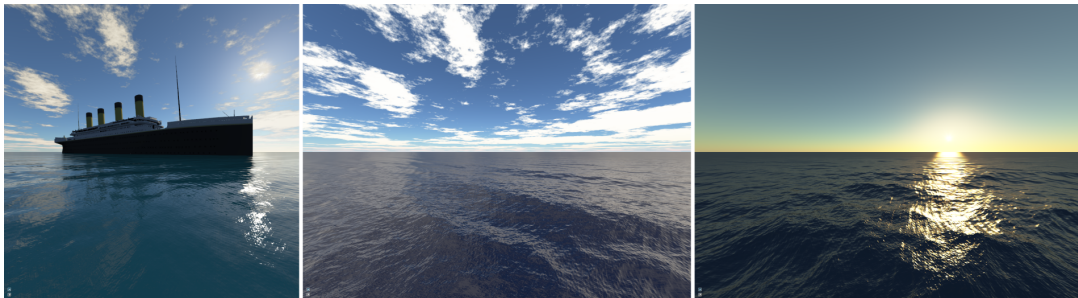


Figure 27. Some real-time results obtained with our ocean lighting algorithm, showing Sun reflections, sky reflections and local reflections from a boat. The lighting is correct at all distances thanks to accurate transitions from geometry to BRDF.

We developed a new algorithm for modelling, animation, illumination and rendering of the ocean, in real-time, at all scales and for all viewing distances. Our algorithm is based on a hierarchical representation, combining geometry, normals and BRDF. For each viewing distance, we compute a simplified version of the geometry, and encode the missing details into the normal and the BRDF, depending on the level of detail required. We then use this hierarchical representation for illumination and rendering. Our algorithm runs in real-time, and produces highly realistic pictures and animations (see Figure 27). This work has been accepted

for publication at the next Eurographics conference (Eurographics 2010). It has also been integrated in the Proland software (see Section 5.4).

6.3.4. Real-time quality rendering of clouds

Participant: Eric Bruneton.

Laurent Belcour worked during his Master thesis on the real-time, realistic rendering of Earth-scale clouds. Its goal was to extend the work of Antoine Bouthors (a former Phd student at Evasion) on the rendering of stratiform clouds. Laurent extended Antoine's model to account for the curvature of the Earth, as well as to support mountains and other non flat terrains (Antoine's model was limited to flat terrains). His model uses spherical harmonics to simulate the light bounces between the clouds and the ground (radiosity). Laurent is now a PhD student in the Aeris team.

6.3.5. Efficient representation of plants and trees

Participants: Philippe Decaudin, Fabrice Neyret.

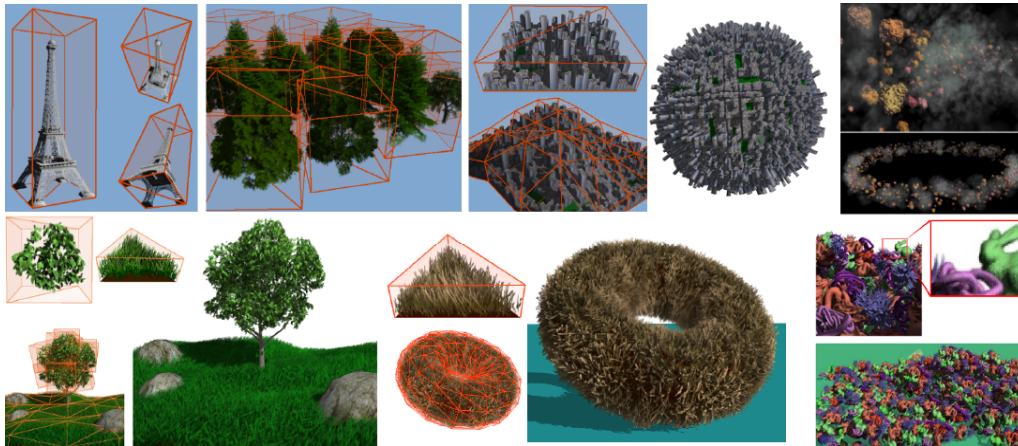


Figure 28. Our Volumetric Billboards model allows us to represent very complex detailed scenes very efficiently and with high visual quality, handling a volumetric-wise filtering of 'geometry'.

We developed a new representation for the efficient representation and filtering of complex data, typically, vegetal elements in a landscape [5]. The volumetric Billboard, which is based on a multiscale volume of voxels. Our rendering algorithm is able to render seamlessly and efficiently a complex self-intersecting distribution of such base volumes relying on common adaptive slicing of them parallel to screen. Equivalent mesh-based seen are more costly to render, more prone to aliasing. Moreover, Volumes allow to properly define the filtering of thin objects (which become fuzzy), see Figure 28. This work has been done by Philippe Decaudin and Fabrice Neyret before 2009, while they were members of the team.

