ANIMA
Authoring and Directing Animated Story Worlds.
A joint research team of Laboratoire Jean Kuntzmann, UMR 5224, Inria, Grenoble INP, CNRS and Univ. Grenoble Alpes.

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1 Personnel

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2 Motivation

In August 2017, the motto for the ACM Siggraph conference became ”Enabling Everyone to Tell Their Stories”. Indeed, narrative contents such as interactive games and animated movies are a major application domain for computer graphics, with implications in entertainment, education, cultural heritage, scientific communication and professional training. In those applications, the creation of 3-D content cannot be limited to the production of shapes and motions; it should also include the necessary steps to organize shapes and motions into compelling stories, using adequate staging, directing and editing. As a result, it becomes essential to conduct research in authoring and directing animated story worlds. We propose the creation of a new team ANIMA as an offspring of IMAGINE to address those new challenges.

2.1 From IMAGINE to ANIMA

The ANIMA team will remain faithful to the original scientific agenda proposed by IMAGINE, with a continued effort to provide more intuitive and expressive tools to graphic artists. To address the challenge of ”making tools as transparent to the artists as special effects were made transparent to the general public”, IMAGINE used the metaphors of painting and sculpting virtual worlds, which was useful for generating ”responsive shapes”, i.e. shapes that can be easily created and edited using graphic abstractions. One important milestone in IMAGINE was the discovery that the same metaphors could also be extrapolated for sketching character animations [38] and camera movements [27]. ANIMA will follow the same route of borrowing metaphors from traditional arts, including theatre and cinema, and extrapolating them to virtual worlds.

Theatre has been described as the art of creating a virtual reality on the stage and compared to video games, which similarly create a virtual reality in real-time on the computer screen. A new research topic for ANIMA will be to provide the necessary tools to author and direct computational story worlds that can serve as stage and screen for virtual reality storytelling. In previous work, we have already tackled the problem of generating responsive shapes such as virtual paper [81], i.e. surfaces that “act like paper” (they can be folded, crumpled and torn apart like paper, even creating the same sounds as paper). This work was not a faithful physical simulation of paper, but a computational mimicry of some important semantic and aesthetic properties of paper. In future work, we would like to further emphasize the metaphor of a computer theatre of virtual props, actors and cameras that can be authored and directed by artists and domain experts to tell stories with computers.

In an animated story world, virtual props need affordances, i.e. actions that can be performed with them. Similarly, virtual actors need skills, i.e. actions that they can perform within the given virtual world. This opens new scientific problems – how do we represent the story computationally? How do we assemble virtual sets for a story? How do we assign characters and objects in the story to actors and props in the virtual world? How do we design virtual actors with the necessary skills, and virtual props with the necessary affordances? How do we sketch and sculpt the choreography of their movements and actions? To address those scientific problems, two central themes of the ANIMA team will be (i) to use the metaphor of movie storyboards as a multimodal depiction of a scene and to sketch entire stories from storyboards; and (ii) to use the metaphor of theatre rehearsals for iteratively improving the quality of virtual performances authored and directed with our systems.

In this context, the research program for the ANIMA project team will focus on developing computer tools for authoring and directing animated movies, interactive games and mixed-reality applications, using virtual sets, actors, cameras and lights.

This raises several scientific challenges. Firstly, we need to build a representation of the story that the user/director has in mind, and this requires dedicated user interfaces for communicating the story. Secondly, we need to offer tools for authoring the necessary shapes and motions for communicating the story visually, and this requires a combination of high-level geometric, physical and semantic models that can be manipulated in real-time under the user’s artistic control. Thirdly, we need to offer tools for directing the story, and this requires new interaction models for controlling the virtual actors and cameras to communicate the desired story while maintaining the coherence of the story world.

2.2 Understanding stories

Stories can come in many forms. An anatomy lesson is a story. A cooking recipe is a story. A geological sketch is a story. Many paintings and sculptures are stories. Stories can be told with words, but also with drawings and gestures. For the purpose of creating animated story worlds, we are particularly interested in communicating the story with words in the form of a screenplay or with pictures in the form of a storyboard. We also foresee the possibility of communicating the story in space using spatial gestures.

The first scientific challenge for the ANIMA team will be to propose new computational models and representations for screenplays and storyboards, and practical methods for parsing and interpreting screenplays and storyboards from multimodal user input. To do this, we will reverse engineer existing screenplays and storyboards, which are well suited for generating animation in traditional formats. We will also explore new representations for communicating stories with a combination of speech commands, 3D sketches and 3D gestures, which promise to be more suited for communicating stories in new media including virtual reality, augmented reality and mixed reality.

2.3 Authoring story worlds

Telling stories visually creates additional challenges not found in traditional, text-based storytelling. Even the simplest story requires a large vocabulary of shapes and animations to be told visually. This is a major bottleneck for all narrative animation synthesis systems.

The second scientific challenge for the ANIMA team will be to propose methods for quickly authoring shapes and animations that can be used to tell stories visually. We therefore need to devise methods for generating shapes and shape families, understanding their functions and styles, their material properties and affordances; authoring animations for a large repertoire of actions, that can be easily edited and transfered between shapes; and printing and fabricating articulated and deformable shapes suitable for creating physical story worlds with tangible interaction.

2.4 Directing story worlds

Lastly, we aim to develop methods for controlling virtual actors and cameras in virtual worlds and editing them into movies in a variety of situations ranging from 2D and 3D professional animation, to virtual reality movies and real-time video games. Starting from the well-established tradition of the storyboard, we would like to offer new tools for directing movies in 3D animation, where the user is really the director, and the computer is in charge of its technical execution using a library of film idioms. We also would like to explore new areas, including the automatic generation of storyboards from movie scripts for use by domain experts, rather than graphic artists.

Our long-term goal will be to allow artists to simultaneously create geometry, animation and cinematography from a single sequence of storyboard sketches. This is a difficult problem in general and it is important to choose application domains where we can demonstrate progress along the way. In unrestricted domains, we will focus on the more tractable problem of quickly creating complex camera movements from sketches given a 3D scene and its animation. We will use the traditional conventions of storyboards to represent camera movements and compute suitable key pose interpolations.

2.5 Organization

ANIMA is a multi-disciplinary team with a common research interest in story understanding, story world authoring and story world directing. We plan to confront those emerging topics from multiple perspectives, by organizing the team into four research themes, where we have the necessary experience and expertise to make significant contributions. Each research theme will examine the same challenges of understanding stories, authoring story worlds, and directing story worlds, from its own perspective and with its own research agenda.

The four research themes pursued by ANIMA are (i) the geometry of story worlds; (ii) the physics of story worlds; (iii) the semantics of story worlds; and (iv) the aesthetics of story worlds. In each theme, significant advances in the state of the art are needed to propose computational models of stories, and build the necessary tools for translating stories to 3D graphics and animation.

Those four research themes are of course not independent. For all practical purposes, we will need a combination of geometry, physics, semantics and aesthetics to understand stories and storyboards; author the necessary story worlds; and direct the stories into compelling animation. We therefore expect a very strong inter-connection between the four research directions pursued by the ANIMA team members.

3 Scientific objectives

To address the above challenges, the team is organized around four scientific themes: (1) geometric modeling of story worlds; (2) physical modeling of story worlds; (3) semantic modeling of story worlds; (4) aesthetic modeling of story worlds. In each case, our goal is both to propose new methods for authoring animated story worlds and new interactions for directing them.

3.1 Geometric modeling of story worlds

Scientist in charge: Stefanie Hahmann
Other participants: Rémi Ronfard, Mélina Skouras

We aim to create intuitive tools for designing 3D shapes and animations which can be used to populate interactive, animated story worlds, rather than inert and static virtual worlds. In many different application scenarios such as preparing a product design review, teaching human anatomy with a MOOC, composing a theatre play, directing a movie, showing a sports event, 3D shapes must be modeled for the specific requirements of the animation and interaction scenarios (stories) of the application.

We will need to invent novel shape modelling methods to support the necessary affordances for interaction and maintain consistency and plausibility of the shape appearances and behaviors during animation and interaction. Compared to our previous work, we will therefore focus increasingly on designing shapes and motions simultaneously, rather than separately, based on the requirements of the stories to be told.

