IN PARTNERSHIP WITH:
Université Rennes 1

Université Haute Bretagne (Rennes 2)

Activity Report 2012

Team MIMETIC

Analysis-Synthesis Approach for Virtual Human Simulation

IN COLLABORATION WITH: Institut de recherche en informatique et systèmes aléatoires (IRISA)

RESEARCH CENTER
Rennes - Bretagne-Atlantique

THEME
Interaction and Visualization

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Team MIMETIC

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1. Members

Research Scientists

Stéphane Donikian [Inria Senior Researcher, CEO of Golaem company]
Julien Pettré [Inria Research Scientist]

Faculty Members

Franck Multon [Team Leader, Professor Univ. Rennes 2, HdR]
Benoit Bideau [Associate Professor Univ. Rennes 2, HdR]
Nicolas Bideau [Associate Professor Univ. Rennes 2]
Marc Christie [Associate Professor, Univ. Rennes 1]
Armel Crétual [Associate Professor Univ. Rennes 2, HdR]
Fabrice Lamarche [Associate Professor, Univ. Rennes 1]
Guillaume Nicolas [Associate Professor Univ. Rennes 2]
Richard Kulpa [Associate Professor Univ. Rennes 2]

Engineers

Emmanuel Badier [Tango project]
Julian Joseph [Tango project]
Orianne Siret [iSpace & Time project]

PhD Students

Thomas Lopez [MNERT Grant, HdR]
Antoine Marin [Biofeedback project]
Sébastien Brault [ENS Cachan grant]
Anthony Sorel [Cifre convention with Artefacto company, HdR]
Christophe Lino [Univ. Nantes and Inria]
Edouard Auvinet [Cifre convention and co-supervision with U. Montreal, HdR]
Anne-Marie Burns [Biofeedback project]
Samuel Lemercier [Pedigree project, HdR]
Jonathan Perrinet [Tango project]
Philippe Rannou [ENS Cachan grant]
Carl-Johan Jorgensen [iSpace & Time project]
Kevin Jordao [Chrome grant, HdR]
Cunka Sanokho [Cinecitta grant, HdR]
David Wolinski [MNERT Grant, HdR]
Steve Tonneau [MNERT Grant]
Kristell Bervet [Cifre convention, HdR]

Post-Doctoral Fellows

Yi Li [Inria,Carnot]
Anne-Hélène Olivier [Inria,Tango project]

Administrative Assistant

Nathalie Denis

2. Overall Objectives

2.1. Presentation

MimeTIC is a multidisciplinary team whose aim is to better understand and model human activity in order to simulate realistic autonomous virtual humans: realistic behavior, realistic motions and realistic interactions with other characters and users. It leads to modeling the complexity of a human body, his environment where he can pick-up information and he can act on it. A specific focus is dedicated to human physical activity and sports as it raises the highest constraints and the highest complexity when addressing these problems. Thus, MimeTIC is composed of experts in computer science and whose research interests are computer animation, behavioral simulation, motion simulation, crowds and interaction between real and virtual humans. MimeTIC is also composed of experts in sports science, motion analysis, motion sensing, biomechanics and motion control (M2S, joint lab. with University Rennes2, ENS Cachan and University Rennes1). Hence, the scientific foundations of MimeTIC are motion sciences (biomechanics, motion control, perception-action coupling, motion analysis), computational geometry (modeling of the 3D environment, motion planning, path planning) and design of protocols in immersive environments (use of virtual reality facilities to analyze human activity).

Thanks to these skills, we wish to reach the following objectives: to make virtual human behave, move and interact in a natural manner in order to increase immersion and to improve knowledge on human motion control. In real situations (see figure 1), people have to deal with their physiological, biomechanical and neurophysiological capabilities in order to reach a complex goal. Hence MimeTIC addresses the problem of modeling the anatomical, biomechanical and physiological properties of human being. Moreover this character has to deal with his environment. Firstly he has to perceive this environment and pick-up relevant information. MimeTIC thus addresses the problem of modeling the environment including its geometry and associated semantic information. Secondly, he has to act on this environment to reach his goal. It leads to cognivitve processes, motion planning, joint coordination and force production in order to act on this environment.

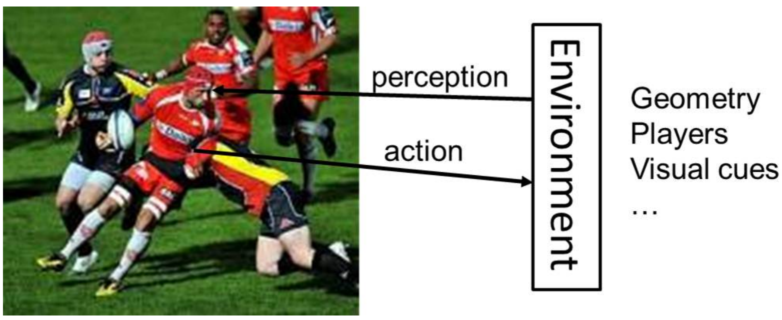

Figure 1. Main objective of MimeTIC: better understand human activity in order to better simulate virtual humans. It leads to modeling the complexity of human body, his environment where he can pick-up information and he can act on it.

In order to reach the above objectives, MimeTIC has to address three main challenges:

- dealing with the intrinsic complexity of human being, especially when addressing the problem of interactions between people for which it is impossible to predict and model all the possible states of the system,
- making the different components of human activity control (such as the biomechanical and physical, the reactive, cognitive, rational and social layers) interact while each of them is modeled with completely different states and time sampling,

- and being able to measure human activity while dealing with the compromise between ecological and controllable protocols, and to be able to extract relevant information in wide databases of information.

Contrary to many classical approaches in computer simulation, which mostly propose simulation without trying to understand how real people do, the team promotes a coupling between human activity analysis and synthesis, as shown in figure 2.

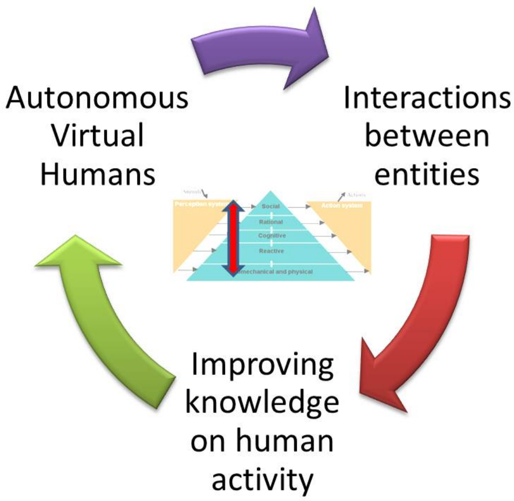

Figure 2. Research path of MimeTIC: coupling analysis and synthesis of human activity. Analysis provides us with more realistic autonomous characters and synthesis enables us to evaluate assumption about human motion control.

In this research path, improving knowledge on human activity enables us to highlight fundamental assumptions about natural control of human activities. These contributions can be promoted in biomechanics, motion sciences, neurosciences, *etc.* According to these assumptions we propose new algorithms for controlling autonomous virtual humans. The virtual humans can perceive their environment and decide of the most natural action to reach a given goal. This work is promoted in computer animation, virtual reality and has some applications in robotics through collaborations. Once autonomous virtual humans have the ability to act as real humans should do in the same situation, it is possible to make them interact with other autonomous characters (for crowds or group simulations) and with real users. The key idea here is to analyze to what extent the assumptions proposed at the first stage lead to natural interactions with real users. This process enables the validation of both our assumptions and our models.

