Activity Report 2018

Team MIMETIC

Analysis-Synthesis Approach for Virtual Human Simulation

Joint team with Inria Rennes – Bretagne Atlantique

D6 – Media and Interactions

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Creation of the Team: 2011 January 01, updated into Project-Team: 2014 January 01

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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 behaviors, realistic motions and realistic interactions with other characters and users. It leads to modeling the complexity of a human body, as well as of 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 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. 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 humans 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 beings. Moreover these characters have to deal with their environment. Firstly they have 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, they have to act on this environment to reach their goals. It leads to cognitive processes, motion planning, joint coordination and force production in order to act on this environment.

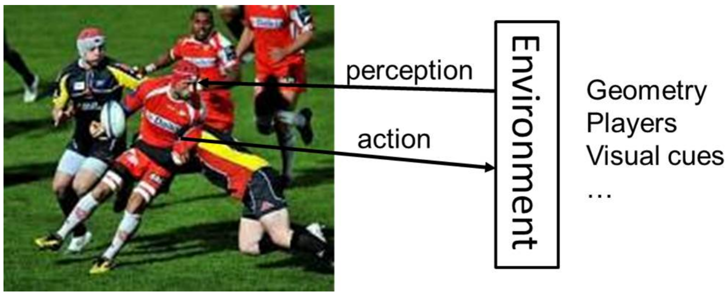

Figure 1. Main objective of MimeTIC: to better understand human activity in order to improve virtual human simulations. It involves modeling the complexity of human bodies, as well as of environments where to pick-up information and act upon.

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

- dealing with the intrinsic complexity of human beings, 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 balancing 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.

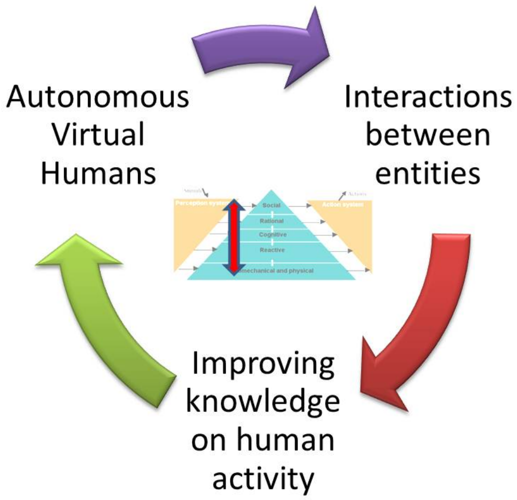

Figure 2. Research path of MimeTIC: coupling analysis and synthesis of human activity enables us to create more realistic autonomous characters and to evaluate assumptions about human motion control.

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 e.g. biomechanics, motion sciences, neurosciences. 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 would in the same situation, it is possible to make them **interact with others**, i.e., autonomous characters (for crowds or group simulations) as well as 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. This domain enables the design of new methods for analyzing the perception-action coupling in human activity, and to validate whether the autonomous characters lead to natural interactions with users,
- **interactions** in small and large groups of individuals, to understand and model interactions with lot of individual variability such as in crowds,
- **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 situations or selecting a natural motor behavior among the whole 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.

3. Research Program

3.1. Biomechanics and Motion Control

Human motion control is a highly 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 exists an 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 an infinity of muscle activation patterns for a unique joint rotation. From the reactive point of view there exists an 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.

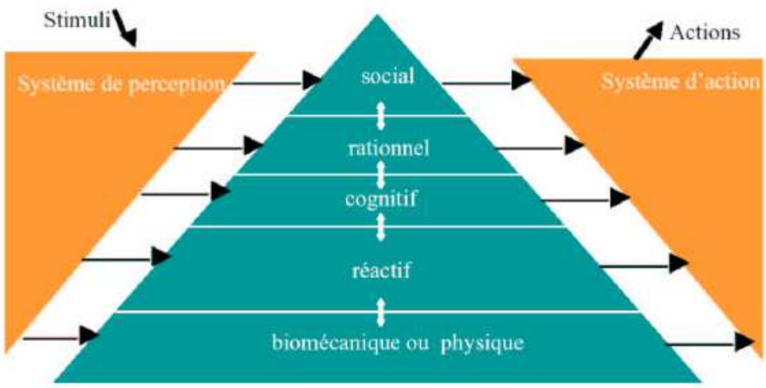

Figure 3. Layers of the motion control natural system in humans.

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 exists an infinity of muscle activation patterns, especially when dealing with antagonist muscles.

An unresolved problem is to define how to use the above criteria to retrieve the actual activation patterns, while optimization approaches still leads to unrealistic ones. It is still an open problem that will require multidisciplinary skills including computer simulation, constraint solving, biomechanics, optimal control, physiology and neuroscience.

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 combinations 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 plane whose angle in the state space is associated with energy expenditure. Although knowledge exists for specific motions, 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 objectively 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.

Neuroscience also addresses 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 large 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 enhance 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 knowledge in human motion control.

3.2. Experiments in Virtual Reality

Understanding interactions between humans is 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, and it is therefore highly complex to understand their individual influence on these human interactions. 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 repeatable 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 of 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 to observe its influence on the perception of the immersed subject. VR can then be used to understand what information is picked up to make a decision. Moreover, cut-offs can also be used to obtain temporal information about when information is picked up. When the subject can moreover react as in a 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 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 inputs are given and the corresponding outputs need 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, or nearest neighbor queries. 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.

In this context, distance geometry relies solely on distances, instead of points and lines, as in classical geometry. Various applications lead to the definition of problems that can be formulated as a distance geometry, including sensor network localization, robot coordination, the identification of molecular conformations, or as in the context of MimeTIC relations between objects in virtual scenes (e.g., distances between body segments, agents, or cameras). In recent years, scientific research has been oriented to the assumptions allowing for discretizing the search space of a given distance geometry problem. The discretization (which is exact in some situations) allows to conceive ad-hoc and efficient algorithms, and for enumerating the entire solution set of a given instance.

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 be compatible with performance constraints imposed by interactive applications.

4. Application Domains

4.1. Autonomous Characters

Autonomous characters are becoming more and more popular as 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.

4.2. 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. In order to obtain a better understanding of human motion, MimeTIC addresses three main situations: everyday motions of a lambda subject, locomotion of pathological subjects and sports gestures.

In the first situation, MimeTIC is interested in studying how subjects maintain their balance in highly dynamic conditions. Until now, balance have 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 largely contributed to gaining a better understanding of collision avoidance between pedestrians. This topic includes the research of the parameters that are interactively controlled and the study of each one?s role within this interaction.

The second situation focuses on locomotion of pathological subjects. When patients cannot walk efficiently, in particular those suffering from central nervous system affections, it becomes very useful for practitioners to benefit from an objective evaluation of their capacities. To facilitate such evaluations, we have developed two complementary indices, one based on kinematics and the other one on muscle 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: a) the tennis serve, where the goal was to understand the contribution of each segment of the body on the speed of the ball and b) 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 example, for collision avoidance.

4.3. Interactions between walkers

Modeling and simulating the interactions between walkers is a very active, complex and competitive domain, interesting various disciplines such as mathematics, cognitive sciences, physics, computer graphics, etc. Interactions between walkers are by definition at the very core of our society since they represent the basic synergies of our daily life. When walking in the street, we take information about our surrounding environment in order to interact with people, move without collision, alone or in a group, intercept, meet or escape to somebody. Large groups of walkers can be first seen as a complex system: numerous local interactions occur between its elements and result into macroscopic emergent phenomena. Interactions are of various nature (e.g., collision avoidance, following) and are undergoing various factors as well. Physical factors are crucial as a group gathers by definition numerous moving people with a certain level of density. But sociological, cultural and psychological factors are important as well, since people?s behavior is deeply changed from country to country, or depending on the considered situations. On the computational point of view, simulating the movements of large groups of walkers (i.e., crowds) pushes traditional simulation algorithms to their limit. As an element of a crowd is subject to interact with any other element belonging the same crowd, a naïve 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 understanding and simulating interactions between walkers, in particular for virtual crowds. Our approach is specific and based on three axes. First, our modeling approach is based on human movement science: we conduct challenging experiments focusing on the perception as well as on the motion involved in local interactions between walkers both using real and virtual set-ups. Second: we develop high-performance solutions for crowd simulation. Third, we develop solutions for realistic navigation in virtual world to enable interaction with crowds in Virtual Reality.

4.4. Motion Sensing of Human Activity

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 problems 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 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.

4.5. 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. 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 interactions 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.

4.6. 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 reasoning, 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 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 literature.

4.7. VR and Ergonomics

The design of workstations nowadays tends to include assessment steps in a Virtual Environment (VE) to evaluate ergonomic features. This approach is more cost-effective and convenient since working directly on the Digital Mock-Up (DMU) in a VE is preferable to constructing a real physical mock-up in a Real Environment (RE). This is substantiated by the fact that a Virtual Reality (VR) set-up can be easily modified, enabling quick adjustments of the workstation design. Indeed, the aim of integrating ergonomics evaluation tools in VEs is to facilitate the design process, enhance the design efficiency, and reduce the costs.

The development of such platforms asks for several improvements in the field of motion analysis and VR. First, interactions have to be as natural as possible to properly mimic the motions performed in real environments. Second, the fidelity of the simulator also needs to be correctly evaluated. Finally, motion analysis tools have to be able to provide in real-time biomechanics quantities usable by ergonomists to analyse and improve the working conditions.