Previous work in the IMAGINE team has emphasized the usefulness of space-time constructions for sketching and sculpting animation both in 2D and 3D. Future work in the ANIMA team will further develop this line of research, with the long-term goal of choreographing complex multi-character animation and providing full authorial and directorial control to the user.

3.1.1 State of the art

Much work has been devoted in the last two decades on creating 3D geometry from 2D sketches, see [21, 19] for recent surveys. The work of Gingold stands out with its clever use of semantic annotations [34]. The Photo Wake-up system uses deep learning methods for reconstructing 3D characters from photos and paintings [91]. Other notable work has been devoted to creating 3D character poses from figure drawings [6] and garment design from fashion sketches [90]

The topic of creating 3D animation from storyboard-like sketches is much younger. In previous work, we have proposed novel topological data structures and algorithms for immersing 3D shapes and motions into a dynamic 2D drawing canvas [16], which is a suitable representation for storyboarding. Our space-time sketching paper [38] goes one step further by allowing users to combine spatial and temporal curves and create character animations interactively. Similar techniques have been proposed in the SketchiMo system [11] and further refined by Ciccone et al. [12]. As a result, sketch-based animation is becoming an alternative to the more traditional keyframe animation techniques used in commercial systems.

Previous work has also investigated the problem of creating 3D animation of classical ballet steps directly from choreographic notation systems such as Laban notation [92] and Benesh notation [69]. Generating aesthetically pleasing and expressive animation from dance notation remains a challenge in general, and so is the even more difficult problem of generating 3D animation directly from storyboards.

Another important trend in recent years is the use of spatial interaction for sketching and sculpting 3D shapes in 3D space using virtual reality headsets and trackers. While the idea dates back to 1995 at least with HoloSketch [18], it has been revived by the recent availability of affordable VR headsets and tracking systems. Some important milestones are JustDrawIt [36], Lift-off [46] and SymbiosisSketch [3]. Proprietary systems such as Google Tilt Brush and Oculus Quill are also available. Their ambition is to evolve from 3D painting tools to end-to-end solutions for making full animated stories. This is an indication that new methods are also in high demand for authoring and directing story worlds in AR and VR.

3.1.2 Research directions

This research axis will focus on methods that enable creative and expressive design of shapes and their motions, continuing the metaphor of creating a *magic pen*, where the user roughly sketches the main features of an object to be (re-)constructed in 3D while at the same time indicating its motion into a space-time storyboard.

Space-time modeling The first new direction of research in this axis will be an investigation of space-time geometric modeling, i.e. the simultaneous creation of shapes and their motions. This is in continuity with our previous work on "responsive shapes", i.e. making 3D shapes respond in an intuitive way during both design and animation.

Standard sketch-based modeling from 2D Sketches or single photograph is still a challenging task. We aim to generate 3D clothes with folds from 2D hand drawn sketches by reverse engineering with prior knowledge on the type of object and minimal user annotations of salient features of the shape (e.g. silhouettes, symmetry axes). Application to leather products [48] and developable surfaces [26] was successful in the past. Starting from a single stylized designer's sketch, we now would like to compute a 3D folded garment in the same style, dress a virtual character with it and enable style preserving transfer to characters of different sizes and morphologies. In the case of storyboards, we will also need to work from multiple panels, which may represent articulated and deformable structures in different views, at different times, in different poses and states. Recovering those complex shapes is an interesting challenge for sketch-based modeling that has not been addressed in previous work. This is difficult because it requires partial matching between the two views, then simultaneous 3D reconstruction of the common object structure and its two poses.

Another important goal will be to create animation directly from storyboards. Starting from our previous work on space-time sketching of character animation, we would like to let computer artists use the conventions of traditional storyboards to draw spatio-temporal motions directly in the storyboard frames and see the results.

Spatial interaction A second new direction of research of the ANIMA team will be the extension of sketching and sculpting tools to the case of spatial 3D interaction using virtual reality headsets, sensors and trackers.

Even though 3D modeling can be regarded as an ideal application for Virtual Reality, it is known to suffer from the lack of control for freehand drawing. Our insight is to exploit the expressiveness of hand (controller) motion and simple geometric primitives in order to form an approximated 3D shape. The goal is not to generate a final well shaped product, but to provide a 3D sketching tool for creating early design shapes, kind of scaffolds, and for rough idea exploration. Standard 3D modeling systems can then take over to generate more complex shape details.

Research directions to be explored include (i) direct interaction using VR; (ii) applications to form a 3D shape from rough design ideas; (iii) applications to modify existing objects during design review sessions; and (iv) provide tools to ease communications about imagined shapes.

We have started to investigate the use of immersive VR in design environments where the user is the director, and shapes behave according to his/her mental representation. We started investigating this topic in the context of automotive design, where shape deformations should be style preserving. When creating an object, designers have a mental representation of desirable shapes [50] that can be referred to as a Mental Shape Space (MSS). At an early design stage, designers explore and modify this MSS, notably through design reviews. In the automotive industry, design reviews are commonly performed using a 3D digital model inside a virtual reality system, where it is visualized at real-size with depth perception and realistic rendering. However, such a digital model cannot be modified in the immersive environment for lack of appropriate methods. Presently, the design review supervisor only gives feedback through verbal communication, which may lead to ambiguities [75]. Our goal is to improve communication by providing the user with a fast and efficient tool that lets him/her explore new 3D shapes during the immersive design review. Because the design review supervisor is not always a modeling expert, we need a simple interaction, and most importantly a predictable, style-preserving deformation method.

In the case of animation, we will also seek to further extend traditional storyboards towards spatial and tangible interaction techniques. We started investigating this topic during Adela Barbulescu's post-doctoral work, where we used instrumented figurines and facial motion capture to create believable character animation by playing make-believe games. The Phd thesis of Maxime Garcia extended this work by automatically generating full body animation matching the movements of the manipulated figurines [30]. The ongoing Phd thesis of Pierre Casati attempts to transfer motions captured by a Kinect camera to characters extracted from relief sculptures.

3.1.3 Four year objectives

In the next four years, we plan to extend our previous work in sketching and sculpting shapes and motions to the requirements of new application domains such as virtual sculpture and choreography, with the common goal of easing creativity and artistic expression while being transparent to the user, i.e., appearing more natural and intuitive than existing tools.

Progressive virtual sculpture Our focus will be on creating surfaces and volumes with proper topology using spatial interaction within an immersive environment. The most recent approach comes from Rosales et al. [78] who use ribbon primitives as input, with a restrictive assumption that the user designing shapes expects these ribbons to be connected to form the suggested surface. In contrast, our goal is enable the user to draw a surface with arbitrary ribbons possibly sparse, not connected and arbitrarily crossing. The user should not be limited in her/his creative expressiveness. We have started to develop a first approach as a proof of concept of ribbon-based shape modeling in VR based on HTC-Vive technology. We also installed the VRDraw 3D line drawing environment, friendly provided by colleagues from Inria Lille, enabling us to display our surfaces. Next, we plan to focus on methods for drawing the 3D shapes on-the-fly, i.e. drawing the shape simultaneously to the ribbons drawn by the user, offering thus an immediate feedback to the user. We therefor need to reach real or interactive executions times. We plan to investigate sparsity and locality of shape interpolation methods.

Choreographic notation to animation Using insights from existing dance notation systems, we plan to extend our previous work in sketch-based animation to allow computer artists to create long-form choreographies by drawing and editing key poses of dancers along a timeline. Fundamental research work is needed to propose novel interpolation methods suitable for the task, which involves the simultaneous resolution of multiple space-time projective constraints. Choreography is chosen as a highly visible test-bed for developing and formally validating techniques that will hopefully generalize to other domains, and serve as a first step towards demonstrating more generic 3D animation from storyboards.

