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 Report

2010

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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

Selected highlights:

- Jean-Rémy Chardonnet, Jean-Claude Léon and co-authors have received the Best Paper Award at the Virtual Reality International Conference for their Hand Navigator prototype which has been exhibited at Laval Virtual [19] and the Best Paper Award at ASME IDETC/CIE [20].
- Adeline Pihuit and co-authors have been nominated to the best paper award at the SBIM 2010 (Sketch Based Interface and Modeling). They received the second best paper aword for their work on on sketch-based modeling of vascular systems [23].
- Olivier Palombi defended his HDR (Habilitation à Diriger des Recherches) in November 2010 [2].
- Several team members have published their work at SIGGRAPH [4], SIGGRAPH-ASIA [14] and TOG [7] which are the most prestigious forums for researches in Computer Graphics.

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 7.1contracts and 8.1.1). 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: Guillaume Bousquet, Ali Hamadi Dicko, François Faure, Benjamin Gilles, François Jourdes.

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.

The flexibility and robustness allows the use of Sofa in various challenging applications. In collaboration with our colleagues in Computer Vision, we have published the framework of our SIGGRAPH 2009 Emerging Technologies a demo of real-time interactions with physical objects in virtual worlds [11], as illustrated in Figure 1, where SOFA is used as physical engine.

SOFA has been chosen as implementation platform by a start-up on cloth simulation, Bell Curves. An industrial contract with company MCE-5 for the application of SOFA in mechanical engineering simulations took place this summer. The creation of an INRIA start-up exploiting the SOFA technology is currently discussed.

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.

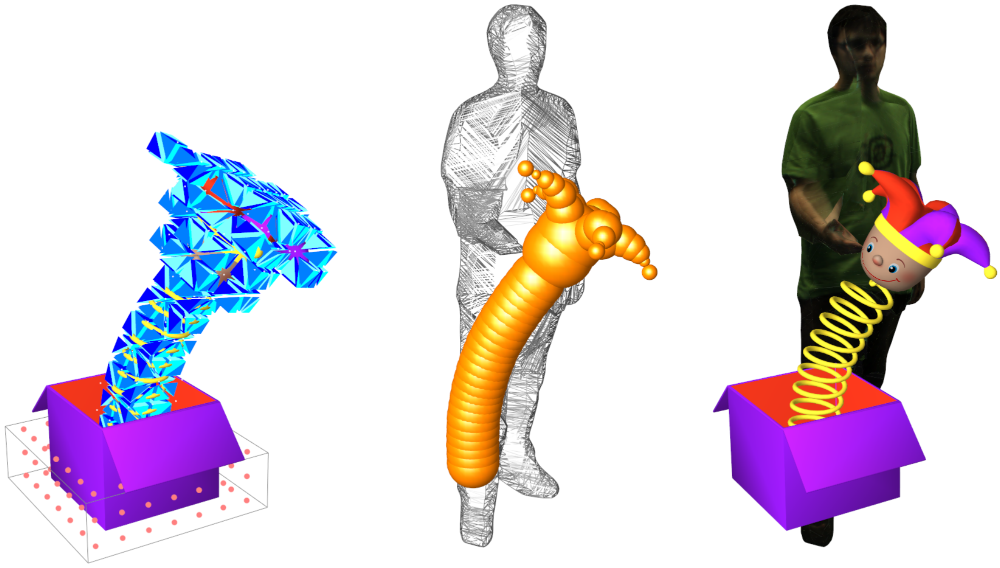

Figure 1. Physical interactions between a virtual object and the avatar of a user.

5.4. Proland

Participants: Eric Bruneton, Antoine Begault, Guillaume Piolat.

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 7.3). The goal of this platform is the real-time rendering and editing of large landscapes. The second version started in 2008 integrated a terrain renderer, billboard cloud forests, and atmospheric effects. 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 6.18). All features can work with planet-sized terrains, for all viewpoints from ground to space. Finally, Antoine Begault updated Proland to use OpenGL 3.3, and we released the lowest layer of Proland as an open source project called Ork (for OpenGL Rendering Kernel). For the MarketSimGame project, Guillaume Piolat ported Proland on ATI cards and drivers. A new Proland version has been deposited to APP this year (Deposit number IDDN.FR.001.390030.002.S.P.2008.000.31500).

5.5. AESTEM Studio

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

AESTEM 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. This software is developed in the framework of a research contract with the company Axiatec.It enables to create a 3D shape by successively painting in 2D and smoothly blending different components: the painting step takes place at different scales and from different viewing angles. 3D is inferred from a 2D painted region by using an isotropic implicit surface along the skeleton of the region. Then, implicit blending, restricted to the intersection areas, is computed to connect the new component with the existing ones. See Figure 3. This relies on our research on free-form sketch-based modeling using geometric skeletons and convolution surfaces. Our prototype is written in C++ as an extension of the Ogre open-source library. Future extensions will include the combination