6.4. Applications covered by this year's results

The above sections presented our research in terms of fundamental tools, models and algorithms. A complementary point of view is to describe it in terms of application domains. The following sections describe our contribution to each of these domains, with references to the tools we relied on if they were already presented above.

6.4.1. Interactive modeling systems

Participants: Adrien Bernhardt, Marie-Paule Cani, Jean-Rémy Chardonnet, Jean-Claude Léon, Adeline Pihuit.

Several of the tools we are developing are devoted to a new generation of interactive modeling systems, following our general methodology based on sculpting and sketching metaphors:

- The hand-on interface presented in Section 6.1.2 is dedicated to interactively deforming virtual objects, such as we do when we sculpt with clay in real;
- The sketching tools presented in Section 6.1.4 addressed both the design of general free form shapes and the combination of a sketch-based interface with a priori knowledge on the object being modeled. They are used in the industrial contract with Axiatex (see Section 7.2).

We are currently working at ways to combine both techniques, in order to inspire from sketching for initial shape design, and from sculpting techniques for further deformation.

6.4.2. Synthesis of natural scenes

Participants: Eric Bruneton, Marie-Paule Cani, Antoine Begault, Adyl Kenouche, Guillaume Piolat.

Many of the diverse fundamental tools we are developing (see Sections 6.3.4, 6.3.3) are contributing to the long term, general goal of modeling and animating natural scenes. Many of them have been combined to allow the large scale specification (up to whole planets), efficient rendering and animation of landscapes (see Section 5.4). A licence of this software has been sold to RSA Cosmos, a company developing digital planetariums. Proland is also used in the MarketSimGame project (see Section 7.4).

6.4.3. Medical applications

Participants: Guillaume Bousquet, Marie-Paule Cani, Florent Falipou, François Faure, Sahar Hassan, Franck Hétroy, Lenka Jeřábková, Olivier Palombi, Adeline Pihuit.

Some of our work on geometric modeling and physically-based animation has been successfully applied to the medical domain.

Our tools for efficient physically-based simulation, and in particular our new contributions to robust finite elements [10] (see section 6.2.1) are being used in the European medical project called *Passport for Liver Surgery* (see Section 8.1.1).

Moreover, the anatomical modeling system [11] presented in section 5.6 has raised a high interest at the workshop of the Virtual Physiological Human community.

6.4.4. Physical simulation

Participants: Guillaume Bousquet, Marie Durand, Florent Falipou, François Faure, François Jourdes.

Physical simulation has a growing importance in our activity. The scientific work of François Faure and the software development of SOFA (section 5.2) were mainly targeted at medical simulation in the recent years. However, interactive medical simulation is such a complex goal that the tools and methods developed to reach it such as complex materials and geometries [10], [14], [23] (sections 6.2.1 and 6.2.3), collision detection, parallelization [20] (section 6.2.2) have applications in other domains such as cloth simulation, sound synthesis, civil engineering (ANR Vucain, section 8.2.5 and BQR Fissures, section 8.3.2), discrete mechanics simulation (ANR RepDyn, section 8.2.6), and CAD (ANR Romma, section 8.2.7).

6.4.5. Scientific visualization

Participants: Sébastien Barbier, Georges-Pierre Bonneau, Christian Boucheny, Alexandre Coninx.

Our work on Visualization (see Sections 6.3.1 and 6.3.2) is applied by our current and former industrial partners from the energy sector, EDF R&D and CEA/CESTA, to improve the postprocessing of their data. The Eye Dome Lighting shading algorithm implemented during the PhD of Christian Boucheny will be made publicly available in the VTK library.

7. Contracts and Grants with Industry

7.1. Hand Navigator (09/2008-12/2009)

Participants: Marie-Paule Cani, Jean-Rémy Chardonnet, Jean-Claude Léon.

We were funded till December 2009 by the consortium GRAVIT, to prepare the industrialization of our new interaction device, the Hand-Navigator (see Section 6.1.2. A patent was issued in June 2008 by INRIA to protect this invention.

7.2. Axiatec (11/2009-04/2011)

Participants: Adrien Bernhardt, Marie-Paule Cani, Jean-Claude Léon, Adeline Pihuit.

The company Axiatec, which sells 3D printers in France, and for whom we designed the sketching software Azalic Studio, just started a new contract with us (December 2009-April 2011), to extend the software, which should be soon distributed to the public. The goal is to provide 3D modelling system based on a very intuitive sketch-based technique, in order to enable the general public to model 3D shapes. See section 6.1.4 for a description of our research work related to this project.