Among all the problems and challenges described above, MimeTIC focuses on the following domains of research:

- motion sensing which is a key issue to extract information from raw motion capture systems and thus to propose assumptions on how people control their activity,
- human activity & virtual reality, which is explored through sports application in MimeTIC, enables us to design new methods for analyzing the perception-action coupling in human activity, and to validate whether the autonomous characters lead to natural interactions with users,
- crowds and groups simulation which is dedicated to model the interactions in small groups of individuals and to see how to extend to larger groups, such as crowds with lot of individual

variability,

- virtual storytelling which enables us to design and simulate complex scenarios involving several humans who have to satisfy numerous complex constraints (such as adapting to the real-time environment in order to play an imposed scenario), and to design the coupling with the camera scenario to provide the user with a real cinematographic experience,
- biomechanics which is essential to offer autonomous virtual humans who can react to physical constraints in order to reach high-level goals, such as maintaining balance in dynamic situation or selecting a natural motor behavior among all the theoretical solution space for a given task,
- and autonomous characters which is a transversal domain that can reuse the results of all the other domains to make these heterogeneous assumptions and models provide the character with natural behaviors and autonomy.

2.2. Highlights of the Year

- Franck Multon co-organized (with Pr. Qunsheng Peng) the 3rd sino-French symposium on computer graphics and virtual reality in QingDao, China, June 18-21 2012 in coordination with the 17th National Chinese Conference on CAD&CG and the Ninth National Conference on Intelligent CAD and Digital Entertainment
- Organization of the 5th international conference on Motion in Games in Rennes, France, November 15-17, 2012. http://mig2012.inria.fr/.
- HDR defense of Benoit Bideau entitled "Biomécanique du mouvement et interactions sportives", Nov 19th, 2012.

3. Scientific Foundations

3.1. Biomechanics and Motion Control

Human motion control is a very complex phenomenon that involves several layered systems, as shown in figure 3. Each layer of this controller is responsible for dealing with perceptual stimuli in order to decide the actions that should be applied to the human body and his environment. Due to the intrinsic complexity of the information (internal representation of the body and mental state, external representation of the environment) used to perform this task, it is almost impossible to model all the possible states of the system. Even for simple problems, there generally exist infinity of solutions. For example, from the biomechanical point of view, there are much more actuators (i.e. muscles) than degrees of freedom leading to infinity of muscle activation patterns for a unique joint rotation. From the reactive point of view there exist infinity of paths to avoid a given obstacle in navigation tasks. At each layer, the key problem is to understand how people select one solution among these infinite state spaces. Several scientific domains have addressed this problem with specific points of view, such as physiology, biomechanics, neurosciences and psychology.

In biomechanics and physiology, researchers have proposed hypotheses based on accurate joint modeling (to identify the real anatomical rotational axes), energy minimization, force and torques minimization, comfort maximization (i.e. avoiding joint limits), and physiological limitations in muscle force production. All these constraints have been used in optimal controllers to simulate natural motions. The main problem is thus to define how these constraints are composed altogether such as searching the weights used to linearly combine these criteria in order to generate a natural motion. Musculoskeletal models are stereotyped examples for which there exist infinity of muscle activation patterns, especially when dealing with antagonist muscles. An unresolved problem is to define how using the above criteria to retrieve the actual activation patterns while optimization approaches still lead to unrealistic ones. It is still an open problem that will require multidisciplinary skills including computer simulation, constraint solving, biomechanics, optimal control, physiology and neurosciences.

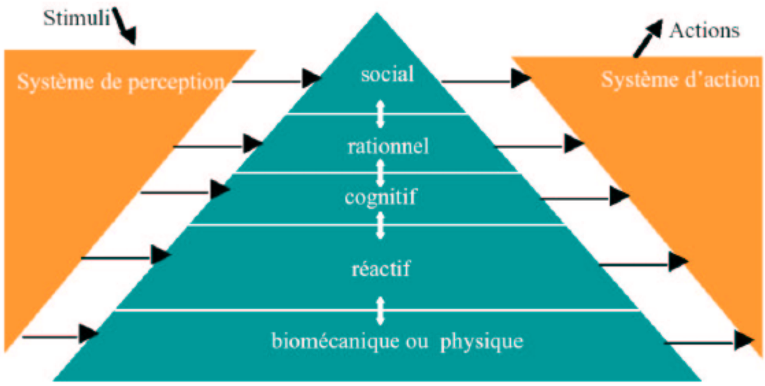

Figure 3. Layers of the motion control natural system in humans.

In neuroscience, researchers have proposed other theories, such as coordination patterns between joints driven by simplifications of the variables used to control the motion. The key idea is to assume that instead of controlling all the degrees of freedom, people control higher level variables which correspond to combination of joint angles. In walking, data reduction techniques such as Principal Component Analysis have shown that lower-limb joint angles are generally projected on a unique plan whose angle in the state space is associated with energy expenditure. Although there exists knowledge on specific motion, such as locomotion or grasping, this type of approach is still difficult to generalize. The key problem is that many variables are coupled and it is very difficult to objectivly study the behavior of a unique variable in various motor tasks. Computer simulation is a promising method to evaluate such type of assumptions as it enables to accurately control all the variables and to check if it leads to natural movements.

Neurosciences also address the problem of coupling perception and action by providing control laws based on visual cues (or any other senses), such as determining how the optical flow is used to control direction in navigation tasks, while dealing with collision avoidance or interception. Coupling of the control variables is enhanced in this case as the state of the body is enriched by the big amount of external information that the subject can use. Virtual environments inhabited with autonomous characters whose behavior is driven by motion control assumptions is a promising approach to solve this problem. For example, an interesting problem in this field is navigation in an environment inhabited with other people. Typically, avoiding static obstacles together with other people displacing into the environment is a combinatory problem that strongly relies on the coupling between perception and action.

One of the main objectives of MimeTIC is to enhanche knowledge on human motion control by developing innovative experiments based on computer simulation and immersive environments. To this end, designing experimental protocols is a key point and some of the researchers in MimeTIC have developed this skill in biomechanics and perception-action coupling. Associating these researchers to experts in virtual human simulation, computational geometry and constraints solving enable us to contribute to enhance fundamental knowleged in human motion control.

3.2. Experiments in Virtual Reality

Understanding interaction between humans is very challenging because it addresses many complex phenomena including perception, decision-making, cognition and social behaviors. Moreover, all these phenomena are difficult to isolate in real situations, it is thus very complex to understand the influence of each of them on the interaction. It is then necessary to find an alternative solution that can standardize the experiments and that allows the modification of only one parameter at a time. Video was first used since the displayed experiment is perfectly repeatible and cut-offs (stop the video at a specific time before its end) allow having temporal information. Nevertheless, the absence of adapted viewpoint and stereoscopic vision does not provide depth information that are very meaningful. Moreover, during video recording session, the real human is acting in front of a camera and not an opponent. The interaction is then not a real interaction between humans.

Virtual Reality (VR) systems allow full standardization of the experimental situations and the complete control of the virtual environment. It is then possible to modify only one parameter at a time and observe its influence on the perception of the immersed subject. VR can then be used to understand what information are picked up to make a decision. Moreover, cut-offs can also be used to obtain temporal information about when these information are picked up. When the subject can moreover react as in real situation, his movement (captured in real time) provides information about his reactions to the modified parameter. Not only is the perception studied, but the complete perception-action loop. Perception and action are indeed coupled and influence each other as suggested by Gibson in 1979.

Finally, VR allows the validation of the virtual human models. Some models are indeed based on the interaction between the virtual character and the other humans, such as a walking model. In that case, there are two ways to validate it. First, they can be compared to real data (e.g. real trajectories of pedestrians). But such data are not always available and are difficult to get. The alternative solution is then to use VR. The validation of the realism of the model is then done by immersing a real subject in a virtual environment in which a virtual character is controlled by the model. Its evaluation is then deduced from how the immersed subject reacts when interacting with the model and how realistic he feels the virtual character is.

3.3. Computational geometry

Computational geometry is a branch of computer science devoted to the study of algorithms which can be stated in terms of geometry. It aims at studying algorithms for combinatorial, topological and metric problems concerning sets of points in Euclidian spaces. Combinatorial computational geometry focuses on three main problem classes: static problems, geometric query problems and dynamic problems.