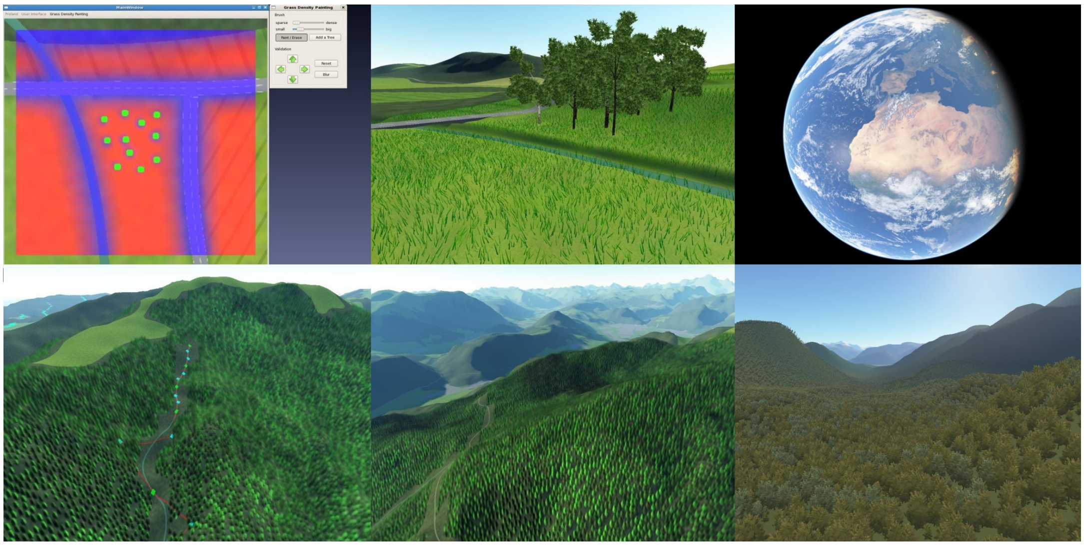

Figure 2. Proland software

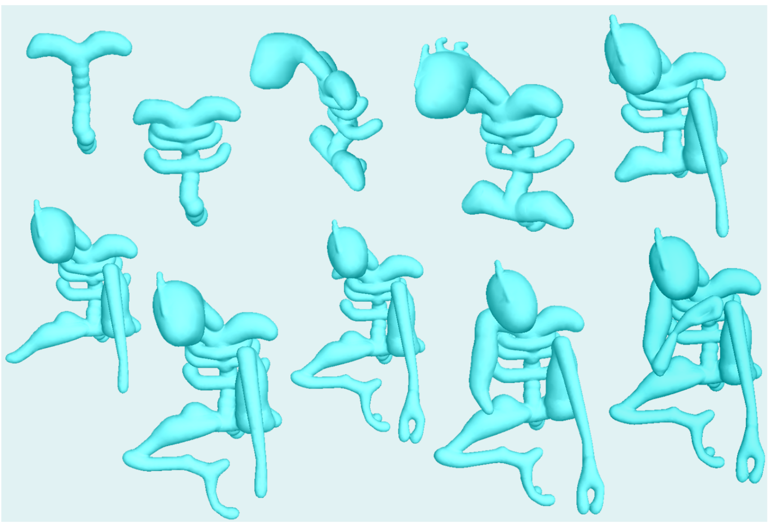

Figure 3. Interactive modelling using AESTEM Studio, our sketch-based modelling software: the different shape component are successively created using implicit surfaces and locally blended to the shape.

of sketching with modeling gestures related to clay sculpting, such as deforming a shape through pulling, pushing, bending or twisting gestures.

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.

6. New Results

6.1. HandNavigator

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

Figure 4. From left to right: new prototypes of the HandNavigator and an example of application to industrial assembly simulation

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

For the past two years, we focused on developing a peripheral device similar to a mouse, called the *HandNavigator*, enabling to control simultaneously ten or more degrees of freedom of a virtual hand. This device consists in a 3D mouse for the position and orientation of the hand in 3D space, enhanced with sensors for moving the virtual fingers. Thanks to a pre-industrialization project funded by the incubator GRAVIT, the first prototype, patented by INRIA, has been extended with the incorporation of new sensors and new shapes to improve the device efficiency.

This year, we focused on ergonomics to improve dexterity and allow the user accurate finger motion of the virtual hand. User tests were conducted to evaluate the different prototypes in terms of usability, performance and actual use. We demonstrated and presented them at Laval Virtual [19] and ASME International Design Engineering Technical Conference [20], where we received the Best Paper Award in both events. Also, a paper submitted to an international journal, Presence, is currently under review. Following the evaluation results, we focused on neuro-psycho-physiological aspects to develop a new prototype that includes tactile feedback through the integration of vibrators and pressure sensors under each finger. In parallel, we included collision detection in our application with both visual and tactile feedbacks to enhance the user's level of immersion in a virtual environment.

Note that this work is also part of our contribution to the PPF "Multimodal interaction" (see Section 8.1.3).

6.2. Implicit Modeling

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

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 genius, they have the ability to be constructed by successively blending different components, which eases interactive modelling tasks.

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. This is part of Adeline Pihuit's PhD Theses [3] and a joubnral paper had been submitted.

Secondly, we are currently collaborating with a researcher in formal computation, Evelyne Hubert, to improve and extend the analytical methods for computing closed form solutions for convolution surfaces. We are also using warping to extend the method to helical skeletons. Two papers paper were submitted for publication.

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 [5]. Sharp details can also be blended without blurring. The method is based on a transition between a clean union and a smooth blending operator, generated into a blending volume automatically computed around intersection curves. This revisited blending makes implicit surfaces much more usable for both constructive modeling and animation. See Figure 5.

Figure 5. Implicit surfaces generated using our new blending mechanism, where surfaces blend only where they intersect.

6.3. 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:

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. This work was supported by a direct industrial contract with Axiatec, leading to the development of the AESTEM studio software (see Section 5.5).