3.2 Physical modeling of story worlds

Scientist in charge: Mélina Skouras
Other participants: Stefanie Hahmann, Rémi Ronfard

When authoring and directing story worlds, physics is important to obtain believable and realistic behaviors, e.g. to determine how a garment should deform when a character moves, or how the branches of a tree bend when the wind start to blow. In practice, while deformation rules could be defined a priori (e.g. procedurally), relying on physics-based simulation is more efficient in many cases as this means that we do not need to think in advance about all possible scenarii. In ANIMA, we want to go a step further. Not only do we want to be able to predict how the shape of deformable objects will change, but we also want to be able to control their deformation. In short, we are interested in solving inverse problems where we adjust some parameters of the simulation, yet to be defined so that the output of the simulation matches what the user wants.

By optimizing design parameters, we can get realistic results on input scenarii, but we can also extrapolate to new settings. For example, solving inverse problems corresponding to static cases can be useful to obtain realistic behaviors when looking at dynamics. E.g. if we can optimize the cloth material and the shape of the patterns of a dress such that it matches what an artist designed for the first frame of an animation, then we can use the same parameters for the rest of the animation. Of course, matching dynamics is also one of our goals.

Compared to more traditional approaches, this raises several challenges. It is not clear what the best way is for the user to specify constraints, i.e. how to define what she wants (we do not necessarily want to specify the positions of all nodes of the meshes for all frames, for example). We want the shape to deform according to physical laws, but also according to what the user specified, which means that the objectives may conflict and that the problem can be over-constrained or under-constrained.

Physics may not be satisfied exactly in all story worlds i.e. input may be cartoonish, for example. In such cases, we may need to adapt the laws of physics or even to invent new ones. In computational fabrication, the designer may want to design an object that cannot be fabricated using traditional materials for example. But in this case, we cannot cheat with the physics. One idea is to extend the range of things that we can do by creating new materials (meta-materials), creating 3D shapes from flat patterns, increasing the extensibility of materials, etc.

To achieve these goals, we will need to find effective metrics (how to define objective functions that we can minimize); develop efficient models (that can be inverted); find suitable parameterizations; and develop efficient numerical optimization schemes (that can account for our specific constraints).

3.2.1 State of the art

Physics is usually not taken into account in sketch-based modeling tools such as True2Form [96] or Teddy [45], which focus on geometry almost exclusively. One notable exception is Plushie, a system for sketching plush toys by sketching pressure forces [65]. We feel that this is a very promising area to investigate in the ANIMA project.

The IMAGINE team has a long history of modeling shapes and their motions with developable surfaces. Recently, meta-materials have emerged as a very promising new paradigm for creating a much richer vocabulary of mechanical behaviors, where the large-scale mechanical structures depends on their small-scale geometry [51, 60]. Schumacher et al [82] study the connection between the geometry and mechanics of structured sheet materials. Physical representations of these patterns exhibit a wide range of macro-mechanical properties mediated only by geometry and topology. Unlike appearance, however, the mechanical properties of those materials are often quite complex and not completely understood.

Inverse modeling of dynamical systems is a hard problem with a long history in computer graphics, starting with the seminal work of Witkin and Kass in 1988, which recasts dynamics as a quadratic optimization problem with spacetime constraints [93]. More recently, McNamara et al. introduced efficient methods for controlling the dynamics of free-surface liquids [64]. They showed how to compute adjoint derivatives through each step of the simulation and describe a new set of control parameters specifically designed for liquids. Recently, researchers have started investigating inverse problems such as optimization of control forces and material parameters for achieving a given motion [89], or fitting of material parameters, with applications in robotic puppetry [100].

Finally, a few authors have investigated the use of physics for simulating cartoon style animation. Chenney et al. [10] demonstrate the use of rigid body mechanics for simulating carton physics. Martin et al. [62] simulate flexible structures with art-directable deformation behaviors (example-based elastic materials) but they do not try to control the dynamics as well.

3.2.2 Research directions

Computational design of articulated and deformable objects We would like to extend sketch-based modeling to the design of physical objects, where material and geometric properties both contribute to the desired behaviors. Our goal in this task will be to provide efficient and easy-to-use physics-aware design tools. Instead of using a single 3D idealized model as input, we would like to use sketches, photos, videos together with semantic annotations relating to materials and motions. This will require the conceptualization of physical storyboards. This implies controlling the matter and includes the computational design of meso-scale materials that can be locally assigned to the objects; the optimization of the assignment of these materials such that the objects behave as expected; the optimization of the actuation of the object (related to the point below). Furthermore, the design of the meta-materials/objects can take into account other properties in addition to the mechanical aspects. Aesthetics, in particular, might be important.

A very important application of this research to storytelling is the computational design of marionettes. Marionettes are puppets actuated by strings attached to different marionettes' body parts and to rigid control plates. Thanks to the simplicity of their structure and their actuation mechanism, marionettes are relatively easy to fabricate. However the relation between the pose of a marionette and the orientation of the rigid plate, which also depends on the number, locations and lengths of the strings, is far from intuitive and mastered only by skilled marionette puppeteers - the marionettists. Therefore, the use of marionettes is mostly reserved to these professionals, and marionettes are almost exclusively seen on the stage of dedicated marionette theaters.

The ANIMA team will investigate novel computational tools to help casual users to design hand operated marionettes so that they can be used for broader applications. Indeed, as physical embodiments of imaginary characters, marionettes could be exploited to facilitate the exploration of alternate choregraphies by artists, for social experiments [59], for educational purposes or simply for casual entertainment.

This goal brings new challenges related to the optimization of the marionette design parameters (number, locations and lengths of the strings), which typically depends on the targeted marionette performance, and to the representation of this target performance itself, which will need to be as intuitive as possible. This project is thus distinct from previous research in the field, which mostly focused on robotic marionettes with fixed design parameters and explored, in particular, the design of robotic actuation systems [9] and control policies [97]. While Murphey and Egerstedt tackled the problem of automation of marionettes plays [66], they assumed the marionette string locations and lengths to be known, whereas we are concerned with the design of the full system, which makes the problem more difficult, but also more interesting.

A promising approach for this research line will be to adapt and extend the formulation that we developed for the design of actuated deformable characters, based on a constrained minimization problem that encourages sparsity of the actuation points [83]. This research will also tackle several open research questions. Since marionettes are under-actuated, several solutions for the strings locations and lengths can lead to the same pose. Can we leverage this redundancy and optimize these parameters such that users can easily compose the results obtained for canonical movements into a single animation? What is the best way to represent the target motions? From a broader point of view, this line of research will be an opportunity for the ANIMA team to work together on the co-optimization of design and actuation parameters of dynamic systems as well as on the representation of complex target motions from, for example, simpler building blocks.

Physical storyboarding Story-boards in the context of physical animation can be seen as a concept to explain how an object/character is supposed to move or to be used (a way to describe the high-level objective). Furthermore, they can be used to represent the same object from different views, in different scales, even at different times and in different situations, to better communicate the desired behavior. Finally, they can be used to represent different objects behaving ”similarly”.

Using storyboards as an input to physical animation raises several scientific challenges. If one shape is to be optimized; we need to make sure that the deformed shape can be reached (i.e. that there is a continuous path from the initial shape to the final shape) - e.g. deployable structures. We will need to explore different types of inputs: full target animations, key-frames, annotations (arrows), curves, multi-modal inputs. Other types of high-level goals, which implies that the object should be moving/deforming in a certain way (to be optimized), e.g locomotion, dressing-up a character.

Another related research topic is reverse dynamics, i.e. the backward simulation of physical systems from known final conditions to unknown initial conditions. While the laws of Newtonian physics are reversible, their application in the real world results in highly irreversible processes. We started investigating this problem in the very special case of geological restoration [31] using a combination of invertible elastic models and irreversible parameter estimation techniques. We will continue to investigate this problem in geology and other sciences.

Finally, we would like to continue investigating the topic of *cartoon physics*, i.e. the idea of adding dynamics to sketch-based character animations for creating expressive, but not necessarily realistic physical animation. We started working on this topic during Martin Guay’s PhD thesis [37]. By viewing the line of action of a character as an elastic, the animator can create energetic movements for 3D character by sketching strokes. To realize this, we provide a 3D motion synthesis procedure that supports smoothly changing body parts that are being driven by the elastic line over time. While the physically-based interpolation method requires fine-tuning stiffness parameters, we were able to reproduce cartoon motions. In particular, we demonstrated its effectiveness for producing anticipation and follow-through. In future work, we would like to further investigate other animation principles along the same lines.