5. Highlights of the Year

5.1. Highlights of the Year

Franck Multon has been recruited as full-time researcher with a national coordination task for the Olympic Games 2024 (SportInria project). He is the national contact for Performance2024, a national initiative from the

French Ministry of Sports, and the French Ministry of Research (MESRI) to support fundamental and applied research in collaboration with sports federation for the Olympic Games 2024. Together with Richard Kulpa and Benoit Bideau, they have been responsible to write a call for national proposals "Liv Lab Sports" from the French Ministry of Sports, to develop areas where people can test and train to sports using new technologies, such as virtual and augmented reality. MimeTIC is also globally involved in the Sciences2024 project leaded by Ecole Polytechnique to enhance collaborations between research groups and French Sports federations. All these involvements demonstrate the national visibility of MimeTIC as a leading research group in applying new technologies for sports.

Two papers on the topic of drone cinematography were presented at SIGGRAPH 2018, the main conference in Computer Graphics and Interaction. The first paper focused on reactive path planning techniques in a specific parametric space (Toric Space) to move cinematographic drones with respect to dynamic targets and obstacles, and to coordinate the motion of multiple drones. The second paper focused on static path planning techniques to construct aesthetic overviews of buildings by integrating viewpoint quality metrics and motion quality metrics.

The team released the CusToM OpenSource Software. Customizable Toolbox for Musculoskeletal simulation (CusToM) is a MATLAB toolbox aimed at performing inverse dynamics-based musculoskeletal analyzes. This type of analysis is essential to access mechanical quantities of human motion in different fields such as clinic, ergonomics and sports. CusToM exhibits several features. It can generate a personalized musculoskeletal model, and can solve from motion capture data inverse kinematics, external forces estimation, inverse dynamics and muscle forces estimation problems with a high level of customization for research purposes. It is also designed for non-expert users interested in motion analysis. CusToM is an OpenSource Software with a github repository available with no restriction.

5.1.1. Awards

Best presentation award for Amaury Louarn in ACM Motion Interaction and Games in Cyprus, November 2018, for the paper "Automated Staging for Virtual Cinematography" [44].

Kimea project has been granted by national innovation committee: "French IoT La Poste challenge" in June 2018.

6. New Software and Platforms

6.1. AsymGait

Asymmetry index for clinical gait analysis based on depth images
KEYWORDS: Motion analysis - Kinect - Clinical analysis
SCIENTIFIC DESCRIPTION: The system uses depth images delivered by the Microsoft Kinect to retrieve the gait cycles first. To this end it is based on a analyzing the knees trajectories instead of the feet to obtain more robust gait event detection. Based on these cycles, the system computes a mean gait cycle model to decrease the effect of noise of the system. Asymmetry is then computed at each frame of the gait cycle as the spatial difference between the left and right parts of the body. This information is computed for each frame of the cycle.
FUNCTIONAL DESCRIPTION: AsymGait is a software package that works with Microsoft Kinect data, especially depth images, in order to carry-out clinical gait analysis. First it identifies the main gait events using the depth information (footstrike, toe-off) to isolate gait cycles. Then it computes a continuous asymmetry index within the gait cycle. Asymmetry is viewed as a spatial difference between the two sides of the body.

- Participants: Edouard Auvinet and Franck Multon
- Contact: Franck Multon

6.2. Cinematic Viewpoint Generator

KEYWORD: 3D animation
FUNCTIONAL DESCRIPTION: The software, developed as an API, provides a mean to automatically compute a collection of viewpoints over one or two specified geometric entities, in a given 3D scene, at a given time. These viewpoints satisfy classical cinematographic framing conventions and guidelines including different shot scales (from extreme long shot to extreme close-up), different shot angles (internal, external, parallel, apex), and different screen compositions (thirds,fifths, symmetric of di-symmetric). The viewpoints allow to cover the range of possible framings for the specified entities. The computation of such viewpoints relies on a database of framings that are dynamically adapted to the 3D scene by using a manifold parametric representation and guarantee the visibility of the specified entities. The set of viewpoints is also automatically annotated with cinematographic tags such as shot scales, angles, compositions, relative placement of entities, line of interest.

- Participants: Christophe Lino, Emmanuel Badier and Marc Christie
- Partners: Université d'Udine - Université de Nantes
- Contact: Marc Christie

6.3. Directors Lens Motion Builder

KEYWORDS: Previzualisation - Virtual camera - 3D animation
FUNCTIONAL DESCRIPTION: Directors Lens Motion Builder is a software plugin for Autodesk's Motion Builder animation tool. This plugin features a novel workflow to rapidly prototype cinematographic sequences in a 3D scene, and is dedicated to the 3D animation and movie previsualization industries. The workflow integrates the automated computation of viewpoints (using the Cinematic Viewpoint Generator) to interactively explore different framings of the scene, proposes means to interactively control framings in the image space, and proposes a technique to automatically retarget a camera trajectory from one scene to another while enforcing visual properties. The tool also proposes to edit the cinematographic sequence and export the animation. The software can be linked to different virtual camera systems available on the market.

- Participants: Christophe Lino, Emmanuel Badier and Marc Christie
- Partner: Université de Rennes 1
- Contact: Marc Christie

6.4. Kimea

Kinect IMprovement for Egronomics Assessment
KEYWORDS: Biomechanics - Motion analysis - Kinect
SCIENTIFIC DESCRIPTION: Kimea consists in correcting skeleton data delivered by a Microsoft Kinect in an ergonomics purpose. Kimea is able to manage most of the occlultations that can occur in real working situation, on workstations. To this end, Kimea relies on a database of examples/poses organized as a graph, in order to replace unreliable body segments reconstruction by poses that have already been measured on real subject. The potential pose candidates are used in an optimization framework.
FUNCTIONAL DESCRIPTION: Kimea gets Kinect data as input data (skeleton data) and correct most of measurement errors to carry-out ergonomic assessment at workstation.

- Participants: Franck Multon, Hubert Shum and Pierre Plantard
- Partner: Faurecia
- Contact: Franck Multon
- Publications: Usability of corrected Kinect measurement for ergonomic evaluation in constrained environment - Validation of an ergonomic assessment method using Kinect data in real workplace conditions - Ergonomics Measurements using Kinect with a Pose Correction Framework - Filtered Pose Graph for Efficient Kinect Pose Reconstruction - Reliability of Kinect measurements for assessing the movement of operators in ergonomic studies

6.5. Populate

KEYWORDS: Behavior modeling - Agent - Scheduling
SCIENTIFIC DESCRIPTION: The software provides the following functionalities:

- A high level XML dialect that is dedicated to the description of agents activities in terms of tasks and sub activities that can be combined with different kind of operators: sequential, without order, interlaced. This dialect also enables the description of time and location constraints associated to tasks.

- An XML dialect that enables the description of agent's personal characteristics.

- An informed graph describes the topology of the environment as well as the locations where tasks can be performed. A bridge between TopoPlan and Populate has also been designed. It provides an automatic analysis of an informed 3D environment that is used to generate an informed graph compatible with Populate.

- The generation of a valid task schedule based on the previously mentioned descriptions.

With a good configuration of agents characteristics (based on statistics), we demonstrated that tasks schedules produced by Populate are representative of human ones. In conjunction with TopoPlan, it has been used to populate a district of Paris as well as imaginary cities with several thousands of pedestrians navigating in real time.
FUNCTIONAL DESCRIPTION: Populate is a toolkit dedicated to task scheduling under time and space constraints in the field of behavioral animation. It is currently used to populate virtual cities with pedestrian performing different kind of activities implying travels between different locations. However the generic aspect of the algorithm and underlying representations enable its use in a wide range of applications that need to link activity, time and space. The main scheduling algorithm relies on the following inputs: an informed environment description, an activity an agent needs to perform and individual characteristics of this agent. The algorithm produces a valid task schedule compatible with time and spatial constraints imposed by the activity description and the environment. In this task schedule, time intervals relating to travel and task fulfillment are identified and locations where tasks should be performed are automatically selected.

- Participants: Carl-Johan Jorgensen and Fabrice Lamarche
- Contact: Fabrice Lamarche

6.6. The Theater

KEYWORDS: 3D animation - Interactive Scenarios
FUNCTIONAL DESCRIPTION: The Theater is a software framework to develop interactive scenarios in virtual 3D environements. The framework provides means to author and orchestrate 3D character behaviors and simulate them in real-time. The tools provides a basis to build a range of 3D applications, from simple simulations with reactive behaviors, to complex storytelling applications including narrative mechanisms such as flashbacks.

- Participant: Marc Christie
- Contact: Marc Christie

6.7. CusToM

Customizable Toolbox for Musculoskeletal simulation
KEYWORDS: Biomechanics - Dynamic Analysis - Kinematics - Simulation - Mechanical multi-body systems
SCIENTIFIC DESCRIPTION: The present toolbox aims at performing a motion analysis thanks to an inverse dynamics method.