Another research direction is 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 human anatomy, as part of Adeline Pihuit's PhD thesis [3]. In particular, progresses were made for using the conventions of anatomical drawing to infer the 3D geometry of vascular systems, with branching and occlusions, from a single sketch [23].

We are also investigating the design of realistic terrains from a single sketch, within the PhD thesis of Adrien Bernhardt.

6.4. Geometrical methods for skinning and clothing animated characters

Participants: Marie-Paule Cani, Damien Rohmer.

Skinning, which consists in computing how the 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. Within Damien Rohmers PhD thesis, we proposed methods for fast contact-volume skinning [24] and for adding geometric wrinkles, aligned along the streamlines of a compression field, onto a coarse cloth animation. The geometry is generated using convolution surfaces as deformers for the mesh. This method was presented at SIGGRAPH Asia 2010 [13]. See figure 6.

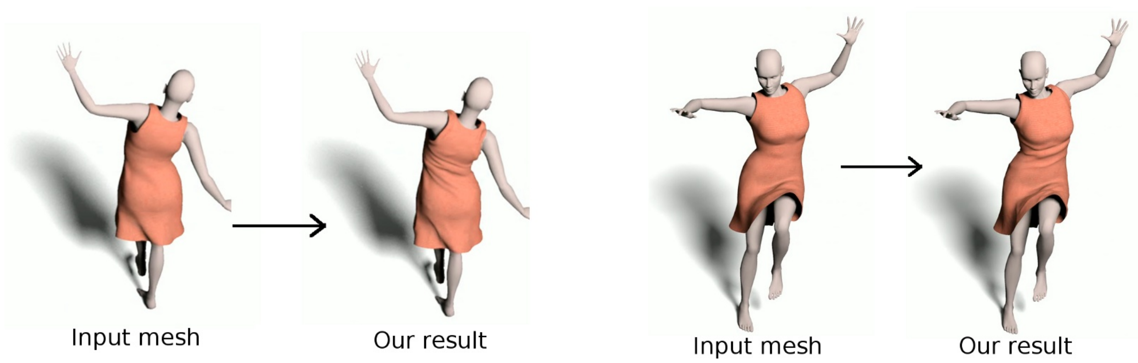

Figure 6. Animation wrinkling.

6.5. 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 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 [21]: 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.

6.6. Homology computation

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

This work is a part of the BQR project IDEAL (see Section 8.1.1) which is performed in collaboration with Leila de Floriani from the University of Genova in Italy. The main goal of this project is to study non-manifold geometrical models and to find out features allowing to classify these models and criteria for determining their shape. We are interested in non-manifold models such as idealized industrial CAD models, since they are still ill-understood even if they are frequently used in computer graphics and many engineering applications.

This year, we have worked on the computation of topological invariants on non-manifold simplicial complexes, such as the homology groups, since they play a crucial role in the field of shape description and analysis. The goal was also to acquire a better understanding of the behaviour of the homological groups on non-manifold models. A first step towards this goal has been achieved this year and we have developed an efficient method for computing the homology of a large simplicial complex from the homologies of its sub-complexes. This work has been already published in a research report [27] and a journal paper is currently under preparation.

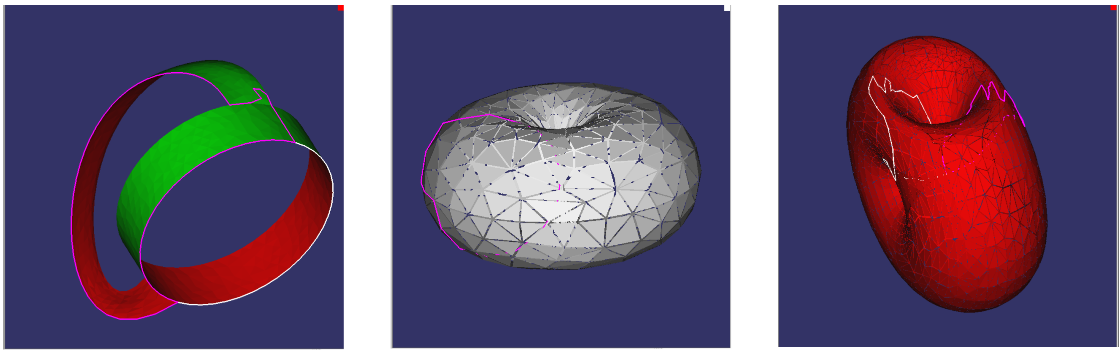

Figure 7. Example of homological generators computed on non-manifold complexes.

6.7. Mesh repair

Participant: Franck Hétroy.

This work is done in collaboration with Carlos Andujar, Pere Brunet and Alvar Vinacua from Universitat Politecnica 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 accepted for publication [9].

6.8. Robust finite elements for deformable solids

Participants: Guillaume Bousquet, François Faure, Benjamin Gilles.

In collaboration with the TIM-C lab, we have proposed and evaluated an automatic method for building meshes that are well adapted to interactive simulation starting from miscellaneous input data [10]. Contrary to commonly used methods based on tetrahedral volume meshing, the object is embedded in a regular grid of deformable hexahedra at an arbitrary resolution. This alleviates the complexities and limitations of tetrahedra and results in regular, well-conditioned meshes. Mass and stiffness are set in order to model the physical properties as accurately as possible at any given resolution, in a manner that takes into account the distribution of material within the hexahedra. This allows us to accurately model the mechanical properties of the partially empty boundary hexahedra, and thus enables us to perform fast simulation at a coarse resolution, as illustrated in Figure 8.