7.3. GENAC (09/2007-10/2010)

Participants: Michaël Adam, François Faure, Antonin Fontanille, Lionel Reveret.

The GENAC project is supported by the "Pôle de Compétitivité Imaginove" from Lyon. The goal of this project is to develop procedural tools for the animation of virtual characters and rendering of complex lighting in the specific case of video games. Participants are EVASION project, ARTIS project, LIRIS laboratory in Lyon 1, Eden Games and Widescreen Games (video games companies in Lyon). The role of EVASION is specifically to provide procedural tools to combine motion capture data and physical simulation of 3D characters. Works on compression of motion capture database by Maxime Tournier in his Master Research will be extended to integrate physical parameters. For this goal, Michaël Adam has achieved an adaptation of the SOFA library to handle articulated rigid body dynamics in the context of the GENAC project.

7.4. MarketSimGame (03/2008-07/2010)

Participants: Eric Bruneton, Adyl Kenouche, Guillaume Piolat.

The MarketSimGame project is a Serious Game project between 3 industrial partners (VSM, PointCube, Heliotrope) and INRIA. It is funded by the DGE ("Direction Générale des Entreprises") as a "Pôle de Compétitivité" project labelled by Imaginove and Pégase. It officially started on March 05, 2008, and will end on July 04, 2010 (28 months). The goal of this project is to develop a marketing tool to promote new or existing aircrafts, thanks to technico-economic simulations. The Serious Game aspect is used to get a better marketing impact. It involves a real-time 3D animation of the simulated aircraft over an existing landscape, which is implemented by using the Proland software (see Section 5.4).

8. Other Grants and Activities

8.1. European projects

8.1.1. PASSPORT (06/2008-05/2011)

Participants: Guillaume Bousquet, François Faure, Lenka Jeřábková.

The PASSPORT for Liver Surgery project (<http://www.passport-liver.eu/Homepage.html>) deals with the objectives of the Virtual Physiological Human ICT-2007.5.3 objective. PASSPORT's aim is to develop patient-specific models of the liver which integrates anatomical, functional, mechanical, appearance, and biological modelling. To these static models, PASSPORT will add dynamics liver deformation modelling and deformation due to breathing, and regeneration modelling providing a patient specific minimal safety standardized FLR. These models, integrated in the Open Source framework SOFA, will culminate in generating the first multi-level and dynamic "Virtual patient-specific liver" allowing not only to accurately predict feasibility, results and the success rate of a surgical intervention, but also to improve surgeons' training via a fully realistic simulator, thus directly impacting upon definitive patient recovery suffering from liver diseases.

8.2. National projects

8.2.1. ANR *Masse de données et simulation KAMELEON (01/2006-05/2009)*

Participants: Marie-Paule Cani, Franck Hétroy, Lionel Reveret.

This project started in 2006 and ended on May 2009. It addresses motion capture of small vertebrates. <http://www-evasion.imag.fr/people/Lionel.Reveret/kameleon>

8.2.2. ANR *Chênes et roseaux (01/2007-12/2009)*

Participant: Lionel Reveret.

This project started in 2007 and ends in December 2009. It addresses the modeling and measurement from video of fruit tree resistance to breaking under wind. http://www.ladhyx.polytechnique.fr/public_cr/index.html
A publication has been obtained at Eurographics 2009 [13].

8.2.3. ANR *Masse de données MADRAS (01/2008-12/2010)*

Participants: Romain Arcila, Franck Hétroy, Lionel Reveret.

This 3-year project, funded by ANR, started on January 1st, 2008. Its goal is threefold:

- create a repository of 3D and 3D+t mesh models, together with ground truth segmentations (either done manually or automatically)
- use human perception to enhance conception and evaluation of segmentation algorithms
- develop new segmentation techniques for 3D and 3D+t meshes, using human perception and results of subjective experiments

On this project, EVASION focuses on sequences of meshes evolving through time. Other partners are LIFL in Lille and LIRIS in Lyon. See <http://www-rech.telecom-lille1.eu/madras/> for more information.

8.2.4. ANR *Cheveux (01/2008-12/2010)*

Participants: Marie-Paule Cani, François Faure.

The ANR project Cheveux (january 2008 - december 2010) groups two partners from the industry, Neomis Animation (animation studio) and Beelight (graphics software company) with three research groupes from INRIA (BIPOP, EVASION, ARTIS) and one from CNRS (LMM). The goal is firstly to develop a Maya plugin from the super-helices model introduced in 2006 by INRIA and CNRS, and to propose some extensions, from improved animation methods to solutions for computing volumetric wisps geometry and for rendering non-photo-realistic hair-styles.