Before performing motion analysis steps, a musculoskeletal model is generated. Its consists of, first, generating the desire anthropometric model thanks to models libraries. The generated model is then kinematical calibrated by using data of a motion capture. The inverse kinematics step, the inverse dynamics step and the muscle forces estimation step are then successively performed from motion capture and external forces data. Two folders and one script are available on the toolbox root. The Main script collects all the different functions of the motion analysis pipeline. The Functions folder contains all functions used in the toolbox. It is necessary to add this folder and all the subfolders to the Matlab path. The Problems folder is used to contain the different study. The user has to create one subfolder for each new study. Once a new musculoskeletal model is used, a new study is necessary. Different files will be automaticaly generated and saved in this folder. All files located on its root are related to the model and are valuable whatever the motion considered. A new folder will be added for each new motion capture. All files located on a folder are only related to this considered motion.
FUNCTIONAL DESCRIPTION: Inverse kinematics Inverse dynamics Muscle forces estimation External forces prediction

- Participants: Antoine Muller, Charles Pontonnier and Georges Dumont
- Contact: Antoine Muller

6.8. MotionGraphVR

KEYWORDS: Virtual reality - Motion capture - Movement analysis
FUNCTIONAL DESCRIPTION: MotionGraphVR is a tool enabling users to automatically create motion graphs in Unity. It is particularly targeting Virtual Reality applications, where with the development of Head Mounted Displays users are now unable to see their real body unless they use expensive motion capture system, or animation techniques (e.g., Inverse Kinematics) which suffer from a lack of visual realism. To lever these limitations, MotionGraphVR automatically builds a graph of human motions from a set of examples captured on a real actor, and identify which motion path is the graph is closest to the user's actions. Additionally, this plugin also provides analysing tools to allow developers of VR applications to visualise similarities between movements to use in their applications before seamlessly connecting them in Motion Graphs.

- Participants: Tiffany Luong, Ludovic Hoyet and Fernando Argelaguet Sanz
- Contact: Ludovic Hoyet

6.9. Platforms

6.9.1. Immerstar Platform

Participants: Georges Dumont [contact], Ronan Gaugne, Anthony Sorel, Richard Kulpa.

With the two platforms of virtual reality, Immersia (http://www.irisa.fr/immersia/) and Immermove (http://m2slab.com/index.php/facilities-4/), grouped under the name Immerstar, the team has access to high level scientific facilities. This equipment benefits the research teams of the center and has allowed them to extend their local, national and international collaborations. The Immerstar platform is granted by a Inria CPER funding for 2015-2019 that enables important evolutions of the equipment. In 2016, the first technical evolutions have been decided and, in 2017, these evolutions have been implemented. On the one side, for Immermove, a third face to the immersive space was added. Moreover, 23 new Qualisys cameras were bought to complete the Vicon motion capture system for a total budget of 160k€half funded by Rennes Métropole. Both systems can interoperate to cover all the gymnasium but can also be used separately. On the other side, for Immersia, the installation of WQXGA laser projectors with augmented global resolution, of a new tracking system with higher frequency and of new computers for simulation and image generation in 2017. In 2018, a Scale One haptic device has been installed,. It allows, as in the CPER proposal, single-handed or dual-handed haptic feedback in the full space covered by Immersia, with the possibility of carrying the user (see Figure 2).

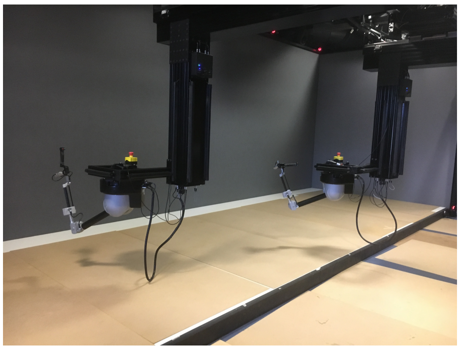

Figure 4. Upgrade of the Immersia platform with the Scale-One Haptic device enabling single-handed or dual-handed haptic feedback in the full space covered by Immersia, with the possibility of carrying the user.

7. New Results

7.1. Outline

In 2018, MimeTIC has maintained his activity in motion analysis, modelling and simulation. In motion analysis, we focused our efforts on two major points: 1) being able to simplify the calibration and simulation of customized musculoskeletal models of the subjects, 2) explore how visual perception act on collision avoidance in pedestrian locomotion with an extension to group behavior.

From a long time, MimeTIC has been promoting the idea of using Virtual Reality to train human performance. On the one hand, it leads to an efficient trade-off between high control and naturalness of the situation. On the other hand, it raises several fundamental questions about the automatic evaluation of the performance of the user, and the transfer of the skills trained in VR to real practice. In 2017, we explored these two questions by 1) developing new automatic methods for users' performance recognition and evaluation, especially online action detection, and 2) biofidelity of mass manipulation in VR using haptic interfaces.

In virtual cinematography, we applied the analysis/synthesis approach to extract and simulate film styles and narration. We also extended our previously defined Toric Space for camera placement to drone toric space to control a group of drones filming the action of an actor to ensure covering cinematographic distinct viewpoints. We also developed original VR-based staging and cinematography methods to make these processes be more interactive and immersive.

7.2. Motion analysis

7.2.1. Biomechanics for motion analysis-synthesis

Participants: Charles Pontonnier [contact], Georges Dumont, Franck Multon, Antoine Muller, Pierre Puchaud.

Based on a former PhD thesis (of Antoine Muller), we aim at democratizing the use of musculoskeletal analysis for a wide range of users. We proposed contributions enabling better performances of such analyses and preserving accuracy, as well as contributions enabling an easy subject-specific model calibration [47], [48]. In order to control the whole analysis process, we propose a global approach of all the analysis steps: kinematics, dynamics and muscle forces estimation. For all of these steps, quick analysis methods have been proposed. Particularly, a quick muscle force sharing problem resolution method [26] has been proposed, based on interpolated data and improvements have been proposed [25]. Moreover, the Music Toolbox is now proposed as an opensource software.

The determination of maximal torque envelopes method that we defined for the elbow torque analysis have been used for the shoulder [43]. It is important, in order to calibrate muscular models, to be able to identify force parameters in a musculoskeletal.

7.2.2. Interactions between walkers

Participants: Anne-Hélène Olivier [contact], Armel Crétual, Richard Kulpa, Sean Lynch.

Interaction between people, and especially local interaction between walkers, is a main research topic of MimeTIC. We propose experimental approaches using both real and virtual environments to study both perception and action aspects of the interaction. In the context of Sean Lynch's PhD, which was defended in October 2018 [12], we aimed at manipulating the nature of the visual information available to the participants to understand which information about the other walker are important to avoid a collision. We presented at IEEE VR 2018, our work on the influence of global and local information appearances [45] as well as on the influence of mutual gaze in the interaction [46].

In the context of transportation research, we developed a new collaboration with Ifsttar (LEPSIS, LESCOT) involving questions about interaction between pedestrians on a narrow sidewalk [50], [40].

We also provide lot of efforts to investigate, in collaboration with Julien Pettré from Inria Rainbow team, the process involved in the selection of interactions within our neighbourhood. Considering the complex case of multiple interactions, we first performed experiments in real conditions where a participant walked across a room whilst either one (i.e., pairwise) or two (i.e., group) participants crossed the room perpendicularly. By comparing these pairwise and group interactions, we assessed whether a participant avoids two upcoming collisions simultaneously, or as sequential pairwise interactions. Results showed that pedestrians are able to interact with two other walkers simultaneously, rather than treating each interaction in sequence. These results are currently in press in Frontiers in Psychology [22]. Second, we performed experiments involving 40 people to understand how collective behaviour emerges [31]. Third, in virtual conditions, we also coupled the analysis of gaze behaviour and the trajectory and showed that human gaze, during navigation, is attracted by other walkers presenting the higher risk of future collision [21], [42].

Finally, we continue working on the applications of studying human behaviour for application in human-moving robot interactions. The development of Robotics accelerated these recent years, it is clear that robots and humans will share the same environment in a near future. In this context, understanding local interactions between humans and robots during locomotion tasks is important to steer robots among humans in a safe manner. In collaboration with Philippe Souères and Christian Vassallo (LAAS, Toulouse), our work analyzed the behavior of human walkers crossing the trajectory of a mobile robot that was programmed to reproduce this human avoidance strategy. In contrast with a previous study, which showed that humans mostly prefer to give the way to a non-reactive robot, we observed similar behaviors between human-human avoidance and human-robot avoidance when the robot replicates the human interaction rules. This result highlight the importance of controlling robots in a human-like way in order to ease their cohabitation with humans [28]. In collaboration with Jose Grimaldo da Silva and Thierry Fraichard (Inria Grenoble), we designed a shared-effort model during interaction between a moving robot and a human relying on walker-walker collision avoidance data [33].

7.2.3. Biomechanical analysis of tennis serve

Participants: Richard Kulpa [contact], Benoit Bideau, Pierre Touzard.

In the context of the exclusive collaboration with the FFT (French Tennis Federation), we made new experiments on top-level young French players (between 12 up to 18 years old) to quantify the relation between motor technical errors and their impact on the risk of injury. We thus concurrently captured the kinematics of their tennis serve and the muscular activities of the upper-body. We recently validated that the Waiter's serve implies higher risk of injuries [27]. It is a movement that was know by the coaches as not productive and risky but it was never validated. Moreover, we evaluated the strategies of pacing use during five-set matches in the top tennis tournaments [20].

7.3. Virtual human simulation

7.3.1. Novel Distance Geometry based approaches for Human Motion Retargeting

Participants: Franck Multon [contact], Ludovic Hoyet, Antonio Mucherino, Zhiguang Liu.

Since September 2016, Antonio Mucherino has a half-time Inria detachment in the MimeTIC team (ended Sept 2018), in order to collaborate on exploring distance geometry-based problems in representing and editing human motion.