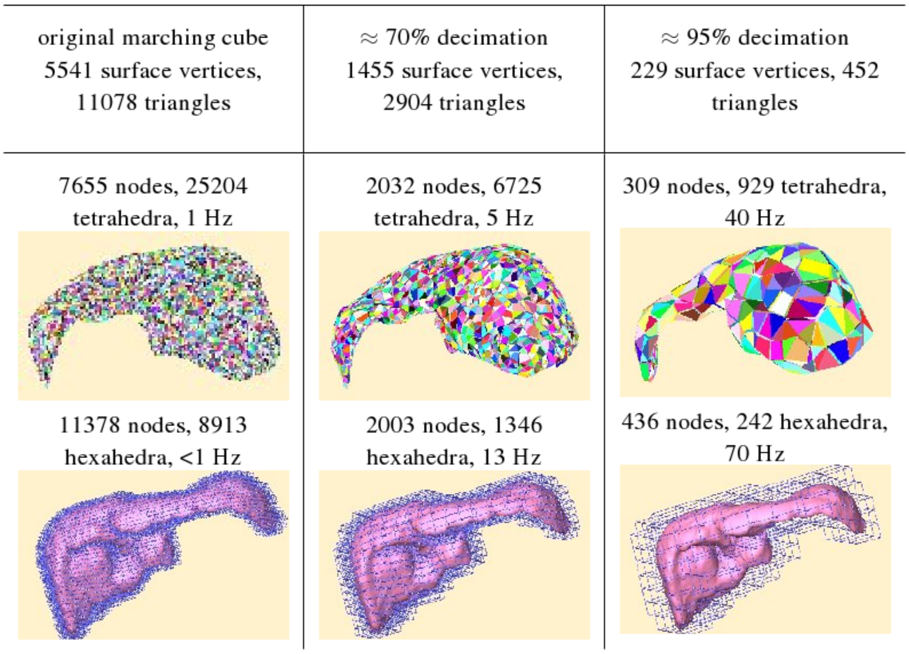

Figure 8. A deformable model using a traditionar tetrahedral mesh (top) and our regular grid (bottom).

6.9. High-Performance Simulation of Complex Models

Participants: Marie Durand, François Faure, Everton Hermann.

Everton Hermann is a Brasilian student funded by a Cordi grant and co-tutored by François Faure in EVASION and Bruno Raffin in MOAIS. He defended his Ph.D. thesis [1] in May and he was directly hired by UbiSoft, a big French videogame company, to set up a parallel computation framework for their new activity of movie making. We have proposed a hybrid CPU/multi-GPU parallelization of interactive physical simulations [22]. Our approach relies on a task parallelism where the code is instrumented to mark tasks and shared data between tasks, and the dynamic choice between CPU and GPU implementations. We have been able to obtain a nearly constant speed-up even when a large number of interactions take place, as illustrated in Figure 9.

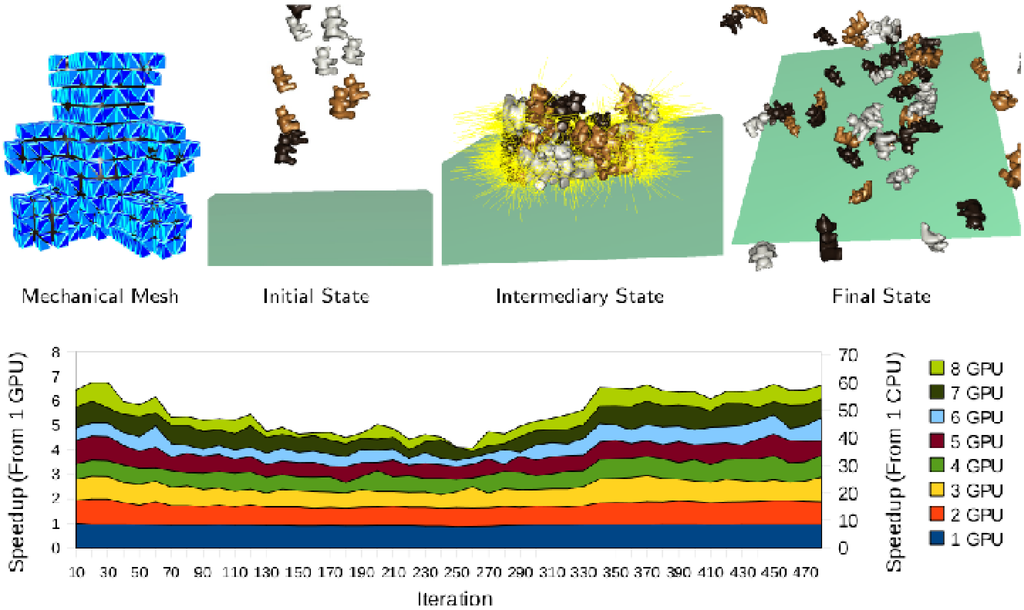

Figure 9. Multi-GPU simulation of an irregular and dynamic scene (top). The speedup (bottom) remains nearly constant even when a large number of interactions take place.