8.2.5. ANR *Vulcain (06/2008-06/2011)*

Participants: Marie Durand, François Faure.

We participate to the ANR Vulcain project (<http://vulcain.ujf-grenoble.fr/>), which purpose is to evaluate the vulnerability of buildings such as industrial facilities undergoing explosions of projectile impacts. Marie Durand is implementing discrete element models in GPU in order to speed up concrete fracturing simulations.

8.2.6. ANR RepDyn (01/2010-12/2012)

Participants: Marie Durand, François Faure.

We will participate to the ANR RepDyn project, starting at the beginning of 2010, in collaboration with CEA, EDF, Laboratoire de Mécanique des Structures Industrielles Durables (LaMSID), and ONERA. The purpose of this project is to enhance the performance of discrete elements and fluid computations, for the simulation of cracks in nuclear reactors or planes. Our task is to propose GPU implementations of particle models, as well as load balancing strategies in the context of multi-core, multi-GPU hardware. Marie Durand will be hired for this task, after the end of her task in the Vulcain project (section 8.2.5).

8.2.7. ANR ROMMA (01/2010-12/2013)

Participants: Georges-Pierre Bonneau, François Faure.

The ANR project ROMMA has been accepted in 2009. It will start in January 2010. The partners of this project are academic and industry experts in mechanical engineering, numerical simulation, geometric modeling and computer graphics. There are three academic members in the consortium: the LMT in Cachan, G-SCOP and LJK (EVASION and MGMI teams) in Grenoble. There are four industrial members: EADS, which coordinates the project, SAMTECH, DISTENE and ANTECIM. The aim of the project is to efficiently and robustly model very complex mechanical assemblies. We will work on the interactive computation of contacts between mechanical parts using GPU techniques. We will also investigate the visualization of data with uncertainty, applied in the context of the project.

8.3. Regional projects

8.3.1. BQR INP IDEAL (04/2009-09/2012)

Participants: Dobrina Boltcheva, Franck Hétroy, Jean-Claude Léon.

3D models, coming for instance from engineering fields, are often "idealized", or "simplified" (topologically speaking), in order to be used for simulation. The goal of this project IDEAL, funded by Grenoble INP, is to study these models, in particular the most general ones which are called "non-manifolds" and which are not handled by current softwares. We collaborate in this project with the University of Genova in Italy (Leila De Floriani).

8.3.2. BQR INP "Modèles multirésolutions de fissures" (04/2009-09/2012)

Participants: François Faure, Bui Huu Phuoc, Marie Durand.

A project on the simulation of fracture propagation in concrete structures has started, funded by INP Grenoble. The purpose is to develop a mixed, dynamic model of structures, using finite elements everywhere excepted near crack fronts, where a discrete model is applied. This goes beyond the ANR Vulcain project (section 8.2.5) because we want to dynamically switch between finite element and discrete models. Bui Huu Phoc has started a Ph.D. in October, co-tutored by Frederic Dufour and Vincent Richefeu, from the L3S-R CNRS laboratory, and François Faure from EVASION.

8.3.3. PPF "Multimodal interaction"

Participants: Adrien Bernhardt, Marie-Paule Cani, Adeline Pihuit.

As a team of the LJK laboratory, we participate to the PPF (plan pluri-formation) 'Multimodal interaction' funded by the four universities of Grenoble, with GIPSA-Lab, LIG, TIMC, LPNC. This year, we collaborated with Renaud Blanch from the IHM group of the LIG, on the evaluation of the sketching and sculpting systems we developed for creating 3D shapes. See http://www.icp.inpg.fr/PEGASUS/PPF_IM.html#mozTocId325800.

8.3.4. PPF "Maths-Computer science interfaces"

Participants: Romain Arcila, Franck Hétroy.

In this project we collaborate with a team from the GIPSA-Lab (Cédric Gérot and Annick Montanvert), to study and analyze animated meshes. We are particularly interested in defining comparison criteria to compare dynamic meshes.

8.3.5. LIMA "Loisirs et Images" (05/2007-05/2010)

Participants: Eric Bruneton, Marie-Paule Cani, François Faure, Lionel Reveret, Lucian Stanculescu.