3.2.3 Four year objectives

In the next four years, we would like to demonstrate that we can make physics-aware design tools more intuitive to the user, by allowing them to support sketches as input, rather than 3D shapes. We would also like to enrich the concept of line-of-action curves by using ribbon-based representations that will enable their use in novel applications, such as the reconstruction and abstraction of dancers' movements.

Sketch-based inverse modeling of physical objects We would like to build on the concept of inverse modeling to propose novel sketch-based physics-aware design tools offering different levels of feedbacks. One key challenge here is to find a problem formulation that will allow to both satisfy the constraints imposed by the physics, e.g. the shape of a deformable object should correspond to a stable equilibrium state, and the constraints coming from the sketch, i.e. the projection of the deformed shape should match the sketch. To this end, we propose to build an internal 3D physically valid representation of the object that will be used to (i) inform the user by highlighting problematic regions in the input sketch, (ii) to provide them with dedicated modeling functions that would let them locally modify the sketch while guaranteeing the physical validity of the underlying 3D model, thanks to sensitivity analysis, and (iii) to automatically repair the object by automatically adjusting the sketch strokes such that they correspond to the 2D projection of the closest 3D valid shape. Potential applications that we would like to tackle comprise the design of deformable furniture and accessories from 2D sketches (armchairs, cushions, etc.), architectural structures (e.g. tensile structures) and draped garments.

Character animation using dynamic ribbons We would like to investigate the idea of using dynamic rods and ribbons to animate deformable characters. Modeling the line of actions by ribbons, that can encode torsion in addition to stretching and flexion, will allow us to get smooth twisting motion, an effect that we could not obtain with the 2D elastica used by Martin Guay. More specifically, we would like to apply this concept to the animation of dancers from motion-captured data. In particular, we would like to represent the dancer's movements in the shape of deformable ribbons originating from the dancer's chest and ending in the dancer's head, feet and hands. We will need to find a suitable ribbon representation, e.g. based on the discrete elastic rod model, and work out the mathematical details of the ribbon dynamics to compute the ribbon motions from a set of markers placed on the dancer's body.

3.3 Semantic modeling of story worlds

Scientist in charge: Oliver Palombi
Other participants: Rémi Ronfard, Nicolas Szilas

Beyond geometry and physics, we aim at representing the semantics of story worlds. We use ontologies to organize story worlds into entities described by well defined concepts and relations between them. Especially important to us is the ability to "depict" story world objects and their properties during the design process [13] while their geometric and material properties are not yet defined. Another important aspect of this research axis is to make it possible to quickly create interactive 3D scenes and movies by assembling existing geometric objects and animations. This requires a conceptual model for semantic annotations, and high level query languages where the result of a semantic query can be a 3D scene or 3D movie.

One important application area for this research axis will be the teaching of human anatomy. The Phd thesis of Ameya Murukutla focuses on automatic generation of augmented reality lessons and exercises for teaching anatomy to medical students and sports students using the prose storyboard language which we introduced during Vineet Gandhi's PhD thesis [76]. By specializing to this particular area, we are hoping to obtain a formal validation of the proposed methods before we attempt to generalize them to other domains such as interactive storytelling and computer games.

3.3.1 State of the art

Research in semantic modeling of story worlds can be traced back to the pioneering work of Kallman and Thalmann on smart objects [49] which heavily influenced the design of the simulation game The Sims, where objects in the scene dictate the actions that the Sims can perform. Another important paper in this area is the domain-specific character animation language Improv proposed by Perlin [73]. Drawing on this pioneering work, researchers have proposed special-purpose programming languages for authoring animation from scenarios. Backman and Kallmann proposed a visual language for designing physics-based controllers using motion graphs [4]. Firmin and Fiume proposed a language for authoring controllers by specifying motion primitives over a number of phases [24]. Mateas and Stern proposed the ABL behavior language [63] and used it to implement Facade, a landmark in interactive drama. In the last two decades, Nicolas Szilas has proposed multiple versions of IDTension, a programming environment for interactive drama [85] and used it to generate narrative games such as ”The mutiny” (2008) and ”Nothing for dinner” (2016).

Other related work includes the scenario language by Devillers and Donikian [20], Visual Scene Maker, a toolkit for creating virtual characters based on statecharts [33], and SEVEN a Petri net modeling toolbox for authoring virtual reality scenarios by Claude et al. [14].

This early work has been revived recently by research groups at Univ. of Pennsyvania, Rutgers University and Disney Research Zurich, with the common goal of providing authoring control for virtual reality storytelling. Their recent work in logical building of story worlds [74] is most relevant to our research goals and has been demonstrated in computer assisted authoring of movie scripts [61] and even animation generation from screenplays [99].

In our previous work, we have made intensive use of an ontology of human anatomy (My Corporis Fabrica, or MCF) for linking semantic properties, roles and functions of human body parts with their geometric representations [71]. This approach has proved useful for generating 3D scenes from semantic descriptions, an instance of text-to-scene generation [8]. Text-to-animation is an even more difficult problem and fundamental work is needed to even understand the semantics of animating 3D events and activities. VoxSim [52] is an open-source, semantically-informed 3D visual event simulator implemented in the Unity game engine that leverages game engine graphics processing, UI, and physics to operationalize events described in natural language within a virtual environment. In a separate line of research, Damiano et al. have designed a comprehensive ontology for drama [17] which they use for annotating and preserving the heritage of recorded drama performances.

3.3.2 Research directions

Story world ontologies We will extend our previous work on ontology modeling of anatomy [71, 88] in two main directions. Firstly, we will add procedural representations of anatomic functions that make it possible to create animations. This requires work in semantic modeling of 3D processes, including anatomic functions in the teaching of anatomy. This needs to be generalized to actor skills and object affordances in the more general setting of role playing games and storytelling. Secondly, we will generalize the approach to other storytelling domains. We are starting to design an ontology of dramatic functions, entities and 3D models. In storytelling, dramatic functions are actions and events. Dramatic entities are places, characters and objects of the story. 3D models are virtual actors, sets and props, together with their necessary skills and affordances. In both cases, story world generation is the problem of linking 3D models with semantic entities and functions, in such a way that a semantic query (in natural language or pseudo natural language) can be used to create a 3D scene or 3D animation.

Story world scenarios While our research team is primarily focused on providing authoring and directing tools to artists, there are cases where we also would like to propose methods for generating 3D content automatically. The main motivation for this research direction is virtual reality, where artists attempt to create story worlds that respond to the audience actions. An important application is the emerging field of immersive augmented reality theatre [40, 23, 58, 67, 35, 22, 53]. In those cases, new research work must be devoted to create plausible interactions between human and virtual actors based on an executable representation of a shared scenario.

For the special case of teaching anatomy to medical students, scripts for the lessons are written in a new formal language called the Anatomy Storyboard Language (ASL) [68]. The scripts are parsed into hierarchical finite state machines (HFSM) and executed in Unity 3D game engine to produce the desired animation at runtime. In the more general case of interactive drama, our goal will be to extend our Prose Storyboard Language (PSL) [76] as a general scenario language suitable for real-time interaction between virtual and human actors in a shared story world [77]. We will follow the route traced by our ongoing work in teaching anatomy and propose methods for translating generic PSL scenarios to HFSMs that can be executed in a real-time game engine.

3.3.3 Four year objectives

In previous work, we have demonstrated the ability to generate static 3D scenes from semantic queries in the limited domain of human anatomy. In the next four years, we plan to extend this work towards generating animated scenes from semantic queries in arbitrary story worlds.

Animated book of anatomy Our initial goal in building story world ontologies will be to extend the MCF ontology to a large number of anatomic functions with temporal structures and to link them with 3D animations. As a result, we would like to demonstrate the ability to easily write queries to the ontology returning procedural animations created on the fly. This would open the way to powerful applications in augmented reality and virtual reality vizualization of anatomy, leading to a future *augmented anatomy theatre*.