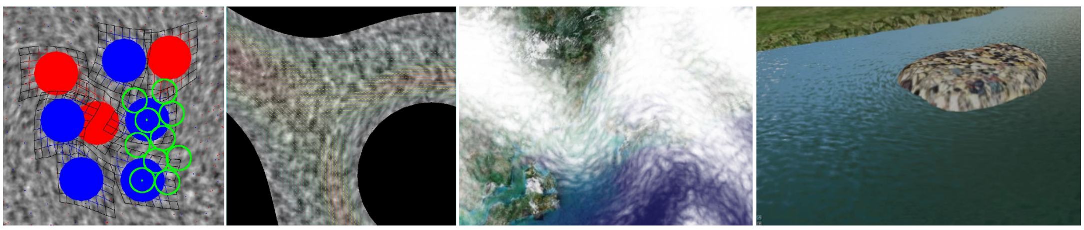

Figure 10. Our Lagrangian texture advection model allows local patches to be deformed and regenerated asynchronously. This yields a better conformance to the appearant flow and to the texture spectrum properties at the same time.

6.10. Lagrangian Texture Advection

Participant: Eric Bruneton.

An article has been accepted for publication in the IEEE journal Transactions on Visualization and Computer Graphics [16], on a Lagrangian texture advection model developped 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 distorsion metrics is passed. This Lagrangian approach solves the problem of local-adaptive regeneration rate, provide a better spectrum and better motion illusion, and avoid the burden of blending several layers (see Figure 10).

6.11. Motion capture and animation of vertebrates

Participants: Estelle Duveau, Benjamin Gilles, Olivier Palombi, Lionel Reveret, Mathieu Rodriguez.

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 anatomical models of animals on CT and MRI scan 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 methodology has also opened new projects : one is focusing on the modeling of walking birds and its potential to be morphed towards anatomy of biped dinosaurs to simulate their locomotion. Another one is focusing on the parameterization of quadrupeds locomotion. The CNES has selected this project to bring the study into micro gravity condition using their zeroG airplane facility. A new set-up adapted to the flight conditions has been built and used during two campaigns of parabolic flights. Data has been collected and will be analysed using markerless reconstruction techniques Estelle Duveau developped during a 6 month stay at the University of Bristish Columbia, working with Professor Dinesh K. Pai.

6.12. Character animation

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

We have presented a general method to intuitively create a wide range of locomotion controllers for 3D legged characters. 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. 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 research program has started with the MNHN to derive a 3D animation controller of quadrupeds from theoretical results obtained at the Museum on the description of quadruped gaits.

This year, Maxime Tournier extended his work on kinematic degrees of freedom reduction for the case of physically-based character animation, and is now finishing writing his PhD thesis. A biped balance controller prototype is being finalized for submission to a conference.

6.13. Modeling motion capture data of human

Participants: Simon Courtemanche, Lionel Reveret, Maxime Tournier, Franck Hétroy.

Works on mathematical modeling of quaternionic signals arising from motion capture have been investigate within the context of the ARC project Fantastik. These works have lead to two INRIA Research Report and one paper has been published at EG09[]. 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 been published at the IEEE Computer Graphics and Applications journal[]. 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.

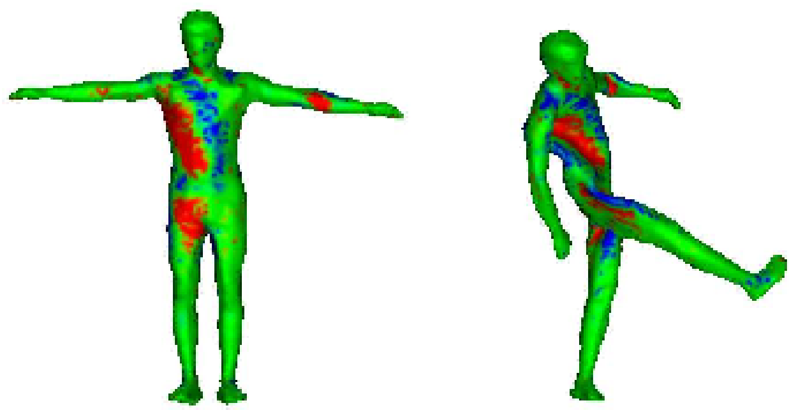

Figure 11. Modeling rock climbing gestures.

A project with Lionel Reveret and Franck Hétroy has been started on the caracterization of climbing gestures. A first data collection has been done with Simon Courtemanche, involved in this project both as a computer scientist and a competitor in rock climbing. Simon Courtemanche has worked on the analyse and the manipulation of these data during his M2R in Computer Graphics and is continuing this work for his PhD. This work is extended as a collaboration with Edmond Boyer from the PERCEPTION team.

6.14. Processing animated meshes

Participants: Romain Arcila, Franck Hétroy.

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 proposed this year a first motion-based segmentation algorithm, which clusters mesh vertices into static, rigid or homogeneously stretched components (see figure 12) [18]. A more robust and generale method to segment on the fly into almost-rigid clusters has been submitted. We also started to work with Ron Rensink from University of British Columbia (Vancouver, Canada) on the visual perception of mesh animations, in order to evaluate compression schemes.

6.15. Visualisation of large numerical simulation data sets

Participant: Georges-Pierre Bonneau.

Figure 12. Segmentation of a horse mesh sequence.

We have generalized in 3D our work on topology preserving simplification of tetrahedral meshes with embedded structures. The goal is to simplify huge tetrahedral meshes with hidden sub-structures that may be 1D or 2D. The topology of the global mesh as well as the topology of the substructures have to be preserved. Based on results of algebraic topology and a careful and efficient implementation we were able to derive an edge collapse criteria in order to properly simplify the meshes and the substructures. The mathematical proof of the underlying theory has been the result of a collaboration with Prof. Vijay Natarajan from the Indian Institute of SCience (IISc, Bangalore). This work has been published in a book chapter focusing on the implementation [26] and in a journal paper focusing on the mathematical theory and the applications [15].