LIMA (Loisirs et Images) is a Rhône-Alpes project in the ISLE cluster (Informatique, Signal, Logiciel Embarqué). It federates many laboratories of the Rhône-Alpes region (LISTIC, LIRIS, LIS, CLIPS, LIGIV, LTSI, ICA and LJK ARTIS, EVASION, LEAR, MOVI) around two research themes: analysis and classification of multimedia data, and computer graphics and computer vision. The objectives are to index multimedia data with "high level" indexes, and to produce, analyze, animate and visualize very large databases, such as very large natural scenes. We obtained a PhD grant, starting in October 2009, for Lucian Stanculescu for working on quality meshing of deforming shapes with Raphaëlle Chaine (LIRIS) and Marie-Paule Cani. LIMA also helped Maxime Tournier and Adeline Pihuit to get an Exploradoc grant this year.

8.4. Mobility grants

Participants: Adeline Pihuit, Maxime Tournier.

Each year several students get a regional Exploradoc grant to spend several months in another laboratory in another country. This year Maxime Tournier and Adeline Pihuit obtained Exploradoc grants to visit respectively Mc Gill University and the University of Montreal from April 16th to October 12th 2009.

8.5. Associate team

Together with the INRIA project BIPOP, we obtained an associate team called SHARE with the University of British Columbia (UBC) in Vancouver, Canada. This project has three foci:

- to design enriched geometric and mechanical models for the shape and motion of soft tissues, skin, cloth and hair;
- to significantly improve on existing models of human and animal motion;
- to model interaction between moving creatures and complex, realistic environments.

In 2009, several researchers from EVASION visited the University of British Columbia: Adrien Bernhardt, Marie-Paule Cani, Lionel Reveret and Damien Rohmer. In the meanwhile several researchers from UBC visited us: Drek Bradley, Tiberius Popa and Michiel van de Panne. It is also to note that Benjamin Gilles, who is postdoctoral researcher from UBC, came to join us and work with Lionel Reveret from January 1st 2009.

9. Dissemination

9.1. Leadership within the international scientific community

Marie-Paule Cani serves as **Director at large** within the executive committee of ACM SIGGRAPH (2008-2011). She was a member of the executive committee of the French chapter of Eurographics till November 2009. She is the vice president in charge of international affairs of the French computer graphics association (2008-2011).

Marie-Paule Cani has been since 2002 a steering committee member of the ACM-EG Symposium on Computer Animation, and was nominated in 2006 steering committee member of the IEEE Shape Modeling & Applications conference. She is also a member of the Eurographics Workshop Board, as a co-chair of the EG working group on Computer Animation. Lastly, she is co-chairing the EG working group on Sketch-Based Interfaces and Modeling.

François Faure has co-organized a tutorial on real-time physical simulation at the IEEE Virtual Reality 2009 conference(<http://conferences.computer.org/vr/2009/>).

9.2. Editorial boards and program committees

Editorial boards:

Marie-Paule Cani joined the editorial board of Computer Graphics Forum (the journal of the Eurographics association) in 2009.

Program Committees:

- Marie-Paule Cani participated to the following program committees in 2009: SBIM 2009, SCA 2009, EG 2010, SMI 2010.
- Georges-Pierre Bonneau participated to the following program committees: SIAM/ACM GPM 2009, IEEE Visualization 2009, SMI 2009.
- François Faure participated to the Eurographics 2010 International Program Committee.

9.3. Invited scientific conferences

Lionel Reveret has been invited by the Department of Ecology and Evolutionary Biology of Brown University to give a talk on "Dimensionality reduction for 3D modeling and animation of quadrupeds". This talk has also been given at UBC, Vancouver.

9.4. Large public conferences and meetings

- The software *Azalic Studio* and the interaction device *Hand-Navigator* presented, together with *Proland*, at Grenoble Innovation Fair.
- *Azalic Studio* was presented and used by school children, teenagers and the general public during the *Remue méninges* festival in April 2009 and the *Fête de la science* in November 2009.
- Franck Héroy organizes twice a year the pedagogical operation *MobiNet* for high-school classes during Grenoble INP "semaines découverte ingénieur".

9.5. Teaching & Administration

In addition to the regular teaching activities (UJF, Grenoble INP) of the faculty members, several researchers at EVASION taught some courses within the "Computer Science" Research Master, the "Mathematic Engineering" Master and to the 3rd year "Image and Virtual Reality" of Ensimag.

Marie-Paule Cani is responsible for the first year of studies at Grenoble INP - Ensimag.

Franck Héroy is responsible for the "Graphics, Vision and Robotics" branch of the Master of Science in Informatics at Grenoble (MoSIG). He is also responsible for Grenoble INP's virtual reality room ("Atelier de réalité virtuelle").

François Faure is taking the responsibility for the "Image and CAO" branch of the Master of Professional Applied Mathematics at UJF-Grenoble. Like every year, he was invited by the University of Vienna for a two weeks lecture on Computer Animation.

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