In static problems, some input is given and the corresponding output needs to be constructed or found. Such problems include linear programming, Delaunay triangulations, and Euclidian shortest paths for instance. In geometric query problems, commonly known as geometric search problems, the input consists of two parts: the search space part and the query part, which varies over the problem instances. The search space typically needs to be preprocessed, in a way that multiple queries can be answered efficiently. Some typical problems are range searching, point location in a portioned space, nearest neighbor queries for instance. In dynamic problems, the goal is to find an efficient algorithm for finding a solution repeatedly after each incremental modification of the input data (addition, deletion or motion of input geometric elements). Algorithms for problems of this type typically involve dynamic data structures. Both of previous problem types can be converted into a dynamic problem, for instance, maintaining a Delaunay triangulation between moving points.

The Mimetic team works on problems such as crowd simulation, spatial analysis, path and motion planning in static and dynamic environments, camera planning with visibility constraints for instance. The core of those problems, by nature, relies on problems and techniques belonging to computational geometry. Proposed models pay attention to algorithms complexity to propose models compatible with performance constraints imposed by interactive applications.

4. Application Domains

4.1. Motion Sensing

Recording human activity is a key point of many applications and fundamental works. Numerous sensors and systems have been proposed to measure positions, angles or accelerations of the user's body parts. Whatever the system is, one of the main is to be able to automatically recognize and analyze the user's performance according to poor and noisy signals. Human activity and motion are subject to variability: intra-variability due to space and time variations of a given motion, but also inter-variability due to different styles and anthropometric dimensions. MimeTIC has addressed the above problems in two main directions.

Firstly, we have studied how to recognize and quantify motions performed by a user when using accurate systems such as Vicon (product of Oxford Metrics) or Optitrack (product of Natural Point) motion capture systems. These systems provide large vectors of accurate information. Due to the size of the state vector (all the degrees of freedom) the challenge is to find the compact information (named features) that enables the automatic system to recognize the performance of the user. Whatever the method is used, finding these relevant features that are not sensitive to intra-individual and inter-individual variability is a challenge. Some researchers have proposed to manually edit these features (such as a Boolean value stating if the arm is moving forward or backward) so that the expertise of the designer is directly linked with the success ratio. Many proposals for generic features have been proposed, such as using Laban notation which was introduced to encode dancing motions. Other approaches tend to use machine learning to automatically extract these features. However most of the proposed approaches were used to seek a database for motions which properties correspond to the features of the user's performance (named motion retrieval approaches). This does not ensure the retrieval of the exact performance of the user but a set of motions with similar properties.

Secondly, we wish to find alternatives to the above approach which is based on analyzing accurate and complete knowledge on joint angles and positions. Hence new sensors, such as depth-cameras (Kinect, product of Microsoft) provide us with very noisy joint information but also with the surface of the user. Classical approaches would try to fit a skeleton into the surface in order to compute joint angles which, again, lead to large state vectors. An alternative would be to extract relevant information directly from the raw data, such as the surface provided by depth cameras. The key problem is that the nature of these data may be very different from classical representation of human performance. In MimeTIC, we try to address this problem in specific application domains that require picking specific information, such as gait asymmetry or regularity for clinical analysis of human walking.

4.2. VR and Sports

Sport is characterized by complex displacements and motions. These motions are dependent on visual information that the athlete can pick up in his environment, including the opponent's actions. The perception is thus fundamental to the performance. Indeed, a sportive action, as unique, complex and often limited in time, requires a selective gathering of information. This perception is often seen as a prerogative for action, it then takes the role of a passive collector of information. However, as mentioned by Gibson in 1979, the perception-action relationship should not be considered sequential but rather as a coupling: we perceive to act but we must act to perceive. There would thus be laws of coupling between the informational variables available in the environment and the motor responses of a subject. In other words, athletes have the ability to directly perceive the opportunities of action directly from the environment. Whichever school of thought considered, VR offers new perspectives to address these concepts by complementary using real time motion capture of the immersed athlete.

In addition to better understanding sports and interaction between athletes, VR can also be used as a training environment as it can provide complementary tools to coaches. It is indeed possible to add visual or auditory information to better train an athlete. The knowledge found in perceptual experiments can be for example used to highlight the body parts that are important to look at to correctly anticipate the opponent's action.

4.3. Biomechanics and Motion Analysis

Biomechanics is obviously a very large domain. This large set can be divided regarding to the scale at which the analysis is performed going from microscopic evaluation of biological tissues' mechanical properties to macroscopic analysis and modeling of whole body motion. Our topics in the domain of biomechanics mainly lie within this last scope.

The first goal of such kind of research projects is a better understanding of human motion. The MimeTic team addresses three different situations: everyday motions of a lambda subject, locomotion of pathological subjects and sports gesture.

In the first set, Mimetic is interested in studying how subjects maintain their balance in highly dynamic conditions. Until now, balance havec nearly always been considered in static or quasi-static conditions. The knowledge of much more dynamic cases still has to be improved. Our approach has demonstrated that first of all, the question of the parameter that will allow to do this is still open. We have also taken interest into collision avoidance between two pedestrian. This topic includes the research of the parameters that are interactively controlled and the study of each one's role within this interaction.

When patients, in particular those suffering from central nervous system affection, cannot have an efficient walking it becomes very useful for practicians to benefit from an objective evaluation of their capacities. To propose such help to patients following, we have developed two complementary indices, one based on kinematics and the other one on muscles activations. One major point of our research is that such indices are usually only developed for children whereas adults with these affections are much more numerous.

Finally, in sports, where gesture can be considered, in some way, as abnormal, the goal is more precisely to understand the determinants of performance. This could then be used to improve training programs or devices. Two different sports have been studied: the tennis serve, where the goal was to understand the contribution of each segments of the body in ball's speed and the influence of the mechanical characteristics of the fin in fin swimming.

After having improved the knowledge of these different gestures a second goal is then to propose modeling solutions that can be used in VR environments for other research topics within MimeTic. This has been the case, for exemple, for the colision avoidance.

4.4. Crowds

Crowd simulation is a very active and concurrent domain. Various disciplines are interested in crowds modeling and simulation: Mathematics, Cognitive Sciences, Physics, Computer Graphics, etc. The reason for this large interest is that crowd simulation raise fascinating challenges.

At first, crowd can be first seen as a complex system: numerous local interactions occur between its elements and results into macroscopic emergent phenomena. Interactions are of various nature and are undergoing various factors as well. Physical factors are crucial as a crowd gathers by definition numerous moving people with a certain level of density. But sociological, cultural and psychological factors are important as well, since crowd behavior is deeply changed from country to country, or depending on the considered situations.

On the computational point of view, crowd push traditional simulation algorithms to their limit. An element of a crowd is subject to interact with any other element belonging the same crowd, a naive simulation algorithm has a quadratic complexity. Specific strategies are set to face such a difficulty: level-of-detail techniques enable scaling large crowd simulation and reach real-time solutions.

MimeTIC is an international key contributor in the domain of crowd simulation. Our approach is specific and based on three axis. First, our modeling approach is founded on human movement science: we conducted challenging experiment on the motion of groups. Second: we developed high-performance solutions for crowd simulation. Third, we develop solutions for realistic navigation in virtual world to enable interaction with crowds in Virtual Reality.

4.5. Interactive Digital Storytelling

Interactive digital storytelling, including novel forms of edutainment and serious games, provides access to social and human themes through stories which can take various forms and contains opportunities for massively enhancing the possibilities of interactive entertainment, computer games and digital applications. It provides chances for redefining the experience of narrative through interactive simulations of computer-generated story worlds and opens many challenging questions at the overlap between computational narratives, autonomous behaviours, interactive control, content generation and authoring tools.