Semantic-rich movie scenes As a first step towards a fully realized augmented reality theatre, we would like to provide a first version of a storytelling ontology (MyDramatisFabrica) applied to movie scenes reconstructed in 3D animation and linked with their screenplays and storyboards, We will use famous movie scenes such as the crop duster scene from the movie ”North by Northwest” and the cafe scene from the movie ”Back to the future” as vehicles to demonstrate the generality of our ontology for modeling the semantics of complex story worlds and scenarios.

3.4 Aesthetic modeling of story worlds

Scientist in charge:Rémi Ronfard
Other participants: Stefanie Hahmann, Mélina Skouras, François Garnier

Data-driven methods for shape modeling and animation are becoming increasingly popular in computer graphics, due to the recent success of deep learning methods. In the context of the ANIMA team, we are particularly interested in methods that can help us capture artistic styles from examples and transfer them to new content. This has important implications in authoring and directing story worlds because it is important to offer artistic control to the author or director, and to maintain a stylistic coherence while generating new content. Ideally, we would like to learn models of our user's authoring and directing styles, and create contents that matches those styles.

3.4.1 State of the art

Computational aesthetics, which bridges science and art, has emerged in the last decades as a new interdisciplinary field with important implications in computer graphics [42, 41]. Recently, interest in style analysis and style transfer has been fostered by the tremendous success of neural style transfer methods [47]. While those methods were initially designed to work with natural images, they were then extended to sketch drawings with excellent results [39]. Researchers in computer graphics are starting to investigate motion style transfer in animation [43] and geometric style transfer in portraits [98]. Sbai et al. have experimented with Generative Adversarial Networks on the task of generating original and compelling fashion designs to serve as an inspirational assistant [80]. This opens interesting new directions for research in the ANIMA team.

Statistical analysis of motion styles and qualities is another emergent topic, where deep learning methods are used to extract motion signatures from real character movements and transfer them to 3D animation [2]. Recently, Aberman et al. have shown that it is possible to learn character-agnostic motion representations working entirely in 2D, which makes it possible to design data-driven methods directly from movies, rather than motion capture databases [1].

Statistical methods have also been proposed for learning and reproducing cinematographic styles. This includes work on automatic video editing of spoken dialogue [54] and live performances [94]. Statistical analysis of film styles includes the analysis of editing rhythm and composition [15]. More work is needed to transfer those styles to new content. In recent work, Thomas et al. have attempted to learn the individual styles of professional photographers from a sample of their artwork [87]. In a similar vein, Svanera et al. attempt to recognize the styles of famous movie directors from manually annotated shots of their movies [84].

3.4.2 Research directions

Learning and transferring shape styles We want to better understand shape aesthetics and styles, with the long-term goal of creating complex 3D scenes with a large number of shapes with consistent styles. We will also investigate methods for style transfer, allowing to re-use existing shapes in novel situations by adapting their style and aesthetics [57].

In the past exhaustive research has been done on *aesthetic* shape design in the sense of fairness, visual pleasing shapes using e.g. bending energy minimization and visual continuity. Note, that these aspects are still a challenge in motion design (see next section). In shape design, we now go one step further by focusing on *style*. Whereas fairness is general, style is more related to application contexts, which we would like to formalize.

We will aim to characterize shape behaviour using a priori knowledge from different domains, e.g. fashion design, cloth design, antique arts. On the example of automotive design, once the initial design of a car is fixed, during all following design stages, shape deformations should be *style preserving* and should meet the designer's mental shape space. Since car bodies are man-made shapes, most existing deformation methods fail due to their organic behaviour. We aim to develop dedicated deformation methods for such man-made objects and manufactured artefacts based on an understanding of their aesthetic and functional qualities. In cloth design, style can on one side be linked to the material, but on the other side also to its geometry. Our focus is on folds design. In the past, we have developed methods for creation of folds in leather clothes and fashion objects, where folds are part of the design elements [48]. In future work, we want to focus on geometric folds generation of clothes by taking into account users' indications as to their desired styles, rather than their (usually unknown) physical properties. In all cases, we seek to develop shape characteristics belonging to the designer's *mental shape space* and deformations methods allowing to transform objects within this space.

In the long term, we would like to address those diverse problems in a more unified framework by developing inverse procedural modeling methods, which have been proposed for generating new shapes and assemblies by learning probabilistic shape grammars from examples and sampling from them [86]. This general approach has been applied with great success for modeling families of 3D shapes such as trees, buildings, cities and villages, but also families of artistic works such as Mondrian paintings. Interestingly, those methods can be controlled artistically by providing sparse constraints in various forms, including example photos or drawings. This is a promising new direction for future work in style analysis and transfer in the ANIMA team.

Learning and transferring motion styles While the aesthetics of spatial curves and surfaces has been extensively studied in the past, resulting in a large vocabulary of spline curves and surfaces with suitable control parameters, the aesthetics of temporal curves and surfaces is still poorly understood. Fundamental work is needed to better understand which geometric features are important in the perception of the aesthetic qualities of motions and to design interpolation methods that preserve them. Furthermore, we would like to transfer the learned motion styles to new animations. This is a very challenging problem, which we started to investigate in previous work in the limited domains of audiovisual speech animation [5] and hand puppeteering [32].

The first approach we would like to investigate is to extend the paradigm of inverse procedural modeling to motion, as proposed by Hyuen et al. who learn motion grammars for the game of basketball [44]. While this methodology is now well established in shape modeling, much work remains to be done in transposing it to the case of generic character animation outside the limited domains of rule-driven sports and games.

The second approach we would like to propose is based on the metaphor of rehearsing. Reinforcement learning methods have been shown recently to allow a virtual character to learn real-time policies for simple behaviors by repeated trial and error [72]. Even more to the point, inverse reinforcement learning methods have been proposed to imitate behavior styles from examples [55]. An interesting topic for future research will be to adapt those methods for more formalized behaviors, such as ballet dancing or dramatic performances.

Learning and transfering film styles In recent years, we have proposed new methods for automatically composing cinematographic shots in live action video [29] or 3D animation [27] and to edit them together into aesthetically pleasing movies [28]. In future work, we plan to apply similar techniques for the new use case of immersive virtual reality. This raises interesting new issues because spatial and temporal discontinuities must be computed in real time in reaction to the user's movements. We have established a strong collaboration with the Spatial Media team at ENSADLAB to investigate those issues. We also plan to transfer the styles of famous movie directors to the generated movies by learning generative models of their composition and film editing styles, therefore extending the previous work of Thomas [87] from photographic style to cinematographic style. The pioneering work of Cutting and colleagues [15] used a valuable collection of 150 movies covering the years 1935 to 2010, mostly from classical Hollywood cinema. A more diverse dataset including European cinema in different genres and styles will be a valuable contribution to the field. Towards this goal, we are building a dataset of movie scenes aligned with their screenplays and storyboards.

3.4.3 Four year objectives

Because aesthetic modeling is a new topic for us, our objectives for the next four years need to be modest, and we will focus on creating data sets suitable for recognizing and transfering styles in the limited domains of fashion and filmed theater.

Fashion styles We started investigating fashion sketches during Amelie Fondevilla's PhD thesis [25] using methods initially designed for accurate sketches and photos. Instead of requiring sketches to be accurate, our insight for the next four years will be to design sketch-based models mimicking the "style" of the sketched garment. To do this, we plan to build a dataset of fashion sketches in different styles and to develop new sketching tools that can reproduce those styles. As a starting point, we plan to analyze fashion sketches by defining garment styles in terms of scale, fit and shape.

Filmed theater styles As part of Qianqian Fu's Phd thesis, we are investigating new methods for automatically generating filmed theater movies from cinematographic rushes, following the classic rules of film editing. One drawback of our methods is that they tend to generate movies with no recognizable style. In the next four years, we would like to recognize distinctive film editing styles and transfer them to new movies in the restricted domain of theater films. As part of this research, we plan to collect a medium size database of filmed theater movies and annotate them with a suitable schema such as our own "prose storyboard language" [76] which makes it possible in principle to learn editing styles in terms of image compositions (number and sizes of actors inside and across shots), camera movements and shot durations. Adapting the learned styles to new contents (different actors and settings) in the restricted domain of filmed theater movies appears to be a realistic mid-term goal towards general understanding and transfer of film style.