6.16. Perceptive visualization

Participants: Georges-Pierre Bonneau, 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.

We have started in January 2010 a new PhD thesis by Alexandre Coninx. Alexandre is focusing his work on the visualization of data with uncertainty. He has developed a way to render the uncertainty of the data using a noise procedural function (Perlin noise). This has led to a precise psychometric study on the perception of Perlin noise. A poster on this subject has been presented in the conference "AVA Christmas meeting 2010" in december 2010.

6.17. Interface detection

Participants: Georges-Pierre Bonneau, Jean-Rémy Chardonnet.

In the framework of the ROMMA ANR project (see section 8.2.5), Jean-Remy Chardonnet has contributed to a method to compute the interfaces between a set of BRep objects. The method is a three step process. First the BRep are tessellated, then a GPU algorithm is used to compute the interfaces between the tessellations, eventually the discrete points of interfaces are glued together in contiguous region parametrized within the BRep structure. Specifically Jean-Remy Chardonnet has developed a plugin for the SOFA framework in order to read BRep objects in the STEP format. The OpenCascade library has been used to tessellate the BReps. Then a GPU collision algorithm from the SOFA project is used to compute discrete point on the interfaces. This work needs now to be pursued in order to achieve the third and last step of the process, where the discrete positions are converted to contiguous regions of interface.

6.18. Real-time realistic ocean lighting

Participant: Eric Bruneton.

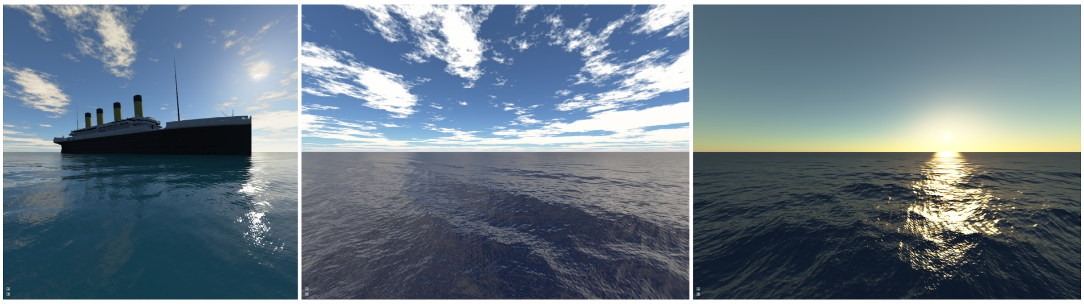

Figure 13. Some real-time results obtained with our ocean lighting algorithm, showing Sun reflections, sky reflections and local reflections from a boat. The lighting is correct at all distances thanks to accurate transitions from geometry to BRDF.

We developped 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 13). This work has been accepted at the Eurographics conference [6]. It has also been integrated in the Proland software (see Section 5.4). After this algorithm has been published, we improved it by using Tessendorf's method to synthesize the ocean surface (see Figure 13 right).

6.19. Sohusim

Participants: Ali Hamadi Dicko, François Faure, Benjamin Gilles.

Sohusim (Soft Human Simulation) is a ANR Project which started on October 1st 2010. It is done in collaboration between: EVASION (INRIA), Fatronik France (TECNALIA), DEMAR (INRIA), HPC PROJECT and the CHU de Montpellier.

This project deals with the problem of modeling and simulation of soft interactions between humans and objects. At the moment, there is no software capable of modeling the physical behavior of human soft tissues (muscles, fat, skin) in mechanical interaction with the environment. The existing software such as LifeMod or OpenSim, models muscles as links of variable length and applying a force to an articulated stiff skeleton. The management of soft tissues is not taken into account and does not constitute the main objective of this software.

A first axis of this project aims at the simple modeling and simulation of a passive human manipulated by a mecatronics device with for objective the study and the systems design of patient's manipulation with very low mobility (clinic bed). The second axis concentrates on the detailed modeling and the simulation of the interaction of an active lower limb with objects like orthesis, exoskeleton, clothes or shoes. The objective being there also to obtain a tool for design of devices in permanent contact with the human who allows determining the adequate ergonomics in terms of forms, location, materials, according to the aimed use.

Dicko Ali Hamadi is a Ph.D. student within EVASION team. His works turns around the problems in SOHUSIM project. He is co-tutored by François Faure and Olivier Palombi in EVASION and Gilles Benjamin in Fatronik (Tecnalia).

6.20. Collision detection and response

Participants: François Faure, Florent Falipou.

In collaboration with McGill, Montreal and INRIA-futurs, Lille, we have presented at SIGGRAPH 2010 a new method for simulating frictional contact between volumetric objects using interpenetration volume constraints [4]. When applied to complex geometries, our formulation results in dramatically simpler systems of equations than those of traditional mesh contact models. Contact between highly detailed meshes can be simplified to a single unilateral constraint equation, or accurately processed at arbitrary geometry-independent resolution with simultaneous sticking and sliding across contact patches. We exploit fast GPU methods for computing layered depth images, which provides us with the intersection volumes and gradients necessary to formulate the contact equations as linear complementarity problems. Straightforward and popular numerical methods, such as projected Gauss-Seidel, can be used to solve the system. This approach allows us to perform challenging simulations in real-time, as illustrated in Figure 14.