Of particular interest for the Mimetic research team, virtual storytelling triggers challenging opportunities in providing effective models for enforcing autonomous behaviours for characters in complex 3D environments. Offering both low-level capacities to characters such as perceiving the environments, interacting with the environment and reacting to changes in the topology, on which to build higher-levels such as modelling abstract representations for efficient reasonning, planning paths and activities, modelling cognitive states and behaviours requires the provision of expressive, multi-level and efficient computational models. Furthermore virtual storytelling requires the seamless control of the balance between the autonomy of characters and the unfolding of the story story through the narrative discourse. Virtual storytelling also raises challenging questions on the conveyance of a narrative through interactive or automated control of the cinematography (how to stage the characters, the lights and the cameras). For example, estimating visibility of key subjects, or performing motion planning for cameras and lights are central issues for which have not received satisfactory answers in the litterature.

4.6. Autonomous characters

Autonomous characters are becoming more and more popular has they are used in an increasing number of application domains. In the field of special effects, virtual characters are used to replace secondary actors and generate highly populated scenes that would be hard and costly to produce with real actors. In video games and virtual storytelling, autonomous characters play the role of actors that are driven by a scenario. Their autonomy allows them to react to unpredictable user interactions and adapt their behavior accordingly. In the field of simulation, autonomous characters are used to simulate the behavior of humans in different kind of situations. They enable to study new situations and their possible outcomes.

One of the main challenges in the field of autonomous characters is to provide a unified architecture for the modeling of their behavior. This architecture includes perception, action and decisional parts. This decisional part needs to mix different kinds of models, acting at different time scale and working with different nature of data, ranging from numerical (motion control, reactive behaviors) to symbolic (goal oriented behaviors, reasoning about actions and changes).

In the MimeTIC team, we focus on autonomous virtual humans. Our problem is not to reproduce the human intelligence but to propose an architecture making it possible to model credible behaviors of anthropomorphic virtual actors evolving/moving in real time in virtual worlds. The latter can represent particular situations studied by psychologists of the behavior or to correspond to an imaginary universe described by a scenario writer. The proposed architecture should mimic all the human intellectual and physical functions.

5. Software

5.1. HPTS++: Hierarchical Parallel Transition System ++

Participants: Stéphane Donikian [contact], Fabrice Lamarche [contact].

HPTS++ is a platform independent toolkit to describe and handle the execution of multi-agent systems. It provides a specific object oriented language encapsulating C++ code for interfacing facilities and a runtime kernel providing automatic synchronization and adaptation facilities.

The language provides functionalities to describe state machines (states and transitions) and to inform them with user specific C++ code to call at a given point during execution. This language is object oriented and supports concepts such as polymorphism and inheritance (state machines and user defined C++ classes). The compilation phase translates a state machine in a C++ class that can be compiled separately and linked through static or dynamic libraries. The runtime kernel includes a scheduler that handles parallel state machines execution and that provides synchronization facilities such as mutual exclusion on resources, dead lock avoidance, notions of priorities and execution adaptation in accordance with resources availability.

HPTS++ also provides a task model. Thanks to this model, the user can describe primitive behaviors through atomic tasks and combine them with operators (sequence, parallelism, loops, alternatives...). Theses operators are fully dynamic. Hence they can be used at runtime to rapidly create complex behaviors.

5.2. MKM: Manageable Kinematic Motions

Participants: Richard Kulpa [contact], Franck Multon.

We have developed a framework for animating human-like figures in real-time, based on captured motions. This work was carried-out in collaboration with the M2S Laboratory (Mouvement, Sport, Santé) of the University Rennes 2.

In this software, we propose a morphology-independent representation of the motion that is based on a simplified skeleton which normalizes the global postural informations. This formalism is not linked to morphology and allows very fast motion retargetting and adaptation to geometric constraints that can change in real-time This approach dramatically reduces the post production time and allows the animators to handle a general motion library instead of one library per avatar.

The framework provides an animation library which uses the motions either obtenained from our off-line tool (that tranforms standard formats into our morphology-independent representation) or parameterized models in order to create complete animation in real-time. Several models are proposed such as grasping, orientation of the head toward a target. We have also included a new locomotion model that allows to control the character directly using a motion database.

In order to create realistic and smooth animations, MKM uses motion synchronization, blending and adaptation to skeletons and to external constraints. All those processes are performed in real-time in an environment that can change at any time, unpredictably.

All these features have been used to anticipate and control the placement of footprints depending on high level parameters. This link between control and behavior levels will be used for reactive navigation in order to have realistic motion adaptations as well as to deal with constrained environments.

5.3. TopoPlan: Topological Planner and Behaviour Library

Participant: Fabrice Lamarche [contact].

TopoPlan (Topological Planner) is a toolkit dedicated to the analysis of a 3D environment geometry in order to generate suitable data structures for path finding and navigation. This toolkit provides a two step process: an off-line computation of spatial representation and a library providing on-line processes dedicated to path planning, environmental requests...

TopoPlan is based on an exact 3D spatial subdivision that accurately identifies floor and ceiling constraints for each point of the environment. Thanks to this spatial subdivision and some humanoid characteristics, an environment topology is computed. This topology accurately identifies navigable zones by connecting 3D cells of the spatial subdivision. Based on this topology several maps representing the environment are extracted. Those maps identify obstacle and step borders as well as bottlenecks. TopoPlan also provides a runtime library enabling the on-line exploitation of the spatial representation. This library provides several algorithms including roadmap-based path-planning, trajectory optimization, footprint generation, reactive navigation and spatial requests through customizable spatial selectors.

TopoPlan behavior is a library built on top of TopoPlan and MKM providing several behaviors described thanks to the HPTS++ task model. Its goal is to provide a high level interface handling navigation and posture adaptation within TopoPlan environments. Provided behaviors include:

- A behavior handling fully planned navigation toward an arbitrary destination. This behavior precisely handles footprint generation within constrained environments such as stairs for instance.
- A behavior controlling an MKM humanoid to follow a trajectory specified by the user.
- A behavior controlling MKM to follow a list of footprints given by the user.

- A behavior adapting the humanoid posture to avoid collision with ceiling. This behavior runs in parallel of all other behaviors and adapts humanoid motion when needed without any user intervention.
- A behavior handling reactive navigation of virtual humans. This behavior plan a path to a given target and follows the path while avoiding collisions with other navigating entities.

Those behaviors have been built using the HPTS++ task model. Thus, they can be easily combined together or with other described behaviors through task operators.

6. New Results

6.1. Motion Sensing and analysis

Participants: Franck Multon [contact], Richard Kulpa, Anthony Sorel, Edouard Auvinet.

Sensing human activity is a very active field of research, with a wide range of applications ranging from entertainment and serious games to personal ambient living assistance. MimeTIC aims at proposing original methods to process raw motion capture data in order to compute relevant information according to the application.

In personal ambient living monitoring, we have collaborated with University of Montreal, Department of Computer Science and Operations Research (DIRO) which main activity is biomedical engineering. A co-supervised student is addressing two complementary problems: detecting people falling in everyday environment and providing easy-to-use clinical gait analysis systems for early detection of potential risks of falling. In the last decade, gait analysis has become one of the most active research topics in biomedical research engineering partly due to recent developpement of sensors and signal processing devices and more recently depth cameras. The latters can provide real-time distance measurements of moving objects. In this context, we present a new way to reconstruct body volume in motion using multiple active cameras from the depth maps they provide. A first contribution of this paper is a new and simple external camera calibration method based on several plane intersections observed with a low-cost depth camera which is experimentally validated. A second contribution consists in a body volume reconstruction method based on visual hull that is adapted and enhanced with the use of depth information. Preliminary results based on simulations are presented and compared with classical visual hull reconstruction. These results show that as little as three low-cost depth cameras can recover a more accurate 3D body shape than twenty regular cameras (see figure 4).