4 Software development

Due to the diversity of topics in the ANIMA team, there is not a single software platform where our software developments can be deployed. The ANIMA project will focus its software development effort on targeted actions such as My Corporis Fabrica, which we will continue to maintain; Kino Ai, which will be made available as an open source project; and new software packages targeting the interactive storytelling and virtual reality communities. In the last category, we are already contributing software to the 3D drawing tool VairDraw [1] for use in artistic projects such as L'Ebauchoir [2].

The ANIMA team is also committed to the Graphics Replicability Stamp Initiative [3], which is an independent group of volunteers who help the community by enabling sharing of code and data as a community resource for non-commercial use. The volunteers check the submitted code and certify its replicability, awarding a replicability stamp, which is an additional recognition for authors of accepted papers who are willing to provide a complete implementation of their algorithm, to replicate the results presented in their paper. Recent work in the team on 2D shape structure [7] has been awarded with the Replicability Stamp. In our future publications, we are planning to similarly publish our associated code to ensure replicability.

5 Applications, technology transfer, and valorization

5.1 Application domains

The research goals of the ANIMA team are applicable to many application domains which use computer graphics and are in demand of more intuitive and accessible authoring and directing tools for creating animated story worlds. This includes arts and entertainment, education and industrial design.

[1] http://mauve.univ-lille.fr/vairdraw
[2] https://www.experimenta.fr/explorer-par-le-geste/
[3] http://www.replicabilitystamp.org

Arts and entertainement

Animated story worlds are central to the industries of 3D animation and video games, which are very strong in France. Designing 3D shapes and motions from storyboards is a worthwhile research goal for those industries, where it is expected to reduce production costs while at the same time increasing artistic control, which are two critical issues in those domains. Furthermore, story is becoming increasingly important in video games and new authoring and directing tools are needed for creating credible interactive story worlds, which is a challenge to many video game companies. Traditional live action cinematography is another application domain where the ANIMA team is hoping to have an impact with its research in storyboarding, virtual cinematography and film editing.

Performance art, including dance and theater, is an emergent application domain with a strong need for dedicated authoring and directing tools allowing to incorporate advanced computer graphics in live performances. This is a challenging application domain, where computer-generated scenography and animation need to interact with human actors in real-time. As a result, we are hoping that the theater stage becomes an experimental playground for our most exploratory research themes. To promote this new application domain, we are organizing the first international workshop on computer theater in Grenoble in February 2020, under the name Journées d'Informatique Théâtrale (JIT). The workshop will assemble theater researchers, artists and computer engineers whose practice incorporates computer graphics as a means of expression and/or a creative tool. With this workshop, our goal is to create a new research discipline that could be termed "computer theater", following the model of computer music, which is now a well established discipline.

Education

Teaching of Anatomy is a suitable domain for research. As professor of Anatomy, Olivier Palombi gives us the opportunity to experiment in the field. The formalization of anatomical knowledge in our ontology called My Corporis Fabrica (MyCF) is already operational. One challenge for us is to formalize the way anatomy is taught or more exactly the way anatomical knowledge is transmitted to the students using interactive 3D scenes.

Museography is another related application domain for our research, with a high demand for novel tools allowing to populate and animate virtual reconstructions of art works into stories that make sense to museum audiences of all ages. Our research is also applicable to scientific museography, where animated story worlds can be used to illustrate and explain complex scientific concepts and theories.

Industrial design

Our research in designing shapes and motions from storyboards is also relevant to industrial design, with applications in the fashion industry, the automotive industry and in architecture. Those three industries are also in high demand for tools exploiting spatial interaction in virtual reality. Our new research program in physical modeling is also applicable to those industries. We have established strong partnerships in the past with PSA and Vuitton, and we will seek to extend them to architectural design as well in the future,

5.2 Technology transfer and valorization

MyCorporisFabrica

MyCorporisFabrica is an anatomical knowledge database developed in our group. It relies on FMA (Foundational Model of Anatomy) [79], developed under Creative Commons license (CCby).

Based on the International Classification of Functioning, Disability and Health [70], also known as ICF, MyCF organizes human functions through a tree of 4330 items. MyCF browser is available on line, and is already in use for education and research in anatomy. MyCF uses a generic programming framework which can be used for other domains as well. We are committed to support it and use it as part of our research axis in semantic modeling of story worlds.

Anatoscope

Anatoscope was founded by François Faure and ANIMA team member Olivier Palombi on August 30, 2015. Olivier Palombi is now a scientific advisor for the company, under status 25-2. The main business of Anatoscope is to produce software to automatically reconstruct human anatomy in 3D based on imaging, to design personalized prostheses and orthoses for this anatomy, and to simulate their biomechanical interaction to validate the design. The users are dental and orthopedic prosthetists. The company already counts 30 employees and showcases a very promising momentum.

KinoAi

KinoAi is a software suite for creating movies of live performances, which is in active development in the ANIMA team, and is supported mostly by InriaHub and the Performance Lab project at UGA. We hold two patents and one software application for this project already, and we are planning to distribute it as an open source project for use by academic researchers and cultural institutions in the performing arts.

EMOFACE

This project coordinated by ex-team member Adela Barbulescu proposes a novel approach towards training social skills for persons on the Autistic Spectrum Disorder, specifically targeting difficulties in recognizing emotions, producing emotions and understanding social situations. Emoface propose an educational game for iPad which uses expressive and interactive 3D avatars in a series of tests and quizzes, which uses our previous work for generating audio-visual prosody in real time.

6 Collaborations and on-going projects

We have ongoing industrial contracts with PSA; with our spin-off company Anatoscope in ANR project Anatomy 2020; with TeamTo and Mercenaries Engineering in the development of the RUMBA animation software; with Mocap Lab Paris; and with ISKN (spin off company from CEA LETI). In 2017, we also joined the SFR Maison de la Création at UGA, which is helping us build collaborations with its affiliated organizations including Cinémathèque de Grenoble, Théâtre de l'Hexagone, MC2 Grenoble, ESAD Grenoble/Valence, etc.

6.1 Collaborations

We have strong collaborations, including joint Phd supervision, with several Inria teams, including Mimetic (Marc Christie), Graphdeco (Adrien Boussaud), Elan (Florence Bertails-Descoubes), Maverick (Georges-Pierre Bonneau), Pervasive Interaction (James Crowley), MFX (Sylvain Lefebvre) and GraphIK (Federico Ulliana).

We also have frequent collaborations with other research groups in France, including the Geometric Visual Computing team at Ecole Polytechnique (Damien Rohmer,Marie-Paule Cani), the

GEOMOD team at LIRIS and Univ. Lyon (Raphaelle Chaine, Julie Digne) and the STORM team in Toulouse (Loic Barthe).

We are starting new collaborations in 2020 with Sarah Fdili (Ex Situ), Mocap Lab Paris and Conservatoire National de Danse on the notation and transcription of Isadora Duncan choreographies; with theater company TF2 (Jean-Francois Peyret) and IRCAM on digital theater (Théâtre Numérique Populaire); with the Spatial Media group at ENSADLAB on spatial montage.

We have ongoing collaborations with the Gallo-roman museum in Fourvières as part of the E-Roma project and with the Univ of Wisconsin (Michael Gleicher) and IIIT Hyderabad (Vineet Gandhi) on automatic cinematography and editing of live performances.

AnatoScope [4] is a young company focused on personalized anatomical modeling and simulation. Its patented technology, based on two decades of research at CNRS and INRIA, registers biomechanical templates to personalized imaging. We currently collaborated to improve the teaching of anatomy in ANR project Anatomy2020 [5] by using virtual reality. The collaboration with Anatoscope gives us the opportunity to develop an effective technology to teach human anatomy based on our research.

6.2 On-going projects

European projects

Starting in January 2020, we are taking part in the H2020 FETOPEN RIA $ADAM^2$ project (Analysis, Design, And Manufacturing using Microstructures), with partners BCAM Bilbao, Technion, EPFL, TU Wien, Univ. Del Pais Vasco, Stratasys LTD, Trimtek SA, Hutchinson SA, Seoul National University. Research within the ADAM^2 project will combine user-guided shape modelling using microstructures, followed by validation and structural optimization using physical process simulation, and finalized by physical realizations via additive and hybrid manufacturing. The contract will fund a PhD thesis with a total grant of 365 k €.