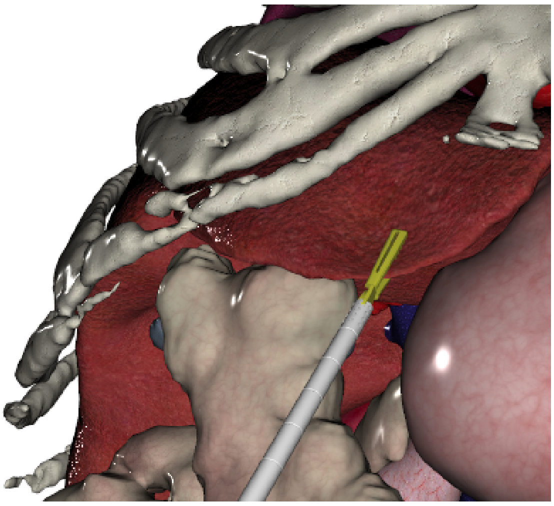

Figure 14. Friction-based grasping and pulling of a deformable liver in an interactive simulation.

6.21. Pre-filtering of complex surfaces

Participant: Eric Bruneton.

A fundamental problem in Computer Graphics, still largely unsolved, is the rendering of very large scenes or highly detailed objects, when many primitives project in a single pixel. A high quality rendering requires an integration over all these primitives, taking self-shadowing and self-masking into account. But an efficient rendering requires the evaluation of a single sample per pixel. In this context we studied two specific cases. Arianna Tampoch, during her Master Thesis, studied the analytic pre-filtering of surfaces made of regular patterns, like building facades. We also studied the pre-filtering of horizon maps, used to compute self-shadows on terrains. The results were not conclusive enough to be published, but this led us to write a survey about the non-linear pre-filtering methods used for normal maps, horizon maps, shadow maps, etc. This survey has been submitted to Transactions on Visualization and Computer Graphics.

6.22. Frame-based simulation of deformable solids

Participants: Guillaume Bousquet, François Faure, Benjamin Gilles.

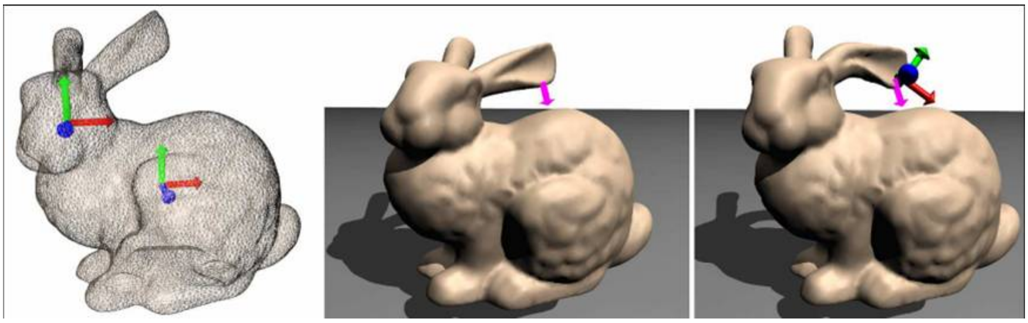

Figure 15. Frame-based simulation of deformable solids

We present a new type of deformable model which combines the realism of physically based continuum mechanics models and the usability of frame-based skinning methods [7]. The degrees of freedom are coordinate frames (see Figure 15). In contrast with traditional skinning, frame positions are not scripted but move in reaction to internal body forces. The displacement field is smoothly interpolated using blending techniques such as dual quaternions . The deformation gradient and its derivatives are computed at each sample point of a deformed object and used in the equations of Lagrangian mechanics to achieve physical realism. This allows easy and very intuitive definition of the degrees of freedom of the deformable object. The meshless discretization allows on-the-fly insertion of frames to create local deformations where needed. We formulate the dynamics of these models in detail and describe some pre-computations that can be used for speed. We show that our method is effective for behaviors ranging from simple unimodal deformations to complex realistic deformations comparable with Finite Element simulations. To encourage its use, the software is freely available in the simulation platform SOFA.

7. Contracts and Grants with Industry

7.1. 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 Aestem 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 6.3 for a description of our research work related to this project.

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

Participants: 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, we have achieved an adaptation of the SOFA library to handle articulated rigid body dynamics in the context of the GENAC project.

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

Participants: Eric Bruneton, 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).

7.4. EDF R&D (2009-2012)

Participants: Georges-Pierre Bonneau, Alexandre Coninx.

Perception-based visualization, accompanying contracts of two CIFRE PhD grants.

7.5. MCE-5 (2010-2011)

Participants: François Faure, Jean-Rémy Chardonnet.

Application of SOFA to MCE-5 VCRi engine's movements.

8. Other Grants and Activities

8.1. Regional Initiatives

8.1.1. 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).

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

Participants: Marie Durand, François Faure.

A project on the simulation of fracture propagation in concrete structures has started, funded by INP Grenoble. The puropose is to develop a mixed, dynamic model of structures, using finite elements everywhere excepted near crak fronts, where a discrete model is applied. This goes beyond the ANR Vulcain project (section 8.2.3) 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.

8.1.3. PPF "Multimodal interaction”

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

As a team of the LJK laboratory, we participle 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 IIHM 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.

8.1.4. 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.

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

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

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.

8.2. National Initiatives

8.2.1. ANR Masse de données MADRAS (01/2008-09/2011)

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.

8.2.2. ANR Cheveux (01/2008-03/2011)

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.