In entertainment and serious games, the problem is different as we need to accurately now the action performed by the user in order to react in a convenient manner. Collaboration with Artefacto Company enabled us to develop such motion recognition methods in serious games scenarios. Given motion capture data provided by an optical motion capture system lead to large state vectors in which the relevant information is hidden. Mixture of Gaussians is generally used as an input of Hidden Markov Models to recognize a motion according to this raw data. To simplify, features are generally introduced in order to capture the relevant geometrical property of the motion with either general information (such as joint angles or Cartesian positions) or application-specific information. The former type of information has the advantage to be generic but leads to recognizers that are very sensitive to style and morphology variations. Previously, we have proposed a new generic feature based on morphology-independent representation that enables to tackle this problem [28]. We now have explored the robustness of this type of features for early recognition, when using mixture of Gaussians instead of Hidden Markov Models. We have shown that a motion can be recognized when only 50% of the motion is performed. The recognition rate is especially high with this type of feature compared to classical Euler angles and Cartesian data, especially when a new user is performing the motion [6].

6.2. VR and Sports

Participants: Richard Kulpa [contact], Benoit Bideau, Sébastien Brault, Anne-Marie Burns.

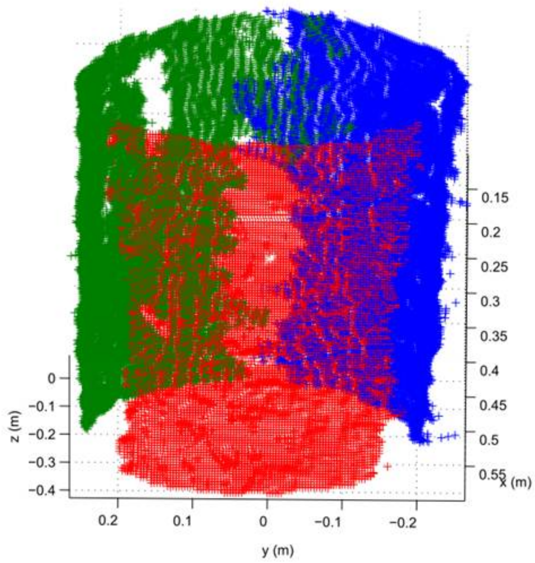

Figure 4. 3D silouhettes reconstructed with three depth-cameras - reconstructed points of a reference cylinder. Each color corresponds to one of the depth camera.

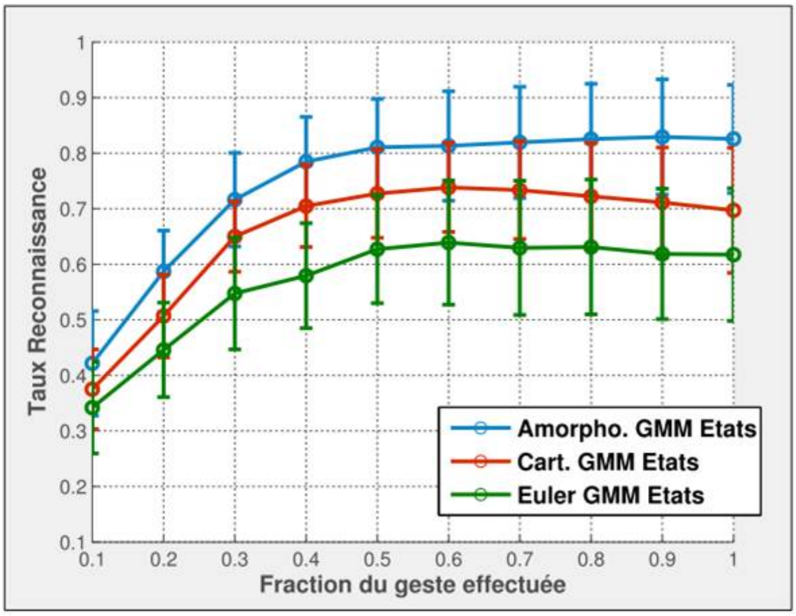

Figure 5. Early recognition of a motion performed by a new user with three different features: Cartesian, Euler and the proposed amorphological features.

In the past, we have worked on the interaction between two opponents in virtual environment. These duels were between a handball goalkeeper and a thrower; and between a rugby defender and an attacker performing deceptive movements. Even if these sports applications are different in terms of kinematic parameters, information picked-up and type of interaction, we have designed a unique framework to simulate such duels in a reality center and to analyze the gestures of real athletes immersed in this environment. This VR framework was validated by showing that behaviors in real and virtual environments were similar. These works have been extended by using perception-action coupling and perception-only studies to evaluate the anticipation of opponents. In order to evaluate the importance of perceived parameters, the ball and/or the character animation was successively hidden to determine their importance and the same kind of study was done on the graphical level of details.

This year, we have addressed the problem of the tennis serve. The first step is the PhD of Caroline Martin who will end next year. This work provides biomechanical analysis of the serve and the influence of the kinematical and dynamic parameters on performance. Thanks to an accepted project funded by the INSEP institute, we are importing this biomechanical model to virtual environment to make perceptual analysis. This work is based on the same methodology used for the detection of deceptive movements in rugby. The next step is to combine the use of cutoffs with biomechanical analysis to extract important kinematic information that could explain differences between experts and novices. This information is then correlated to kinematical parameters of this player. Concurrently, we are working on the creation of models of rugby defenders based on the results of the previous perceptual analyses

Finally, we have worked on the use of virtual environments to train athletes. The first step was to evaluate if a better score in the virtual environment implied only an improvement of the athlete in the virtual game or also a better performance back on the field. The PhD of Anne-Marie Burns has demonstrated that the improvement of training based on virtual environment was similar to training with a real teacher or based on videos. The use of VR for sports training, at least by imitation, is thus possible. Furthermore, we have explored the influence of the self-representation of the immersed learner by displaying his avatar as if he was in front of a virtual mirror. We made both kinematical and evocation analyses. The results do not show significant difference with or without the use of the mirror and it is confirmed by the subjective analysis that shows that the use of the virtual mirror by immersed athletes was limited. This work was partially funded by the Biofeedback project.

6.3. Biomechanics and Motion Analysis

6.3.1. Interaction strategies between two walkers to avoid collision

Participants: Armel Crétual, Julien Pettré, Anne-Hélène Olivier, Antoine Marin.

Walkers are extremely efficient in avoiding collisions, even in relatively condition of density. We experimentally addressed two questions. What are the conditions for walkers to perform adaptations to their trajectory, and second, how avoidance performed in time. We checked several hypothesis, that led to two contributions, as presented in [15]. First, human are able to anticipate the future conditions of an interactions and the distance they would meet. They react accordingly, i.e., if and only if a future risk of collision can be predicted. Second, we demonstrated that the avoidance is performed with anticipation, i.e., avoidance maneuvers are over before walkers get at closest distance.

6.3.2. Quantification of pathological motion

Participant: Armel Crétual.

In clinical routine, precise quantification of patients' gesture remains a challenge. Several simple means are daily used by practicians in physical medecine. Their main drawback is often a large inter-operator variability and even sometimes an intra-operator one. To overcome this, we have developed and validated still simple to remain usable) but much more objective tools in two different fields: gait and shoulder laxity.

First, we have proposed a new index of gait quantification based on EMG profiles called KeR-EGI (for Kerpape-Rennes EMG-based Gait Index). Our recent works allowed us to demonstrate its reproducibility even in patients with severe troubles. Moreover, we have also demonstrated the complementarity of this index based on muscular activation and an index based on kinematics, the Edinburgh Visual Gait Score (EVGS) that can be computed easily from a simple video recordings of the patient's gait. Indeed, we have shown that the relationship between these indices depends on the fact that pathology is congenital or acquired. Using both indices at the time, allows to evaluate the potential kinematics compensation the patient does to improve his/her gait despite a damaged motor control.