In this context, an extension of a distance geometry approach to dynamical problems was proposed in [24], and we co-supervised Antonin Bernardin for his Master thesis in 2017, which focused on applying such extended approach for retargeting human motions. In character animation, it is often the case that motions created or captured on a specific morphology need to be reused on characters having a different morphology. However, specific relationships such as body contacts or spatial relationships between body parts are often lost during this process, and existing approaches typically try to determine automatically which body part relationships should be preserved in such animation. Instead, we proposed a novel frame-based approach to motion retargeting which relies on a normalized representation of all the body joints distances to encompass all the relationships existing in a given motion. In particular, we proposed to abstract postures by computing all the inter-joint distances of each animation frame and to represent them by Euclidean Distance Matrices (EDMs). Such EDMs present the benefits of capturing all the subtle relationships between body parts, while being adaptable through a normalization process to create a morphology independent distance-based representation. Finally, they can also be used to efficiently compute retargeted joint positions best satisfying newly imposed distances. We demonstrated that normalized EDMs can be efficiently applied to a different skeletal morphology by using a dynamical distance geometry approach, and presented results on a selection of motions and skeletal morphologies.

Concurrently, we proposed a pose transfer algorithm from a source character to a target character, without using skeleton information. Previous work mainly focused on retargeting skeleton animations whereas the contextual meaning of the motion is mainly linked to the relation- ship between body surfaces, such as the contact of the palm with the belly. In the context of the Inria PRE program, we propose a new context-aware motion retargeting framework [37], based on deforming a target character to mimic a source character poses using harmonic mapping. We also introduce the idea of Context Graph: modeling local interactions between surfaces of the source character, to be preserved in the target character, in order to ensure fidelity of the pose. In this approach, no rigging is required as we directly manipulate the surfaces, which makes the process totally automatic. Our results demonstrate the relevance of this automatic rigging-less approach on motions with complex contacts and interactions between the character's surface.

7.3.2. Investigating the Impact of Training for Example-Based Facial Blendshape Creation.

Participant: Ludovic Hoyet [contact].

In collaboration with Technicolor and Trinity College Dublin, we explored how certain training poses can influence the Example-Based Facial Rigging (EBFR) method [32]. We analysed the output of EBFR given a set of training poses to see how well the results reproduced our ground truth actor scans compared to a pure Deformation Transfer approach (Figure 5). We found that, while the EBFR results better matched the ground truth overall, there were certain cases that didn't see any improvement. While some of these results may be explained by lack of sufficient training poses for the area of the face in question, we found that certain lip poses weren't improved by training despite a large number of mouth training poses supplied. Our initial goal for this project was to identify what facial expressions are important to use as training when using Example-Based Facial Rigging to create facial rigs. This preliminary work has indicated certain parts of the face that might require more attention when automatically creating blendshapes, which still require to be further investigated, e.g., to identify a subset of facial expressions that would be considered the "ideal" subset to use for training the EBFR algorithm.

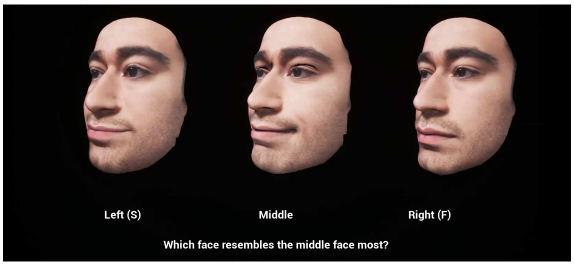

Figure 5. An example of stimuli shown to participants comparing the facial rigs created without training, and those with training.

7.4. Human motion in VR

7.4.1. Motion recognition and classification

Participants: Franck Multon, Richard Kulpa [contact], Yacine Boulahia.

Action recognition based on human skeleton structure represents nowadays a prospering research field. This is mainly due to the recent advances in terms of capture technologies and skeleton extraction algorithms. In this context, we observed that 3D skeleton-based actions share several properties with handwritten symbols since they both result from a human performance. We accordingly hypothesize that the action recognition problem can take advantage of trial and error approaches already carried out on handwritten patterns. Therefore, inspired by one of the most efficient and compact handwriting feature-set, we proposed a skeleton descriptor referred to as Handwriting-Inspired Features. First of all, joint trajectories are preprocessed in order to handle the variability among actor's morphologies. Then we extract the HIF3D features from the processed joint locations according to a time partitioning scheme so as to additionally encode the temporal information over the sequence. Finally, we used Support Vector Machine (SVM) for classification. Evaluations conducted on two challenging datasets, namely HDM05 and UTKinect, testify the soundness of our approach as the obtained results outperform the state-of-the-art algorithms that rely on skeleton data.

Being able to interactively detect and recognize actions based on skeleton data, in unsegmented streams, has become an important computer vision topic. It raises three scientific problems in relation with variability. The first one is the temporal variability that occurs when subjects perform gestures with different speeds. The second one is the inter-class spatial variability, which refers to disparities between the displacement amounts induced by different classes (i.e. long vs. short movements). The last one is the intra-class spatial variability caused by differences in style and gesture amplitude. Hence, we designed an original approach that better considers these three issues [15]. To address temporal variability we introduce the notion of curvilinear segmentation. It consists in extracting features, not on temporally-based sliding windows, but on segments in which the accumulated curvilinear displacement of skeleton joints equals a specific amount. Second, to tackle inter-class spatial variability, we define several competing classifiers with their dedicated curvilinear windows. Last, we address intraclass spatial variability by designing a fusion system that takes the decisions and confidence scores of every competing classifier into account. Extensive experiments on four challenging skeleton-based datasets demonstrate the relevance and efficiency of the proposed approach.

This work has been carried-out in collaboration with the IRISA Intuidoc team, with Yacine Boulahia who is a co-supervised PhD student with Eric Anquetil.

7.4.2. Automatic evaluation of sports gesture

Participant: Richard Kulpa [contact].

Automatically evaluating and quantifying the performance of a player is a complex task since the important motion features to analyze depend on the type of performed action. But above all, this complexity is due to the variability of morphologies and styles of both the experts who perform the reference motions and the novices. Only based on a database of expert's motions and no additional knowledge, we propose an innovative 2-level DTW (Dynamic Time Warping) approach to temporally and spatially align the motions and extract the imperfections of the novice's performance for each joints [23]. We applied our method on tennis serve and karate katas.

7.4.3. Studying the Sense of Embodiment in VR Shared Experiences

Participants: Rebecca Fribourg, Ludovic Hoyet [contact].

To explore how the sense of embodiment is influenced by the fact of sharing a virtual environment with another user, we conducted an experiment where users were immersed in a virtual environment while being embodied in an anthropomorphic virtual representation of themselves [35], in collaboration with Hybrid Inria team. In particular, two situations were studied: either users were immersed alone, or in the company of another user (see Figure 6). During the experiment, participants performed a virtual version of the well-known whac-a-mole game, therefore interacting with the virtual environment, while sitting at a virtual table. Our results show that users were significantly more "efficient" (i.e., faster reaction times), and accordingly more engaged, in performing the task when sharing the virtual environment, in particular for the more competitive tasks. Also, users experienced comparable levels of embodiment both when immersed alone or with another user. These results are supported by subjective questionnaires but also through behavioural responses, e.g. users reacting to the introduction of a threat towards their virtual body. Taken together, our results show that competition and shared experiences involving an avatar do not influence the sense of embodiment, but can increase user engagement. Such insights can be used by designers of virtual environments and virtual reality applications to develop more engaging applications.

Figure 6. Setup of the experiment: each user was able to interact in the virtual environment with his own avatar, while the physical setup provided both a reference frame and passive haptic feedback. From left to right: experimental conditions Alone, Mirror and Shared; Physical setup of the experiment.

7.4.4. Biofidelity in VR

Participants: Simon Hilt, Charles Pontonnier, Georges Dumont [contact].

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 challenge is to be able to automatically recognize and analyze the user's performance according to poor and noisy signals. Hence, recognizing and measuring human performance are important scientific challenges especially when using low-cost and noisy motion capture systems. MimeTIC has addressed the above problems in two main application domains. In this section, we detail the ergonomics application of such an approach. Firstly, in ergonomics, we explored the impact of uncertainties on friction coefficients on haptic feedback. The coefficients are tuned thanks to an experimental protocol enabling a subjective comparison between real and virtual manipulations of a low mass object. The compensation of friction on the first and second axes of the haptic interface showed significant improvement of both realism and perceived load. This year, we conducted experiments aiming at comparing gesture, recorded by an optoelectronic setup, and muscular activities, recorded by EMG, between real and virtual (with haptic feedback) manipulation.

7.5. Digital storytelling

7.5.1. Film Editing Patterns: Thinking like a Director

Participant: Marc Christie [contact].

We have introduced *Film Editing Patterns (FEP)*, a language to formalize film editing practices and stylistic choices found in movies. FEP constructs are constraints expressed over one or more shots from a movie sequence [29] that characterize changes in cinematographic visual properties such as shot size, region, angle of on-screen actors.

We have designed the elements of the FEP language, then introduced its usage in annotated film data, and described how it can support users in the creative design of film sequences in 3D. More specifically: (i) we proposed the design of a tool to craft edited filmic sequences from 3D animated scenes that uses FEPs to support the user in selecting camera framings and editing choices that follow certain best practices used in cinema; (ii) we conducted an evaluation of the application with professional and non-professional filmmakers. The evaluation suggested that users generally appreciate the idea of FEP, and that it can effectively help novice and medium experienced users in crafting film sequences with little training and satisfying results.

7.5.2. Directing Cinematographic Drones

Participants: Marc Christie [contact], Quentin Galvane.