National initiatives

- ANR Anatomy 2020 (2017 - 2020). This 4-year contract is a joint project with TIMC Laboratoire des Techniques de l'Ingénierie Médicale et de la Complexité - Informatique, Mathématiques, Applications - Grenoble, Anatoscope, GIPSA-lab Laboratoire Grenoble Images Parole Signal Automatique, LIBM Laboratoire interuniversitaire de biologie de la motricité, LIG Laboratoire d'Informatique de Grenoble. The total amount of the grant received by ANIMA is 123 k €. Olivier Palombi is a co-leader of the project.
- ANR EROMA (2017 - 2020) This 3-year contract is a joint project with the GeoMod team at LIRIS and Lugdunum, the Roman Museum of Lyon in Fourvières. The contract started in November 2017 and is funding the PhD thesis of Pierre Casati with a total grant of 155 k €.
- ANR FOLDYN (2017 - 2020) This 3-year contract is a joint project with the University of Toulouse. The contract started in November 2017 and is funding the PhD thesis of Thomas Buffet with a total grant of 163 k €.
- KINOVIS (2011-2020) The KINOVIS project [6] is funded within the "Equipements d'Excellence" framework of the French program "Investissement d'Avenir" (ANR grant 2 130 000) . The Kinovis equipment and facilities are aimed at producing visual data on moving shapes, such as human bodies, for the analysis, the interpretation and the synthesis of real dynamic objects. Olivier Palombi is a co-leader of the project.

[4] http://anatoscope.com/
[5] https://www-timc.imag.fr/Anatomy2020
[6] http://kinovis.inria.fr/

- SIDES 3.0 (2016-2020) The project is founded by the French program “Investissement d’Avenir” (ANR grant: 1.8 M €). The aim of the project is to offer high value-added services to medical students and teachers based on learning traces on the SIDES national LMS platform. Olivier Palombi is the leader of the project.

Industrial contracts

PSA is funding the PhD thesis of Youna Le Vaou (under the direction of Stéfanie Hahmann, Jean-Claude Léon).

Inria Project Labs, Exploratory Research Actions and Technological Development Actions

ADT KINO AI (Rémi Ronfard, Rémi Colin de Verdière) started in Septembre 2018 and is funding the work of Rémi Colin de Verdiere for two years. The goal is to provide an integrated web-based interface to the rush generation system implemented in ADT ULTRAHD. This will result in a client-server architecture where all heavy video processing is performed on the server side, and all user interaction is performed on the client side. The resulting system is targeted for teachers in performing arts and documentary movie-makers, making it possible for them to quickly reframe, compose and edit movies.

Other funding

- PERFORMANCE LAB is a cross-disciplinary research project (CDP) of IDEX UGA funding the PhD thesis of Qianqian Fu, as well as artistic residences on the topic of digital dramaturgy in collaboration with the Performing Arts departments at UGA.
- METAMOD is funding Master’s theses and equipment to support the research of Mélina Skouras.
- MONTAGE SPATIAL is funded by the French ministry of culture. Our partner is the SPATIAL MEDIA team at ENSADLAB.
- Théâtre Numérique Populaire (TNP) is funded by IDEX UGA. Our partners are the Litt & Arts department at UGA and TF2 theater company in Paris.
- Isadora Duncan Interactive Archive is funded by the national academy of dance. Our partners are the Inria EX-SITU team and the Conservatoire de Dance in Paris.
- L’ébauchoir is funded by Conseil Général de l’Isère and Region Rhone Alpes. Our partners are ISKN and Théâtre de l’Hexagone.

7 Positioning

ANIMA is a unique multi-disciplinary team with expertise in geometry, physics, semantics and aesthetics, focusing on a common research subject from four different perspectives. This leads us to a distinct, different positioning from other research groups in Computer Graphics, Virtual Reality, and Computer Vision.

- Capturing and reconstructing existing objects or motion leads to process masses of low-level data, such as point clouds or fine meshes for geometry. In contrast, creative design leads us to study non-standard, higher level representations which directly enable complex operations, such as for instance developable surfaces, sparse curve networks, lines of actions and vector graphic complexes.
- Our work in character animation focuses on virtual actors, rather than virtual humans, a topic tackled for years by other groups. As a result, we are less interested in real-time simulation of virtual human behaviours, and more interested in real-time execution of synchronized, scripted behaviours of virtual actors. We share this focus with researchers in

"artificial intelligence for games", an emerging research topic not yet addressed by existing Inria teams.

- Multi-modal interaction is becoming an important component in our research, and an area where we have limited expertise. We will intensify our collaborations with more specialized teams at Inria in the fields of human-computer interaction and mixed reality.

ANIMA is also relatively small project team and we need to establish strong collaborations with other teams working in the field of interactive storytelling and computer arts in order to have an impact in those communities. We have established an association with external collaborators Nicolas Szilas at the University of Geneva and François Garnier at Ecole Nationale Supérieure des Arts décoratifs in Paris (ENSAD) to increase the impact of our research in those fields. More sepcifically, Nicolas Szilas will be involved in out research theme on "semantic modeling" and François Garnier will take part in our research theme on "aesthetic modeling".

7.1 International positioning

Four groups directly address the problem of authoring and directing story worlds directly, and dominate the field of visual storytelling.

- The Computer Graphics Lab led by Markus Gross at ETH Zurich and Disney Research Studio is a leading research group in interactive, hand-drawn and directable animation (Bob Sumner, Martin Guay), computer-assisted story authoring, story world building and augmented creativity.
- Ken Perlin's Future Reality Lab at NYU explores how people will use future mixed reality technologies to better communicate and interact with each other when they are in the same physical space, with an emphasis on storytelling and creative activities. Similar to ANIMA, they design authoring tools such as ChalkTalk and Holojam.
- Norman Badler's lab at Univ. of Pennsylvania continues Badler's pioneering work on parameterized action representation (PAR) for digital humans and embodied agent models and crowd simulation. Their research focuses on understanding the bi-directional relationships between human movement, natural languages, instructions, and communication, with application to storytelling, archaeology and cultural heritage.
- Mubbasir Kapadia's Intelligent Visual Interface Lab at Rutgers University School of Arts and Sciences addresses digital storytelling directly, with important research work in knowledge representation and reasoning of animated stories, narrative animation synthesis, and authoring of interactive narratives.

Given the importance of storytelling applications in computer graphics, this is still a relatively small community, and we expect that ANIMA can become a major player with a significant impact in this emerging field of story-driven computer graphics.

Digital storytelling In the related field of digital storytelling, the leading groups are Michael Young's Liquid Narrative group at the University of Utah; Michael Mateas and Noah Wardrip-Fruin's Expressive Intelligence Studio at the University of California in Santa Cruz; Mark Riedl's Entertainment Intelligence Lab at Georgia Tech; Marc Cavazza's group at the University of Teeside; and Lance Weiler's Digital Storytelling Lab at Columbia University School of the Arts. Those groups focus on generating stories in digital story worlds and are complementary with ANIMA since our goal is to create those story worlds in the first place.