Secondly, in shoulder surgery, the surgeon has to choose between different protocols depending on whether the patient is hyperlax or not. Until now, shoulder laxity is very roughly evaluated without actual measurement and above all mobilizing only one axis (external rotation) of this complex joint. By measuring precisely the whole Range Of Motion of 28 subjects recruited to ensure a large spectrum of laxity (from hypo to hyper-laxity), we have shown that the usual clinical indices fail to actually classify subjects, as they do focus on only one dimension of mobility. From, that result, we have then proposed a new method to evaluate laxity that remains simple and usable in daily routine but that takes into account all dimensions of shoulder's mobility.

6.3.3. Modeling gesture in sports: fin swimming

Participants: Nicolas Bideau, Guillaume Nicolas, Benoit Bideau, Richard Kulpa.

In swimming, experimental approaches are commonly used to analyze performance. However, due to obvious limitations in experimental approaches (impoossibility to standardize any situations etc.), it is difficult to characterize surrounding fluid. To overcome this limitation, we currently develop analysis, modeling and simulation of aquatic locomotion, using CFD computer simulation and new methods based on animation of virtual characters.

- A first application of this topic enables to evaluate the influence of swim fin flexibility on efficiency during swimming based on a CFD structure interaction model. Finite elements simulations are carried out for various material properties and various prescribed kinematics. Besides the significant effect of flexibility on propulsive forces, the results indicate that the propulsive efficiency is greatly influenced by the stroke frequency and the initial angle of attack. For the selected material properties, the results show that efficiency increases from 3.6 percents to 11.9 percents when the stroke frequency is increased from 0 to 1.7 Hz. Moreover efficiency is clearly increased from 5.0 percents to 24.2 percents when increasing the angle of attack from 0 to 45 degrees. Therefore, an interesting prospect of the present work could be an enhancement of the design of better performing swim fins.
- A second application of this topic related to aquatic propulsion deals with a new method to evaluate cross-sectional area based on computer animation of swimming. Indeed, reducing cross sectional area (CSA) during starts and turns is a key part of performance optimisation. Different methods have been used to obtain this parameter without any standard: total human body volume to the power 2/3, wetted area or frontal area based on planimetry technique (PT). These different methods can lead to discrepancies in drag values. Recently, we used two synchronized camcorders to evaluate drag parameters during the different phases of an undulatory stroke cycle. However, such a technique needs accurate synchronization and calibration of the different camcorders views. The aim of this study is to provide a new method based on animation of virtual characters to obtain instantaneous cross-sectional area in an undulatory stroke cycle. Its main advantage is to obtain cross-sectional area as well as biomechanical analysis with a single camcorder in a sagittal plan and without space calibration. A camcorder placed side-on to the swimmer recorded the undulatory movements in the sagittal plane of eight swimmers. This information provided the angles between limbs. These data were then used by our animation engine to animate a virtual swimmer whose anthropometric data came from the real swimmer. A specific algorithm has been developed to automatically obtain the CSA using body outlines. In order to validate our method, we also calculated the CSA using PT with a frontal camcorder view of the same undulatory movements. Our results show similar values of maximum CSA using PT and the frontal camcorder view and our algorithm based on 3D animation. The mean coefficient of variation between the results obtained from the two methods is

7.3 percents. This difference could be related to the level of details of the mesh used to model the avatar. One prospect to this work is to take resistive and propulsive body segments into account in CSA calculation. From this method, we intend to better understand swimming hydrodynamics and the way CSA influences active drag. More generally, this approach has been designed to provide new practical insights into swimming analysis protocols.

6.4. Crowds

Participants: Julien Pettré [contact], Richard Kulpa, Anne-Hélène Olivier, Samuel Lemercier, Jonathan Perrinet, Kevin Jordao.

6.4.1. A realistic model of following behaviors in crowds

Following is an important type of interactions between individuals in crowds. In uni- or bidirectionnal pedestrian traffic, density prevent people from overtaking and going through the crowd: they just start following each other. Based on some experiments performed in the frame of the national project ANR-PEDIGREE, we elaborated a model for simulating following behavior with a very high level of realism. Contributions were presented in [9]. Especially, realism was evaluated both at the microscopic scale and at the macroscopic scale. At the microscopic scale, we carefully reproduce how human do control their motion to follow another walker. At the macroscopic scale, we focused on the emergence of stop-and-go waves that emerge from such traffic. Detailed analysis of experimental data analysis is described in 2 papers in Physical Review E: [15] and [35].

6.5. Interactive Virtual Cinematography

Participants: Marc Christie [contact], Christophe Lino.

The domain of Virtual Cinematography explores the operationalization of rules and conventions pertaining to camera placement, light placement and staging in virtual environments. In 2012, we have tackled two key issues in relation to the reactive control of virtual cameras: (i) the design of an efficient occlusion-free target tracking technique in dynamic environments and (ii) the design of a novel composition technique based on a 2D-manifold representation of search space.

The first issue is related to maintaining the visibility of target objects, a fundamental problem in automatic camera control for 3D graphics applications. Practical real-time camera control algorithms generally only incorporate mechanisms for the evaluation of the visibility of target objects from a single viewpoint, and idealize the geometric complexity of target objects. Drawing on work in soft shadow generation, we perform low resolution projections, from target objects to rapidly compute their visibility for a sample of locations around the current camera position. This computation is extended to aggregate visibility in a temporal window to improve camera stability in the face of partial and sudden onset occlusion. To capture the full spatial extent of target objects we use a stochastic approximation of their surface area. Our implementation is the first practical occlusion-free real-time camera control framework for multiple target objects. The result is a robust component that can be integrated to any virtual camera control system that requires the precise computation of visibility for multiple target (see [20]).

The second challenge is related to the automatic positioning a virtual camera in a 3D environment given the specification of visual properties to be satisfied (on-screen layout of subjects, vantage angles, visibility) is a complex and challenging problem. Most approaches tackle the problem by expressing visual properties as constraints or functions to optimize, and rely on computationally expensive search techniques to explore the solution space. We have shwon how to express and solve the exact on-screen positioning of two or three subjects by expressing the solution space for each couple of subjects as a 2D manifold surface [23]. We demonstrate how to use this manifold surface to solve Blinn's spacecraft problem with a straightforward algebraic approach. We extend the solution to three subjects and we show how to cast the complex 6D optimization problem tackled by most contributions in the field in a simple 2D optimization on the manifold surface by pruning large portions of the search space. The result is a robust and very efficient technique which finds a wide range of applications in virtual camera control and more generally in computer graphics.

We have also explored the application of automated editing techniques to Machinema [19].

Besides we have been involved in the process of rendering camera motions (from real movies) using haptic devices (a joint work with Technicolor and VR4i, accepted at VRST 2012 [21]), and have authored a state of the art report on Haptic Audiovisual (published in Transactions on Haptics [8]).

6.6. Autonomous Virtual Humans

6.6.1. Unifying activity scheduling and path-planning

Participants: Carl-Johan Jorgensen, Fabrice Lamarche [contact].

Crowd distribution in cities highly depends on how people schedule their daily activities. This schedule depends on temporal constraints like appointments or shops opening times. It also relies on the city structure and the locations of the places where activities can be achieved. Personal preferences also affect this schedule: choosing favorite shops or paths for instance.

Within the framework of iSpace&Time project, we are currently working on a model that unifies activity scheduling and path planning into a single process. This process takes city topological configuration into account, as well as time constraints and personal preferences. Applied to thousands of agents, his approach allows us to credibly populate cities. Credible flows of people automatically emerge depending on the time of the day and the city topology.

6.6.2. Long term planning and opportunism

Participants: Philippe Rannou, Fabrice Lamarche [contact].