We have designed a set of high-level tools for filming dynamic targets with quadrotor drones. To this end, we proposed a specific camera parameter space (the Drone Toric space) together with interactive on-screen viewpoint manipulators compatible with the physical constraints of a drone. We then designed a real-time path planning approach in dynamic environments which ensures both cinematographic properties in viewpoints along the path and ensures the feasibility of the path by a quadrotor drone. We finally have demonstrated how the Drone Toric Space can be combined with our path planning technique to coordinate positions and motions of multiple drones around dynamic targets to ensure the coverture of cinematographic distinct viewpoints. The proposed research prototypes have been evaluation by an experienced drone pilot and filmmaker, as well as by non-experts users. Not only does the tool demonstrate it's benefit in rehearsing complex camera moves for the film and documentary industries, but it demonstrates it's usability for everyday recording of aesthetic camera motions. The work was published in the Transactions on Graphics journal and was accepted for presentation at SIGGRAPH [18].

In addition we have focused on full automated and non-reactive path-planning for cinematographic drones. Most existing tools typically require the user to specify and edit the camera path, for example by providing a complete and ordered sequence of key viewpoints. In our contribution, we propose a higher level tool designed to enable even novice users to easily capture compelling aerial videos of large-scale outdoor scenes. Using a coarse 2.5D model of a scene, the user is only expected to specify starting and ending viewpoints and designate a set of landmarks, with or without a particular order. Our system automatically generates a diverse set of candidate local camera moves for observing each landmark, which are collision-free, smooth, and adapted to the shape of the landmark. These moves are guided by a landmark-centric view quality field, which combines visual interest and frame composition. An optimal global camera trajectory is then constructed that chains together a sequence of local camera moves, by choosing one move for each landmark and connecting them with suitable transition trajectories. This task is formulated and solved as an instance of the Set Traveling Salesman Problem. The work was published and presented at SIGGRAPH [30].

7.5.3. Automated Virtual Staging

Participants: Marc Christie [contact], Quentin Galvane, Fabrice Lamarche, Amaury Louarn.

While the topic of virtual cinematography has essentially focused on the problem of computing the best viewpoint in a virtual environment given a number of objects placed beforehand, the question of how to place the objects in the environment with relation to the camera (referred to as staging in the film industry) has received little attention. This work first proposes a staging language for both characters and cameras that extends existing cinematography languages with multiple cameras and character staging. Second, we propose techniques to operationalize and solve staging specifications given a 3D virtual environment. The novelty holds in the idea of exploring how to position the characters and the cameras simultaneously while maintaining a number of spatial relationships specific to cinematography. We demonstrate the relevance of our approach through a number of simple and complex examples [44].

7.5.4. VR Staging and Cinematography

Participants: Marc Christie [contact], Quentin Galvane.

Creatives in animation and film productions have forever been exploring the use of new means to prototype their visual sequences before realizing them, by relying on hand-drawn storyboards, physical mockups or more recently 3D modelling and animation tools. However these 3D tools are designed in mind for dedicated animators rather than creatives such as film directors or directors of photography and remain complex to control and master. In this work we propose a VR authoring system which provides intuitive ways of crafting visual sequences, both for expert animators and expert creatives in the animation and film industry. The proposed system is designed to reflect the traditional process through (i) a storyboarding mode that enables rapid creation of annotated still images, (ii) a previsualisation mode that enables the animation of the characters, objects and cameras, and (iii) a technical mode that enables the placement and animation of complex camera rigs (such as cameras cranes) and light rigs. Our methodology strongly relies on the benefits of VR manipulations to re-think how content creation can be performed in this specific context, typically how to animate contents in space and time. As a result, the proposed system is complimentary to existing tools, and provides a seamless back-and-forth process between all stages of previsualisation. We evaluated the tool with professional users to gather experts' perspectives on the specific benefits of VR in 3D content creation [36].

7.5.5. Improving Camera tracking technologies

Participants: Marc Christie [contact], Xi Wang.

Robustness of indirect SLAM techniques to light changing conditions remains a central issue in the robotics community. With the change in the illumination of a scene, feature points are either not extracted properly due to low contrasts, or not matched due to large differences in descriptors. In this work, we propose a multi-layered image representation (MLI) in which each layer holds a contrast enhanced version of the current image in the tracking process in order to improve detection and matching. We show how Mutual Information can be used to compute dynamic contrast enhancements on each layer. We demonstrate how this approach dramatically improves the robustness in dynamic light changing conditions on both synthetic and real environments compared to default ORB-SLAM. This work focalises on the specific case of SLAM relocalisation in which a first pass on a reference video constructs a map, and a second pass with a light changed condition relocalizes the camera in the map [38], [39].

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Contracts with Industry

8.1.1. BPI-PCR Robo-KII

Participant: Armel Crétual [contact].

This contract has started in February 2017 and ended in October 2018. In M2S, it involved two permanent members of MimeTic team, Armel Crétual and Franck Multon, and two engineers, Antoine Marin (18 months grant) and Brice Bouvier (10 months grant).

This project was a collaboration between BA Healthcare and M2S lab. It aimed at developing a robotics platform to allow physicians to start gait rehabilitation as soon as possible, even before patients are able to maintain upright posture alone. The usual way to perform such rehab sessions is to make the patient walk on a treadmill benefiting from a harness to prevent patient from falling. The two main limits of this approach are that:

- only straightforward at constant speed gaits are feasible whereas falling risks are much higher when modifying speed or turning
- walking on a treadmill when motor abilities are very affected can be challenging and can generate strong apprehension.

In a previous project, Robo-K, ended in september 2016, BA Healthcare has developed a first prototype of a mobile robot which strongly modified the approach: the harness is mobile and follows the patient displacement. In this way, the patient walks on the ground at his/her desired speed and the physician can include curved trajectories in the rehab process.

The main novelty of Robo-KII project was to implement a biofeeedback system onto the robotics platform to reinforce rehab sessions. Closely working with physicians from two PMR services, CHU Rennes and Kerpape center, we tested several parameters of the feedback to be given to the patients. In particular, in a clinical pre-test, we focused on the temporal aspect, i.e. providing the feedback at each gait cycle or only after one rehab exercise (up to 20 steps) to avoid dual tasks situation as patients in this early stage after stroke usually also suffer from cognitive issues.

8.1.2. Unity - Cinecast

Participants: Marc Christie [contact], Quentin Galvane.

Cinecast is a research collaboration between Unity and Inria Rennes. The collaboration is focused on automated cinematography and automated editing technologies for creating video casts of 3D game sessions. The project has started in July 2018 for one year, and with a budget of 45kE. The challenge consists in specializing the general editing techniques proposed in our Automated Editing paper (AAAI 2015), reducing the knowledge of the editing algorithm from the full sequence to only 3 seconds. A first demonstration of the results was presented at the Unite 2018 event in Los Angeles.

8.1.3. SolidAnim - Solidtrack

Participants: Marc Christie [contact], Xi Wang.

In the scope of the ANR project LabCom, the purpose of this research collaboration is to develop SLAM technologies which are robust to changes in the lighting conditions. The collaboration started in October 2018, with a budget of 180kE for a duration of three years. The budget is mostly dedicated to hiring PhD student Xi Wang. The work is a co-supervision with Eric Marchand (from Rainbow team).

8.1.4. Cifre Faurecia - Monitoring de l'efficience gestuelle d'opérateurs sur postes de travail

Participants: Franck Multon [contact], Georges Dumont, Charles Pontonnier, Olfa Haj Mahmoud.

This Cifre contract has started in September 2018 for three years and is funding the PhD thesis of Olfa Haj Mamhoud. It consists in designing new methods based on depth cameras to monitor the activity of workers in production lines, compute the potential risk of musculoskeletal disorders, and efficiency compared to reference workers. It raises several fundamental questions, such as adapting previous methods to assess the risk of musculoskeletal disorders, as they generally rely on static poses whereas the worker is performing motion. Based on previous works in the team (previous Cifre PhD thesis of Pierre Plantard) we will provide 30Hz motion capture of the worker, that will enable us to evaluate various time-dependent assessment methods.

We will also explore how to estimate joint forces based and torques on such noisy and low-sampling motion data. We will then define a new assessment method based on these forces and torques.

The Cifre contracts funds the PhD salary and 30K€ per year for the supervision and management of the PhD thesis.

8.2. Bilateral Grants with Industry

8.2.1. Bilateral contract with Technicolor

Participant: Marc Christie.

Bilateral contract with Technicolor on empowering drones with cinematographics knowledge. Participants: Philippe Guillotel, Julien Fleureau, Quentin Galvane. Amount 25kE. Duration 24 months.

9. Partnerships and Cooperations

9.1. Regional Initiatives

- SATT "Ouest valorisation" grant for the maturation of the Kimea software and projet (Franck Multon and Pierre Plantard). 12 months of three full-time people 300KE. Creation of the start-up company planned beginning of 2018.
- SATT "Ouest valorisation" grant for the maturation of the Populate software (Fabrice Lamarche). One full-time engineer (2017-2018).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR PRCE Cineviz

Participants: Marc Christie [contact], Quentin Galvane.

Cineviz is a 3-year ANR LabCom project (2016-2019). Amount: 300kE. Parnters: SolidAnim, UR1.

The project is a bilateral collaboration with the SolidAnim company. The objective is to jointly progress on the design and implementation of novel tools for the preproduction in the film industry. The project will address the challenges related to (i) proposing expressive framing tools, (ii) integrating the technical aspects of shooting (how to place the cameras, lights, green sets) directly at the design stage), and (iii) novel interaction metaphors for designing and controlling the staging of lights in preproduction, using an example-based approach.

9.2.1.2. ANR JCJC Per2

Participants: Ludovic Hoyet [contact], Benjamin Niay, Anne-Hélène Olivier, Antonio Mucherino, Richard Kulpa, Franck Multon.