8.2.3. 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.

8.2.4. 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 has started a PhD thesis on this task.

8.2.5. 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.

8.2.6. ANR jeune chercheur: SimOne (12/2010-12/2013)

Participants: Eric Bruneton, Manuel Vennier.

We are funded by the ANR research program "jeune chercheur" (grants for young researchers) for a joint research project with the *ARTIS* INRIA project-team. The goal of this project is to develop "Scalable Interactive Models Of Nature on Earth" (including shape, motion and illumination models for ocean, clouds, and vegetation). The grant started in December 2010, for 36 months.

8.2.7. ANR CONTINT: RTIGE (12/2010-12/2014)

Participant: Eric Bruneton.

We are funded by the ANR CONTINT (Contents and Interactions) research program, for a joint research project with the *ARTIS* INRIA project-team, the *GEPI* and *LERMA* research teams at Paris Observatory, and the RSA Cosmos company. The goal of this project is to develop a "Real-Time and Interactive Galaxy for Edutainment", in particular for digital planetariums. The grant started in December 2010, for 48 months.

8.2.8. ANR Sohusim (2010-2014)

Participants: Ali Hamadi Dicko, François Faure, Benjamin Gilles.

This project deals with the problem of modeling and simulating the mechanical interaction between human soft tissues and medical devices.

8.2.9. ANR Morpho (2010-2014)

Participants: Simon Courtemanche, Franck Hétroy, Lionel Reveret.

The ANR project Morpho is a collaboration between GIPSA Lab in Grenoble and 3 INRIA teams: EVASION and PERCEPTION in Grenoble and ALICE in Nancy. The project is aimed at designing new tools and technologies for the measure and the analysis of human shapes and motions using visual data.

8.2.10. Descartes (Direct founding 2010-2015)

Participants: Estelle Duveau, Lionel Reveret, Mathieu Rodriguez.

The project is in collaboration with Descartes University and CNES. The goal is to study vestibular control of skeletal postures of mouses, with and without gravity.

8.2.11. PlantScan3D (ARC INRIA 09/2009-09/2011)

Participants: Dobrina Boltcheva, Marie-Paule Cani, Franck Hétroy, Cédric Zanni.

This project is in collaboration with Vitual Plants and Galaad teams. Its objective is to develop the use of laser scanner for plant geometry reconstruction, in partnership with biologists-agronomists from several teams in France and Europe.

8.3. European Initiatives

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

Participants: Guillaume Bousquet, François Faure.

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.

8.4. International Initiatives

- I-MAGE (INRIA associate team, 2005-2008) with the DGP laboratory of the University of Toronto.
- Share (INRIA associate team, 2009-2011): together with the INRIA project BIPOP, we obtained an associate team funding to work with the University of Vancouver.

9. Dissemination

9.1. Animation of the scientific community

9.1.1. Organisation of Conferences

- SIGGRAPH Asia Sketches & Poster program, Marie-Paule Cani, co-chair, 2010.
- ACM-EG Symposium on Computer Animation (SCA), François Faure, conference co-chair, 2010.
- ACM-EG Sketch-based Interfaces and Modeling (SBIM), Jean-Claude Léon, conference co-chair, 2010.

9.1.2. Programm committees

Members of the project team participated to the program committees of: SGP 2009 and 2010, SBIM 2007 to 2010, SCA 2007 to 2010, EUROGRAPHICS 2007 to 2010, SMI 2008 and 2010, SPM 2007 and 2008, SIGGRAPH 2007, EG PGV 2007, VRYPHIS 2007 to 2010.

9.1.3. Management and Administration of Scientific Organisations

- Director at Large within the ACM SIGGRAPH executive committee, Marie-Paule Cani, 2008-2011.
- Steering committee of ACM-EG Symposium on Computer Animation (SCA), Marie-Paule Cani until 2010.
- Vice president of AFIG (Association Française d'Informatique Graphique) in charge of international issues, Marie-Paule Cani, 2008-2011.

9.2. Educational activities

9.2.1. Responsabilities of academic programs

- ENSIMAG/INPG 1A, Marie-Paule Cani, since 2007-2010.
- UJF "Ingénierie de l'Image et de la CAO", Mastère 2 Professionnel, François Faure, 2008-2010.
- Graphics, Vision and Robotics, program of the M2R MOSIG, Franck Hétroy, 2008-2010.
- PerForm (conception of new pedagogical practices) ENSIMAG/INPG, Franck Hétroy, 2007-2010.

9.2.2. Teaching

- Georges-Pierre Bonneau, 200 hours a year, Polytech'Grenoble RICM and UFR IMA, L3, M1, M2, UJF
- Marie-Paule Cani, 200 hours a year, ENSIMAG/INPG (years 1 to 3), M1R MOSIG (INPG/UJF)
- François Faure, 200 hours a year, L3, M1, M2 pro, M2 research, UJF
- Franck Hetroy, 220 hours a year, ENSIMAG/INPG (years 1 to 3)
- Olivier Palombi, 200 hours a year, UFR medicine UFF: L1, L2, M1 Master Ingénierie pour la santé, UJF
- Lionel Reveret, 200 hours a year, ENSIMAG/INPG (years 2 and 3), M2R MOSIG (INPG/UJF).

Note that MOSIG is joint master program between University Joseph Fourier (UJF) and Institut Polytechnique de Grenoble (INPG) taught in English since it hosts a number of internal students. If belongs to the doctoral school MSTII.

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Publications of the year

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