Autonomous virtual characters evolve in dynamic virtual environments in which changes may be unpredictable. However, they need to behave properly and adapt their behavior to perceived changes while fulfilling their goals. We propose a system that combines long term action planning with failure anticipation and opportunism [27]. The system is based on a modified version of an HTN planning algorithm. It generates plans enriched with information that enable a monitor to detect relevant changes of the environment. Once those changes are detected, a plan adaptation is triggered. Such adaptations include modifying the plan to react to a predicted failure and more importantly to exploit opportunities offered by the environment.

6.6.3. Space-Time planning in dynamic environments

Participants: Thomas Lopez [contact], Fabrice Lamarche [contact].

When automatically populating 3D geometric databases with virtual humanoids, modeling the navigation behavior is essential since navigation is used in most exhibited behaviors. In many application fields, the need to manage navigation in dynamic environments arises (virtual worlds taking physics laws into account, numerical plants in which step stools can be moved,...). This study focuses on the following issue: how to manage the navigation of virtual entities in such dynamic environments where topology may change at any time i.e. where unpredictable accessibility changes can arise at runtime. In opposition to current algorithms, movable items are not only considered as obstacles in the environment but can also help virtual entities in their navigation.

The proposed algorithm [10] splits that problem into two complementary processes: a topology tracking algorithm and a path planning algorithm. The aim of the topology tracking algorithm is to continuously detect and update topological relations between moving objects i.e. accessibility or obstruction, while storing temporal information when recurring relations are observed. The path planning algorithm uses this information to plan a path inside the dynamic environment. The coupling of those algorithms endows a virtual character with the ability to immediately use inserted / moved object to reach previously unreachable locations. Moreover, this algorithm is able to find a path through moving platforms to reach a target located on a surface that is never directly accessible.

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Contint: iSpace&Time

Participants: Fabrice Lamarche [contact], Julien Pettré, Marc Christie, Carl Jorgensen.

The iSpace&Time project is founded by the ANR and gathers six partners: IGN, Lamea, University of Rennes 1, LICIT (IFSTAR), Telecom ParisTech and the SENSE laboratory (Orange). The goal of this project is the establishment of a demonstrator of a 4D Geographic Information System of the city on the web. This portal will integrate technologies such as web2.0, sensor networks, immersive visualization, animation and simulation. It will provide solutions ranging from simple 4D city visualization to tools for urban development. Main aspects of this project are:

- Creation of an immersive visualization based on panoramic acquired by a scanning vehicle using hybrid scanning (laser and image).
- Fusion of heterogeneous data issued by a network of sensor enabling to measure flows of pedestrians, vehicles and other mobile objects.
- Use of video cameras to measure, in real time, flows of pedestrians and vehicles.
- Study of the impact of a urban development on mobility by simulating vehicles and pedestrians.
- Integration of temporal information into the information system for visualization, data mining and simulation purpose.
- The mimetic team is involved in the pedestrian simulation part of this project. This project started in 2011 and will end in 2013.

7.1.2. ANR Contint: Chrome

Participants: Julien Pettré [julien.pettre@inria.fr], Kevin Jordao, Orianne Siret.

Chrome is a national project funded by the French Research Agency (ANR). The project is leaded by Julien Pettré, member of MimeTIC. Partners are: Inria-Grenoble IMAGINE team (Remi Ronfard), Golaem SAS (Stephane Donikian), and Archivideo (Francois Gruson). The project has been launched in september 2012.

The Chrome project develops new and original techniques to massively populate huge environments. The key idea is to base our approach on the crowd patch paradigm that enables populating environments from sets of pre-computed portions of crowd animation. These portions undergo specific conditions to be assembled into large scenes. The question of visual exploration of these complex scenes is also raised in the project. We develop original camera control techniques to explore the most relevant part of the animations without suffering occlusions due to the constantly moving content. A far term goal of the project is to enable populating a large digital mockup of the whole France (Territoire 3D, provided by Archivideo). Dedicated efficient Human animation techniques are required (Golaem). A strong originality of the project is to address the problem a crowded scene visualisation thorugh the scope of virtual camera control (Inria Rennes and Grenoble)

7.1.3. ANR TecSan: RePLiCA

Participant: Armel Crétual [contact].

The goal of RePLiCA project is to build and test a new rehabilitation program for facial praxia in children with cerebral palsy using an interactive device.

In a classical rehabilitation program, the child tries to reproduce the motion of his/her therapist. The feedback he/she has lays on the comparison of different modalities: the gesture of the therapist he/she has seen few seconds ago (visual space) and his/her own motion (proprioceptive space). Unfortunately, besides motor troubles these children often have some cognitive troubles and among them a difficulty to convert the information from a mental space to another one.

The principle of our tool is that during a rehabilitation session the child will observe simultaneously on the same screen an avatar, the virtual therapist's one, performing the gesture to be done, and a second avatar animated from the motion he actually performs. To avoid the use of a too complex motion capture system, the child will be filmed by a simple video camera. One first challenge is thus to be able to capture the child's facial motion with enough accuracy. A second one is to be able to provide him/her an additional feedback upon the gesture quality comparing it to a database of healthy children of the same age.

7.1.4. ANR JCJC: Cinecitta

Participants: Marc Christie [marc.christie@irisa.fr], Cunka Sanokho.

Cinecitta is a 3-year young researcher project funded by the French Research Agency (ANR), lead by Marc Christie and that started in October 2012.

The main objective of Cinecitta is to propose and evaluate a novel workflow which mixes user interaction using motion-tracked cameras and automated computation aspects for interactive virtual cinematography that will better support user creativity. We propose a novel cinematographic workflow that features a dynamic collaboration of a creative human filmmaker with an automated virtual camera planner. We expect the process to enhance the filmmaker's creative potential by enabling very rapid exploration of a wide range of viewpoint suggestions. The process has the potential to enhance the quality and utility of the automated planner's suggestions by adapting and reacting to the creative choices made by the filmmaker. This requires three advances in the field. First, the ability to generate relevant viewpoint suggestions following classical cinematic conventions. The formalization of these conventions in a computationally efficient and expressive model is a challenging task in order to select and propose the user with a relevant subset of viewpoints among millions of possibilities. Second, the ability to analyze data from real movies in order to formalize some elements of cinematographic style and genre. Third, the integration of motion-tracked cameras in the workflow. Motion-tracked cameras represent a great potential for cinematographic content creation. However given that tracking spaces are of limited size, there is a need to provide novel interaction metaphors to ease the process of content creation with tracked cameras. Finally we will gather feedback on our prototype by involving professionals (during dedicated workshops) and will perform user evaluations with students from cinema schools.

7.2. European Initiatives

7.2.1. FP7 STREP Fet-Open Tango

Participants: Julien Pettré [contact], Jonathan Perrinet, Anne-Hélène Olivier.

The goal of the TANGO project is to take some familiar ideas about affective communication one radical step further by developing a framework to represent and model the essential interactive nature of social communication based on non-verbal communication with facial and bodily expression. Indeed, many everyday actions take place in a social and affective context and presuppose that the agents share this context. But current motion synthesis techniques, e.g. in computer graphics, mainly focus on physical factors. The role of other factors, and specifically psychological variables, is not yet well understood.

In 2012, we focused on interactions between real and virtual humans based on Virtual Reality. During body-based interactions between real and virtual actors, we modulate the emotional expression of the virtual actor. We experimentally observe how the real human react to this modulation.

7.3. International Initiatives

7.3.1. Inria Associate Teams

7.3.1.1. SIMS

Title: Toward realistic and efficient simulation of highly complex systems

Inria principal investigator: Julien Pettré

International Partner (Institution - Laboratory - Researcher):

University of North Carolina at Chapel Hill (United States) - GAMMA Research Group - Ming LIN

Duration: 2012 - 2014

The general goal of SIMS is to make significant progress toward realistic and efficient simulation of highly complex systems which raise combinatory explosive problems. This proposal is focused on human motion and interaction, and covers 3 active topics with wide application range: 1. Crowd simulation: virtual human interacting with other virtual humans, 2. Autonomous virtual humans: who interact with their environment, 3. Physical Simulation: real humans interacting with virtual environments. SIMS is orthogonally structured by transversal questions: the evaluation of the level of realism reached by a simulation (which is a problem by itself in the considered topics), considering complex systems at various scales (micro, meso and macroscopic ones), and facing combinatory explosion of simulation algorithms.