Per2 is a 42 month ANR JCJC project (2018-2022) entitled *Perception-based Human Motion Personalisation* (Budget: 280kE; website: https://project.inria.fr/per2/)

The objective of this project is to focus on how viewers perceive motion variations to automatically produce natural motion personalisation accounting for inter-individual variations. In short, our goal is to automate the creation of motion variations to represent given individuals according to their own characteristics, and to produce natural variations that are perceived and identified as such by users. Challenges addressed in this project consist in (i) understanding and quantifying what makes motions of individuals perceptually different, (ii) synthesising motion variations based on these identified relevant perceptual features, according to given individual characteristics, and (iii) leveraging even further the synthesis of motion variations and to explore their creation for interactive large-scale scenarios where both performance and realism are critical.

This work was performed in collabration with Julien Pettré from Rainbow team.

9.2.1.3. ANR PRCI HoBis

Participants: Franck Multon [contact], Armel Crétual, Georges Dumont, Charles Pontonnier, Anthony Sorel.

Hobis is a 42 month ANR collaborative (PRCI) project (2018-2022) entitled *HoBiS (Hominin BipedalismS): Exploration of bipedal gaits in Hominins thanks to Specimen-Specific Functional Morphology*. HoBis is leaded by the Museum Nationale d'Histoires Naturelles (CNRS), with CNRS/LAAS, and Antwerpen University (Belgium), with a total of 541KE budget (140KE for MimeTIC).

HoBiS (Hominin BipedalismS) is a pluridisciplinary research project, fundamental in nature and centred on palaeoanthropological questions related to habitual bipedalism, one of the most striking features of the human lineage. Recent discoveries (up to 7 My) highlight an unexpected diversity of locomotor anatomies in Hominins that lead palaeoanthropologists to hypothesize that habitual bipedal locomotion took distinct shapes through our phylogenetic history. In early Hominins, this diversity could reveal a high degree of locomotor plasticity which favoured their evolutionary success in the changing environments of the late Miocene and Pliocene. Furthermore, one can hypothesize based on biomechanical theory that differences in gait characteristics, even slight, have impacted the energy balance of hominin species and thus their evolutionary success. However, given the fragmented nature of fossil specimens , previous morphometric and anatomo-functional approaches developed by biologists and palaeoanthropologists, do not allow the assessment of the biomechanical and energetic impacts of such subtle morphological differences, and the manners in which hominin species walked still remains unknown. To tackle this problem, HoBiS proposes as main objective a totally new specimen-specific approach in evolutionary anthropology named Specimen-Specific Functional Morphology: inferring plausible complete locomotor anatomies based on fossil remains, to link these reconstructed anatomies and corresponding musculoskeletal models (MSM) with plausible gaits using simulations. Both sub-objectives will make use of an extensive comparative anatomical and gait biomechanical data bases (challenges). To this end, we will integrate anatomical and functional studies, tools for anatomical modelling, optimization and simulation rooted in informatics, biomechanics, and robotics, to build an in-silico decision-support system (DSS). This DSS will provide biomechanical simulations and energetic estimations of the most plausible bipedal gaits for a variety of hominin species based on available remains, from partial to well-preserved specimens. To achieve this main objective, the project will address the following sub-objectives and challenges

MimeTIC is Leader of WP3 "Biomechanical simulation", aiming at predicting plausible bipedal locomotion based on paleoanthropological heuristics and a given MSM.

9.2.2. National scientific collaborations

9.2.2.1. Cavaletic

Participant: Franck Multon [contact].

The Cavaletic collaborative project is leaded by University Bretagne Sud and also involves University Rennes2 (CREAD Lab.). It has been funded by the National IFCE (Institut Français du Cheval et de l'Equitation) in order to develop and evaluate technological assistance in horse riding learning, thanks to a user-centered approach. MimeTIC is involved in measuring expert and non-expert horse riders' motions in standardized situations in order to develop metrics to measure riders' performance. It will be used to develop a technological system embedded on users to evaluate their performance and provide them with real-time feedback to correct potential errors.

The project ended in 2018 but we are submitting a proposal to SATT Ouest Valorisation in order to finish the development of the technological prototype, and to evaluate the possibility to patent the process, and transfer it to private companies.

9.2.2.2. French Federation of Tennis

Participants: Richard Kulpa [contact], Benoit Bideau, Pierre Touzard.

An exclusive contract has been signed between the M2S laboratory and the French Federation of Tennis for three years. The goal is to perform biomechanical analyses of 3D tennis serves on a population of 40 players of the Pôle France. The objective is to determine the link between injuries and biomechanical constraints on joints and muscles depending on the age and gender of the players. At the end, the goal is to evaluate their load training.

9.2.3. ADT: Immerstar 2020

Participants: Ronan Gaugne [contact], Georges Dumont.

The ADT-Immerstar 2020 is driven by the SED and aims at developing new tools and facilities for the scientific community in order to develop demos and use the two immersive rooms in Rennes: Immersia and Immermove. The engineer (Quentin Petit, SED) has the responsibility of homogenizing the software modules and development facilities in each platform, of installing new upgrades and of developping collaborative applications between the two sites.

9.2.4. PRE

Participants: Franck Multon [contact], Ludovic Hoyet, Antonio Mucherino.

The Inria PRE projet entitled "Smart sensors and novel motion representation breakthrough for human performance analysis" aims at designing a new description for human motion in order to automatically capture, measure and transfer the intrinsic constraints of human motion. Current approached consisted in manually editing the constraints associated with a motion, to use classical skeleton representation with joint angles based on direct or indirect measurements, and then perform inverse kinematics to fulfill these constraints. We aim at designing a new representation to simplify this process pipeline and make it automatic, together with relevant motion sensors that could provide enough information to automatically extract these intrinsic constraints. To this end, this project has been jointly proposed with the Inria CAIRN team, which develops sensors based on joint orientations and distances between sensors. We aim at extending this type of device to measure new types of information that would help to simplify the above mentionned pipeline. A postdoc Zhiguang Liu arrived in November 2016 to jointly work with CAIRN.

Our results show that shape transfer could be used to transfer a pose from a source character to a target character while maintaining the contextual meaning of the original pose, even if the two characters have different morphology. The main contribution is the definition of a new data structre, named "context graph", to model relative Laplacian coordinates of sub-sampled surfaces points, enabling us to capture the topological relations betwen surfaces of the body.

We have obtained a proof of concept presented in ACM Motion in Games 2018, and we are planning to submit an extended version of the paper to IEEE TVCG.

9.2.5. AUTOMA-PIED

Participants: Anne-Hélène Olivier [contact], Armel Crétual, Anthony Sorel.

The AUTOMA-PIED project is driven by IFSTTAR. Using a set-up in virtual reality, the first objective of the project aims at comparing pedestrian behaviour (young and older adults) when interacting with traditional or autonomous vehicles in a street crossing scenario. The second objective is to identify postural cues that can predict whether or not the pedestrian is about to cross the street.

9.2.6. IPL Avatar

Participants: Ludovic Hoyet [contact], Franck Multon.

This project, led by Ludovic Hoyet, aims at design avatars (i.e., the user's representation in virtual environments) that are better embodied, more interactive and more social, through improving all the pipeline related to avatars, from acquisition and simulation, to designing novel interaction paradigms and multi-sensory feedback. It involves 6 Inria teams (GraphDeco, Hybrid, Loki, MimeTIC, Morpheo, Potioc), Prof. Mel Slater (Uni. Barcelona), and 2 industrial partners (Technicolor and Faurecia).

Website: http://avatar.inria.fr

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- Program: Joint Program Initiative
- Project Acronym: SCHEDAR
- Project title: Safeguarding the Cultural HEritage of Dance through Augmented Reality
- Duration: June 2018-June 2021
- Coordinator: University of Cyprus
- Other partners: Algolysis LTD (Cyprus), University of Warwick (UK), University of Reims Champagne Ardennes (France)
- Abstract: Dance is an integral part of any culture. Through its choreography and costumes dance imparts richness and uniqueness to that culture. Over the last decade, technological developments have been exploited to record, curate, remediate, provide access, preserve and protect tangible CH. However, intangible assets, such as dance, has largely been excluded from this previous work. Recent computing advances have enabled the accurate 3D digitization of human motion. Such systems provide a new means for capturing, preserving and subsequently re-creating ICH which goes far beyond traditional written or imaging approaches. However, 3D motion data is expensive to create and maintain, encompassed semantic information is difficult to extract and formulate, and current software tools to search and visualize this data are too complex for most end-users. SCHEDAR will provide novel solutions to the three key challenges of archiving, re-using and re-purposing, and ultimately disseminating ICH motion data. In addition, we will devise a comprehensive set of new guidelines, a framework and software tools for leveraging existing ICH motion databases. Data acquisition will be undertaken holistically; encompassing data related to the performance, the performer, the kind of the dance, the hidden/untold story, etc. Innovative use of state-of-the-art multisensory Augmented Reality technology will enable direct interaction with the dance, providing new experiences and training in traditional dance which is key to ensure this rich culture asset is preserved for future generations. MimeTIC is responsible for WP3 "Dance Data Enhancement".