7.3.2. Inria International Partners

- Collaboration with Zhejiang University, State Key Lab CAD&CG, China. Lead by Franck Multon and Julien Pettré (France) and Qunsheng Peng and Weidong Geng (China), following the EA BIRD (ended in 2010). The collaboration mainly involves the co-supervision of a PhD student.
- Collaboration with Queen's University Belfast, UK. Lead by Benoit Bideau and Richard Kulpa (France) and Cathy Craig (UK).

7.4. International Research Visitors

7.4.1. Visits of International Scientists

7.4.1.1. Internships

Hui-Yin WU (from May 2012 until Jul 2012)

Subject: Structured story models for Interactive Storytelling

Institution: National Cheng Chi University (Taiwan)

Funding: Inria Internship

Alexandra COVACI (from Jan 2012 until Jul 2012)

Subject: VR accelerator for learning basketball throws

Institution: University of Brasov (Romania)

Funding: Romanian funding for PhD mobility

7.4.2. Visits to International Teams

- Julien Pettré, Explorateur vist, July 2012, Trinity College Dublin (1 month)
- Edouard Auvinet, joint PhD with University of Montreal, Canada (24 months in Canada on 36 months), Cifre funding
- David Wolinski, (Master student), 3 month visit to Chapel Hill, University of North Carolina, USA

8. Dissemination

8.1. Scientific Animation

8.1.1. Scientific Community Animation

- F. Multon: **Leader** of the Mimetic research team

- F. Multon: **Member** of the European Society of Biomechanics, the ACM association, the IEEE association, the Computer Society association, the Eurographcis association, the European Society of Biomechanics, the French "Societe de Biomecanique", the French "Association Française de Realite Virtuelle", **Reviewer** Journal of Biomechanics, IEEE Transaction of Affective Computing, CASA internation conference, Computer Methods in Biomedical Engineering journal, Computer & Graphics journal, Eurographics 2011, IEEE International Symposium on Robot and Human Interactive Communication conference, IEEE TVCG journal, **Program Committee member** of ACM SIGGRAPH Asia (Sketches and posters), Motion in Games Conference MIG2011, SKILLS conference, **Scientific expert** for "Pole Productique de Bretagne", and Auteo association, in ergonomics, **Guest editor** of Presence - Mit Press, VR & Sports special issue: Benoit Bideau, Richard Kulpa, Franck Multon, **Program chair** of Simulation of Sports Motion co-located with CASA2011, and of the 3rd sino-French Symposium in QingDao 2012, **Session chairman** of "Modélisation musculo-squelettique" in ACAPS'2011 conference and "Analyses Biomécanique de la performance motrice" in ACAPS'2011, **Conference Chair** of Motion in Games 2012, **Associate Editor** of the Presence journal MIT Press since 2012.
- M. Christie: **Member** of Eurographics, AFIG and AFRV, **Reviewer for** Eurographics 2012, Foundations of Digital Games 2012, IEEE Visualisation 2012, **Reviewer for journals** Computer Graphics Forum, Transactions on Visualisation and Computer Graphics, Transactions on Mutlimedia, Transactions on Graphics, **Scientific expert** for Candadian NSERC fundings, **Session chair** at MIG 2012.
- R. Kulpa: **Reviewer** for IEEE VR, Siggraph Asia, New Media & Society; **Leader** of a European Intensive Program called "Routine & Cutting-edge Technologies in Physical Activity: Implication for Health & Sport Performance" with the Queen's University of Belfast and the Universitat de Valencia.
- F. Lamarche: **Reviewer** for Computer Animation and Virtual Worlds. **PhD Committee** of Hakim Soussi.
- J. Pettré: **Member** of ACM and IEEE associations, **Reviewer for** Transactions on Graphics, Siggraph, Siggraph Asia, Eurographics, Pacific Graphics, Computer Animation and Social Agents, ACM/Eurographics Symposium on Computer Animation, IEEE Transactions on Visualization and Computer Graphics, Computer Animation and Virtual Worlds, ICRA, VR, Journal of Computational Science, Computer Graphics Forum, Autonomous Robots, Motion in Game Conference, **Program Committee member** of Pacific Graphics, Symposium on Computer Animation, International Conference on Computer Graphics Theory and Applications **Scientific expert** for ANR
- A. Crétual: **Reviewer** of Medical & Biological Engineering & Computing, Journal of Electromyography and Kinesiology, American Journal of Physical Medicine & Rehabilitation, Journal of Musculoskeletal & Neuronal Interactions, Prosthetics & Orthotics International, **Editorial Board** of Journal of Electromyography and Kinesiology, **PhD Committee** of Caroline Moreau, **Scientific expert** for ANR TecSan program, PCCA (Romanian equivalent of French ANR).

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Master:

- R. Kulpa: Biomechanics and scientific programming, University of Rennes 2, Computer Animation IUT Bordeaux 1.
- F. Lamarche: Computer Animation ESIR IN, AI for Video Games ESIR IN, Real Time Rendering and Computer Animation MASTER GL, IFSIC - MIT, ENS CACHAN/RENNES.
- F. Multon: Master of Computer Science Ifsic : Image and Motion; MASTER OF PHYSICAL EXERCISE University Rennes2

- A. Crétual: Master course on Sports or pathological Gesture analysis, Univ. Rennes 2
- M. Christie, Multimedia and Android, 48h, M2 GL/MITIC/MIAGE, University of Rennes 1

8.2.2. Supervision

HdR: Benoît Bideau, "Biomécanique du mouvement et interactions sportives", University of Rennes 2, Nov. 2012 [3].

PhD: Samuel Lemercier, "Simulation du comportement de suivi dans une foule de piétons à travers l'expérience, l'analyse et la modélisation", Université de Rennes 1, Avril 2012, supervised by Stéphane Donikian and Julien Pettré [4].

PhD: Anthony Sorel, "Gestion de la variabilité morphologique pour la reconnaissance de gestes naturels à partir de données 3D", Université de Rennes 2, Dec. 2012, supervised by Franck Multon and Richard Kulpa [6].

PhD: Thomas Lopez, "Planification de chemin et adaptation de posture en environnements dynamiques.", INSA Rennes, March 2012, supervised by Stéphane Donikian and Fabrice Lamarche [5].

PhD: Kristell Bervet, "Kerpape-Rennes-EMG-based-Gait-Index: Définition d'un index de quantification de la marche pathologique par électromyographie", Université de Rennes 2, Sep. 2012, supervised by Armel Crétual [2].

PhD: Edouard Auvinet, "Analyse d'information tri-dimensionnelle issue de systèmes multi-caméras pour la détection de la chute et l'analyse de la marche", PhD STAPS (Sports Sciences) University Rennes2 and Biomedical Engineering Université de Montreal, June 14th 2012, Franck Multon and Jean Meunier (co-supervised PhD) [1].

9. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] E. AUVINET. *Analyse d'information tri-dimensionnelle issue de systèmes multi-caméras pour la détection de la chute et l'analyse de la marche*, University of Rennes 2, June 2012.

[2] K. BERVET. *Kerpape-Rennes-EMG-based-Gait-Index: Définition d'un index de quantification de la marche pathologique par électromyographie.*, University of Rennes 2, September 2012.

[3] B. BIDEAU. *Biomécanique du mouvement et interactions sportives*, University of Rennes 2, November 2012, Habilitation à Diriger des Recherches.

[4] S. LEMERCIER. *Simulation du comportement de suivi dans une foule de piétons à travers l'expérience, l'analyse et la modélisation*, Université Rennes 1, April 2012, http://hal.inria.fr/tel-00724072.

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