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. FORMOSA

Title: Fostering Research on Models for Storytelling Applications

International Partner (Institution - Laboratory - Researcher):

NCCU (Taiwan) - Intelligent Media Lab (IML) - Tsai-Yen Li

Start year: 2016

See also: http://www.irisa.fr/mimetic/GENS/mchristi/EA-FORMOSA/

Interactive Storytelling is a new media which allows users to alter the content and outcome of narratives through role-playing and specific actions. With the quality, the availability and reasonable costs of display technologies and 3D interaction devices on one side, and the accessibility of 3D content creation tools on the other, this media is taking a significant share in entertainment (as demonstrated by the success of cinematographic games such as Heavy Rain or Beyond: two souls). These advances push us to re-think the way narratives are traditionally structured, explore new interactive modalities and provide new interactive cinematographic experiences. As a sequel of the first associate team FORMOSA 1, we propose to address new challenges pertained to interactive storytelling such as the use of temporal structures in narratives, interaction modalities and their impact in terms of immersion, and the adaptation of cinematographic real data to 3D environments. To achieve these objectives, the associate team will rely on the complementary skills of its partners and on the co-supervision of students.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- Dr. Rachel McDonnell, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)
- Prof. Carol O Sullivan, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)
- Prof Michael Cinelli, University Wilfrid Laurier, Waterloo, Canada (on-going collaboration with Anne-Hélène Olivier)
- Prof. Hannes Kaufmann, TU Wien, Austria (on-going collaboration with Anne-Hélène Olivier)
- Prof. Hui Huang, Shenzhen University (on-going collaboration with Marc Christie)
- Prof. Baoquan Chen, Pekin University (on-going collaboration with Marc Christie)
- Dr. Bin Wang, Beijing Film Academy University (on-going collaboration with Marc Christie)

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Prof. Pascal Madeleine, Aalborg Univeristy, Denmark, 1 week stay in may 2018 for collaborations with Georges Dumont and Charles Pontonnier about physical and cognitive load in virtual environments.
- Michael Cinelli, Associate Professor, Kinesiology and Physical Education, Wilfrid Laurier University, Canada, June 2018

9.5.1.1. Internships

- Victoria Rapos, Wilfrid Laurier University, Canada (Master supervisor: Michael Cinelli), 3 month internship from May to July 2018 with A.H. Olivier and A. Crétual about collision avoidance strategies in kids.
- Natalie Snyder, Wilfrid Laurier University, Canada (Master supervisor: Michael Cinelli), 3 month internship from May to July 2018 with A.H. Olivier and A. Crétual about collision avoidance strategies in previously concussed athletes.
- Ching Yu Kang, NCCU from July to September 2018 with Marc Christie on Virtual Staging techniques
- Wan Yu Lee, NCCU from July to September 2018 with Marc Christie on Drone Cinematography

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

- Anne-Hélène Olivier, Workshop VHCIE 2018, IEEE VR 2018, Reutlingen, Germany, March 2018
- Anne-Hélène Olivier, Workshop "walkers behaviour: from analysis to applications", Rennes, June 2018, broadcasted as a Webinar for the International Society of Posture and Gait Research.

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

Ludovic Hoyet: Animation & Simulation Area Program Chair, International Conference on Computer Graphics Theory and Applications 2019, Prague, Czech Republic, Feb. 2019

Anne-Hélène Olivier: co-chair of the IEEE VR 2019 Conference paper track, Osaka, Japan.

10.1.2.2. Member of the Conference Program Committees

Ludovic Hoyet, ACM Motion in Games MIG 2018, Cyprus, Nov. 2018

Ludovic Hoyet, ACM Symposium on Applied Perception 2018, Vancouver, Canada, Aug. 2018

Ludovic Hoyet, ACM Siggraph Asia Courses 2018, Tokyo, Japan, Deb. 2018

Anne-Hélène Olivier, ACM Motion in Games MIG 2018, Cyprus, Nov. 2018

Anne-Hélène Olivier, Euro-VR 2018 London, UK, October 2018.

Franck Multon, ACM Motion in Games MIG 2018, Cyprus, Nov. 2018

Franck Multon, Computer Animation and Social Agents 2018, Beijing, May 2018

Marc Christie, ACM Motion in Games 2018, Cyprus, Nov. 2018

Marc Christie, ACM TVX 2018, Seoul, June. 2018

Richard Kulpa, International Conference on Computer Graphics Theory and Applications (GRAPP), 2018

10.1.2.3. Reviewer

Ludovic Hoyet, ACM Siggraph 2018, IEEE VR 2019, Artificial Intelligence and Virtual Reality

Anne-Hélène Olivier, IEEE VR 2019 TVCG Conference paper, ACM VRST 2018, IEEE International Conference on Automatic Face and Gesture Recognition

Richard Kulpa, IEEE VR, ACM CHI (Computer Human Interface), Computer & Graphics

Franck Multon, IEEE VR 2019, Pacific Graphics 2018

Marc Christie, ACM Siggraph, ACM Siggraph Asia, ACM CHI, Eurographics

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- Franck Multon, Presence, MIT Press
- Franck Multon, Computer Animation and Virtual Worlds CAVW, John Wiley
- Antonio Mucherino, Guest Editor of Optimization Letters, Springer
- Armel Crétual, Editorial board of Journal of Electromyography and Kinesiology
- Marc Christie, Associate Editor of the Visual Computer

10.1.3.2. Reviewer - Reviewing Activities

Franck Multon, Medical & Biological Engineering & Computing, Applied Ergonomics, IEEE Journal of Biomedical and Health Informatics, International Journal of Industrial and Operations Research, Human Movement Sciences

Ludovic Hoyet, IEEE Transactions on Visualization and Computer Graphics, Computers & Graphics, Computer Graphics Forum, ACM Transactions on Applied Perception

Anne-Hélène Olivier, Gait and Posture, Human Movement Science, TVCG, CAG, Transactions on Neural Systems & Rehabilitation Engineering, VIRE

Antonio Mucherino, Journal of Global Optimization, Springer, Discrete Applied Mathematics, Elsevier

Armel Crétual, ACM Transactions on Graphics, Clinical Biomechanics, IEEE Robotics and Automation Letters

Richard Kulpa, PlosOne, Journal of Sport Science, Human Movement Science, Sports Medicine, Journal of Sports Engineering and Technology, International Journal of Sports Science & Coaching,

Marc Christie, IEEE TVCG, The Visual Computer, CGF

Charles Pontonnier, Applied Ergonomics, Multibody System Dynamics

10.1.4. Invited Talks

Anne-Hélène Olivier, IFSTTAR Marne la Vallée, March 2018

Ludovic Hoyet, IFSTTAR Marne la Vallée, March 2018

Charles Pontonnier, EMC2 Institute, Matinale "Opérateur du futur", November 2018

Marc Christie, ACM TVX, Seoul, Korea, 2018

Marc Christie, Beijing Film Academy, Beijing, China, October 2018

Marc Christie, ChinaVR, Qingdao, China, October 2018

Franck Multon, Université Reims Champagne Ardennes, July 2018

Franck Multon, Université Paris Sud, July 2018

10.1.5. Scientific Expertise

Franck Multon, ANR expert, member of the ANR CPDS 4 "Santé Bien-être" through the Allistene national Alliance to design the next ANR call for projects,

Armel Crétual, ANR expert (TecSan)

10.1.6. Research Administration

Franck Multon is member of the University Rennes2 Research steering committee "commission recherche", and Academic Council "CAC"

Franck Multon is coordinator of Inria national initiative "Sport @ Inria" in relation with the French Ministry of Sports, and the French Ministry of Research, for Olympic Games 2024

Ludovic Hoyet is an elected member of the Board of Managers for the French Computer Graphics Association (Association Française d'Informatique Graphique) since Oct. 2017

Georges Dumont is president of the elected group at scientific council of École Normale Supérieure de Rennes, member of the scientific council of École Normale Supérieure de Rennes

Georges Dumont is scientific head of Immerstar platforms (Immersia + Immermove) jointly for Inria and Irisa Partners

Richard Kulpa is member of the University Rennes2 Research steering committee "commission recherche", Academic Council "CAC" and Committee of International Affairs "CAI"il "CAC",

Benoit Bideau is director of the M2S Lab

Fabrice Lamarche is an elected member of the CNU (French National Cuoncil of Universities).

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Master : Franck Multon, co-leader of the IEAP Master (1 and 2) "Ingénierie et Ergonomie de l'Activité Physique", STAPS, University Rennes2, France

Master : Franck Multon, "Santé et Performance au Travail : étude de cas", leader of the module, 30H, Master 1 M2S, University Rennes2, France

Master : Franck Multon, "Analyse Biomécanique de la Performance Motrice", leader of the module, 30H, Master 1 M2S, University Rennes2, France

Master: Charles Pontonnier, "Analytical Mechanics" , 40H (M1), École Spéciale Militaire de Saint-Cyr Coëtquidan, France

Master: Charles Pontonnier, "Design and control of legged robots", 38H (M1), École Spéciale Militaire de Saint-Cyr Coëtquidan, France

Master: Charles Pontonnier, "Simulation of multibody system dynamics", 34H (M1), École Normale Supérieure de Rennes, France

Master: Charles Pontonnier, "oral preparation to agregation competitive exam", 18H (M2), École Normale Supérieure de Rennes, France

Master : Georges Dumont, Responsible of the second year of the master Engineering of complex systems, École Normale Supérieure de Rennes and Rennes 1 University, France

Master : Georges Dumont, Mechanical simulation in Virtual reality, 36H, Master Engineering of complex systems and Mechatronics, Rennes 1 University and École Normale Supérieure de Rennes, France

Master : Georges Dumont, Mechanics of deformable systems, 40H, Master FE, École Normale Supérieure de Rennes, France

Master : Georges Dumont, oral preparation to agregation competitive exam, 20H, Master FE, École Normale Supérieure de Rennes, France

Master : Georges Dumont, Vibrations in Mechanics, 10H, Master FE, École Normale Supérieure de Rennes, France

Master : Georges Dumont, Multibody Dynamics, 9H, Master FE, École Normale Supérieure de Rennes, France

Master : Georges Dumont, Finite Element method, 12H, Master FE, École Normale Supérieure de Rennes, France

Master : Ludovic Hoyet, Motion for Animation and Robotics, 9h, University Rennes 1, France

Master : Ludovic Hoyet, Motion Analysis and Gesture Recognition, 12h, INSA Rennes, France

Master : Ludovic Hoyet, Réalité Virtuelle pour l'Analyse Ergonomique, Master Ingénierie et Ergonomie des Activités Physique, 21h, University Rennes 2, France

Master : Anne-Hélène Olivier, "Biostatstiques", 7H, Master 2 APPCM, University Rennes2, France

Master : Anne-Hélène Olivier, "Evaluation fonctionnelle des pathologies motrices", 9H Master 2 APPCM, University Rennes2, France

Master : Anne-Hélène Olivier, "Maladie neurodégénératives : aspects biomécaniques", 2H Master 1 APPCM, University Rennes2, France

Master : Anne-Hélène Olivier, "Biostatstiques", 7H, Master 1 EOPS, University Rennes2, France

Master : Anne-Hélène Olivier, "Méthodologie", 4H, Master 1 EOPS/APPCM, University Rennes2, France

Master : Anne-Hélène Olivier, "Contrôle moteur : Boucle perceptivo-motrice", 3H, Master 1IEAP, Université Rennes 2, France

Master: Antonio Mucherino, "Programmation Parallèle", M1 en Informatique, 16H, University of Rennes, France

Master: Fabrice Lamarche, "Compilation pour l'image numérique", 29h, Master 1, ESIR, University of Rennes 1, France

Master: Fabrice Lamarche, "Synthèse d'images", 12h, Master 1, ESIR, University of Rennes 1, France

Master: Fabrice Lamarche, "Synthèse d'images avancée", 28h, Master 1, ESIR, University of Rennes 1, France

Master: Fabrice Lamarche, "Modélisation Animation Rendu", 36h, Master 2, ISTIC, University of Rennes 1, France

Master: Fabrice Lamarche, "Jeux vidéo", 26h, Master 2, ESIR, University of Rennes 1, France

Master: Fabrice Lamarche, "Motion for Animation and Robotics", 9h, Master 2 SIF, ISTIC, University of Rennes 1, France.

Master : Armel Crétual, "Méthodologie", leader of the module, 20H, Master 1 M2S, University Rennes2, France

Master : Armel Crétual, "Biostatstiques", leader of the module, 30H, Master 2 M2S, University Rennes2, France

Master : Richard Kulpa, "Boucle analyse-modélisation-simulation du mouvement", 27h, leader of the module, Master 2, Université Rennes 2, France

Master : Richard Kulpa, "Méthodes numériques d'analyse du geste", 27h, leader of the module, Master 2, Université Rennes 2, France

Master : Richard Kulpa, "Cinématique inverse", 3h, leader of the module, Master 2, Université Rennes 2, France

Master: Marc Christie, "Multimedia Mobile", Master 2, leader of the module, 32h, Computer Science, University of Rennes 1, France

Master: Marc Christie, "Projet Industriel Transverse", Master 2, 32h, leader of the module, Computer Science, University of Rennes 1, France

Licence : Franck Multon, "Ergonomie du poste de travail", Licence STAPS L2 & L3, University Rennes2, France

Licence : Anne-Hélène Olivier, "Analyse cinématique du mouvement", 100H , Licence 1, University Rennes 2, France

Licence : Anne-Hélène Olivier, "Anatomie fonctionnelle", 7H , Licence 1, University Rennes 2, France

Licence : Anne-Hélène Olivier, "Effort et efficience", 12H , Licence 2, University Rennes 2, France

Licence : Anne-Hélène Olivier, "Locomotion et handicap", 12H , Licence 3, University Rennes 2, France

Licence : Anne-Hélène Olivier, "Biomécanique spécifique aux APA", 8H , Licence 3, University Rennes 2, France

Licence : Anne-Hélène Olivier, "Biomécanique du viellissement", 12H , Licence 3, University Rennes 2, France

Licence: Antonio Mucherino, "Informatique 1", 80H, L1, University of Rennes, France

Licence: Charles Pontonnier, "Serial robotics", 34H (L3), École Normale Supérieure de Rennes, France

Licence: Fabrice Lamarche, "Initiation à l'algorithmique et à la programmation", 56h, License 3, ESIR, University of Rennes 1, France

License: Fabrice Lamarche, "Programmation en C++", 46h, License 3, ESIR, University of Rennes 1, France

Licence: Fabrice Lamarche, "IMA", 24h, License 3, ENS Rennes, ISTIC, University of Rennes 1, France

Licence : Armel Crétual, "Analyse cinématique du mouvement", 100H, Licence 1, University Rennes 2, France

Licence : Richard Kulpa, "Biomécanique (dynamique en translation et rotation)", 48h, Licence 2, Université Rennes 2, France

Licence : Richard Kulpa, "Méthodes numériques d'analyse du geste", 48h, Licence 3, Université Rennes 2, France

Licence : Richard Kulpa, "Statistiques et informatique", 15h, Licence 3, Université Rennes 2, France

Licence : Marc Christie, "Programmation Impérative 1", leader of the module, University of Rennes 1, France

10.2.2. Supervision

PhD in progress (beginning september 2017): Simon Hilt, Haptique Biofidèle pour l'Interaction en réalité virtuelle, Ecole normale supérieure, Georges Dumont& Charles Pontonnier

PhD in progress (beginning september 2017): Pierre Puchaud, Développement d'un modèle musculo-squelettique générique du soldat en vue du support de son activité physique, Ecole normale supérieure, Charles Pontonnier& Nicolas Bideau & Georges Dumont

PhD in progress: Diane Dewez, Avatar-Based Interaction in Virtual Reality, Oct. 2018, Ferran Argelaguet & Ludovic Hoyet & Anatole Lécuyer

PhD in progress: Rebecca Fribourg, Enhancing Avatars in Virtual Reality through Control, Interactions and Feedback, Sept. 2017, Ferran Argelaguet & Ludovic Hoyet & Anatole Lécuyer

PhD in progress: Florian Berton, Design of a virtual reality platform for studying immersion and behaviours in aggressive crowds, Nov. 2017, Ludovic Hoyet & Anne-Hélène Olivier & Julien Petré

PhD in progress: Benjamin Niay, A framework for synthezing personalised human motions from motion capture data and perceptual information, Oct. 2018, Ludovic Hoyet & Anne-Hélène Olivier & Julien Petré

PhD in progress: Hugo Brument, Toward user-adapted interactions techniques based on human locomotion laws for navigating in virtual environments, Oct. 2018, Ferran Argelaguet & Anne-Hélène Olivier & Maud Marchal.

PhD in progress: Carole Puil, Impact d'une stimulation plantaire orthétique sur la posture d'individus sains et posturalement déficients au cours de la station debout, et lors de la marche, Oct. 2018, Armel Crétual & Anne-Hélène Olivier.

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10.2.3. Juries

PhD: 2018, Marien Couvertier, Identification des paramètres inertiels segmentaires humains, Université de Poitiers. 2018 december 18st, Georges Dumont Rapporteur.

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HDR: 2018, Antonio Mucherino, On the Discretization of Distance Geometry: Theory, Algorithms and Applications, 2018 July, Franck Multon, Examinateur

HDR: 2018, Hazem Wannous, Towards Understanding Human Behavior by Time-Series Analysis of 3D Motion, Universite Lille, 2018 December 5, Franck Multon, President

PhD: 2018, Margarita Khokhlova, Evaluation clinique de la démarche à partir de données 3D, Universite Bourgogne, 2018 November 19, Franck Multon, Rapporteur

PhD: 2018, Martin Bossard, Visual perception of selfmotion: the relative contribution of viewpoint oscillation to the perception of distance travelled, Aix-Marseille Université, 2018 October, Richard Kulpa, Président

Adrien Verhulst, Étude de Faisabilité d'Études Consommateurs d'Achat de Fruits et Légumes « Moches » dans un Supermarché Virtuel, Ecole Centrale de Nantes, Franck Multon, 2018 July 4, Examinateur

10.3. Popularization

10.3.1. Internal or external Inria responsibilities

Franck Multon is coordinator of Inria national initiative "Sport Inria" in relation with the French Ministry of Sports, and the French Ministry of Research, for Olympic Games 2024

10.3.2. Articles and contents

Co-author of a book dedicated to undergraduate STAPS students, Elsevier Health Sciences, Sept. 2018. « STAPS: anatomie, physiologie, neurosciences et biomécanique » (P Delamarche, F Multon, T Horrut, V Nougier). Author of the chapter entitled « Biomécanique de la performance motrice » (47 pages).

Book chapter "Réalité virtuelle au service du sport" in a book "Corps et Sport" dedicated to general public, pages 148–164, Editions de la Martinière, 2018.

Book chapter "The democratization of VR-AR" in a book "Virtual Reality and Augmented Reality: Myths and Realities" dedicated to general public, pages 73-123, ISTE Ltd, 2018.

Book chapter "Vers une démocratisation de la RV-RA ?" in a book "Réalité virtuelle et réalité augmentée" dedicated to general public, pages 95-141, ISTE Ltd, 2018.

10.3.3. Interventions

Richard Kulpa was member of the scientific committee for temporary exhibition (1000m2) entitled "Corps et Sport" in "Cité des sciences et de l'industrie", Octobre 16th 2018 to January 5th 2019. The idea is to propose a new approach of sports ti the wide public audience.

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