Other computer graphics groups address storytelling less directly, while still making important contributions to the field:

- The Dynamic Graphics Project lab of the University of Toronto is one of the leading research groups in computer graphics (Karan Singh, Eugene Fiume, Eitan Grinspun, Alec Jacobson) and also includes researchers from the field of human computer interaction. Their work frequently addresses issues in authoring and directing story worlds.
- The graphics group at UBC (Michiel van de Panne, Alla Sheffer, Dinesh Pai) is an interdisciplinary group doing research in algorithms and interfaces for animation and modeling, with applications to virtual clothing and storytelling.
- The MIRALab at University of Geneva is another interdisciplinary group working in the field of Computer Graphics, Computer Animation and Virtual Worlds. While MIRALab does not directly address storytelling applications, it shares many research interests with ANIMA in 3D virtual patient simulation, virtual coaching, and cultural heritage.
- The GRUVI team at Simon Fraser University is another inter-disciplinary team of researchers working in visual computing, with research topics including 3D printing and content creation, animation, AR/VR, geometric and image-based modelling, machine learning, natural phenomenon, and shape analysis.
- The Computer Graphics Group at MIT CSAIL is very active in computational design, inverse modeling and topology optimization (Wojciech Matusik). Their research does not explicitly address storytelling applications but is relevant to our research axis on physical modeling of story worlds.
- Maneesh Agrawala's group at Stanford focuses on investigating how cognitive design principles can be used to improve the effectiveness of audio/visual media. Their goals are to discover the design principles and then instantiate them in both interactive and automated design tools. This includes important work in virtual cinematography and film editing.
- The Virtual Environments and Computer Graphics group at University College London (Niloy Mitra, Mel Slater) investigates fundamentals and applications that enrich human experience of digital content. Similar to ANIMA, they aim to build rich and expressive environments that can be experience by users, including completely hypothesised scenes built from examples. Contrary to ANIMA, they are not targeting storytelling applications.
- Jehee Lee's Movement Research Lab at Seoul National University is another important group working in character animation, interactive avatar control, intelligent synthetic characters and physically based simulation, with direct applications to narrative animation synthesis.
- Yiorgos Chrysantou's Computer Graphics Lab at the University of Cyprus pursues several research directions in common with ANIMA, including virtual choreography and reconstruction of everyday life in cultural heritage applications.

In France, the Geometric Visual Computing team at Ecole Polytechnique (Marie-Paule Cani, Damien Rohmer) focuses on creative prototyping and modeling of virtual objects and characters that automatically adapt to the context and the user interactions with applications in entertainment and artistic creation, but not targeting storytelling applications directly. Catherine Pelachaud's team at Sorbonne Université works at the intersection between computer animation and social agents. This is an area which we are not investigating ourselves, and is complementary to our research goals. The Spatial Media team at ENSADLAB/Paris Sciences et Lettres, investigates artistic uses of immersive virtual reality, including storytelling. The team is led by François Garnier, who is an external collaborator of the ANIMA team.

7.2 Inria positioning

Within Inria, research in animated story worlds has been tackled in the past by the BUNRAKU team. Since 2013, this research effort is split between two separate teams with very different research directions.

- MIMETIC focuses on designing methods for simulating virtual humans that behave in realistic manners and act with realistic motions. This is contrast to the ANIMA team which focuses on designing methods for generating expressive virtual actors that behave in non realistic manners and act with non realistic motion. Within the MIMETIC team, we are closest with the research themes pursued by Marc Christie and Fabrice Lamarche in cinematography and storytelling [56, 95].
- HYBRID focuses on virtual reality and 3D interaction with virtual environments. While storytelling is not their primary concern, the team conducts research in modeling interactive scenarios [14] and target applications in computer arts and real-time video games. While ANIMA is more focused on authoring and directing tools, HYBRID is more focused on building real-time virtual environments. The two teams are therefore quite complementary.

Computer graphics While not directly targeting storytelling applications, several other computer graphics teams at Inria share research interests with us:

- GRAPHDECO attempts to automate the design and artistic principles that guide the creation of visual content to facilitate professional practices and making such endeavors accessible to all. This includes common research goals including the generation of 3D artefacts from artistic sketches and the generation of 2D sketches from 3D models. We have already established a long-standing collaboration with Adrien Boussaud on those topics and we will continue to do so.
- MAVERICK aims at producing representations and algorithms for efficient, high-quality computer generation of pictures and animations. Their work in expressive rendering, where their create an artistic representation of a virtual world, overlaps with our research axis in aesthetic modeling of story worlds, and we are planning to establish future collaborations on those topics with Joelle Thollot and Romain Vergne.
- ELAN focuses on the interface between computer graphics and mechanics, with the goal of realistically simulating complex physical systems such as hair and clothes. ANIMA works on similar topics (including clothes) from a different perspective, with the goal of providing artistic control on such simulations, at the expense of physical realism.
- MFX focuses on applications of computer graphics to additive synthesis and 3D printing. Our goals are therefore very different. ANIMA makes use of 3D printed figurines and marionettes with applications to tangible storytelling and Melina Skouras also has expertise in those fields, which makes it possible to envision future collaborations.
- TITANE focuses on geometric modeling of complex scenes from physical measurements. MORPHEO focuses on video-based geometric modeling of dynamic scenes, including people and their clothing. Both teams aim at producing 3D reconstructions of the real world, whereas ANIMA is more concerned by the creation of imaginary virtual worlds.

Computer arts Other Inria teams are active in computer arts, including POTIOC (Martin Hachet, Pascal Guitton), FLOWERS (Pierre-Yves Oudeyer), DEFROST (Christian Duriez), EX-SITU (Sarah Fdili-Alaoui) and HEPHAISTOS (Yves Papegay). ANIMA is different because artistic creation is a central, rather than peripheral, theme and application area for our team.

References

[1] K. Aberman, R. Wu, D. Lischinski, B. Chen, and D. Cohen-Or. Learning character-agnostic motion for motion retargeting in 2d. ACM Trans. Graph., 38(4), July 2019.

[2] A. Aristidou, E. Stavrakis, M. Papaefthimiou, G. Papagiannakis, and Y. Chrysanthou. Style-based motion analysis for dance composition. The Visual Computer, 34:1725–1737, 2017.

[3] R. Arora, R. Habib Kazi, T. Grossman, G. Fitzmaurice, and K. Singh. Symbiosissketch: Combining 2d & 3d sketching for designing detailed 3d objects in situ. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, CHI '18, 2018.

[4] R. Backman and M. Kallmann. Designing controllers for physics-based characters with motion networks. Computer Animation and Virtual Worlds, 24(6):553–563, 2013.

[5] A. Barbulescu, R. Ronfard, and G. Bailly. A Generative Audio-Visual Prosodic Model for Virtual Actors. IEEE Computer Graphics and Applications, 37(6):40–51, Nov. 2017.

[6] M. Bessmeltsev, N. Vining, and A. Sheffer. Gesture3d: Posing 3d characters via gesture drawings. ACM Transactions on Graphics (Proceedings of ACM SIGGRAPH Asia 2016), 35(6), 2016.

[7] A. Carlier, K. Leonard, S. Hahmann, G. Morin, and M. Collins. The 2D shape structure dataset: A user annotated open access database. Computers and Graphics, 58:23–30, 2016.

[8] A. Chang, W. Monroe, M. Savva, C. Potts, and C. Manning. Text to 3d scene generation with rich lexical grounding. In Association for Computational Linguistics and International Joint Conference on Natural Language Processing, 2015.

[9] I.-M. Chen, S. Xing, R. Tay, and S. H. Yeo. Many strings attached: from conventional to robotic marionette manipulation. IEEE Robotics Automation Magazine, 12(1), 2005.

[10] S. Chenney, M. Pingel, R. Iverson, and M. Szymanski. Simulating cartoon style animation. In Proceedings of the 2Nd International Symposium on Non-photorealistic Animation and Rendering, NPAR '02, pages 133–138, New York, NY, USA, 2002. ACM.

[11] B. Choi, R. B. i Ribera, J. P. Lewis, Y. Seol, S. Hong, H. Eom, S. Jung, and J. Noh. Sketchimo: Sketch-based motion editing for articulated characters. ACM Trans. Graph., 35(4), July 2016.

[12] L. Ciccone, C. Öztireli, and R. W. Sumner. Tangent-space optimization for interactive animation control. ACM Trans. Graph., 38(4), July 2019.

[13] H. Clarck. Depicting as a method of communication. Psychological Review, 123:324–347, 2016.

[14] G. Claude, V. Gouranton, R. Bouville Berthelot, and B. Arnaldi. Seven, a sensor effector based scenarios model for driving collaborative virtual environment. In Eurographics Symposium on Virtual Environments.

[15] J. E. Cutting, J. E. DeLong, and C. E. Nothelfer. Attention and the evolution of hollywood film. Psychological Science, 21(3):432–439, 2010.

[16] B. Dalstein, R. Ronfard, and M. Van De Panne. Vector Graphics Animation with Time-Varying Topology. ACM Transactions on Graphics, 34(4):Article No. 145, 12 p, July 2015.

[17] R. Damiano, V. Lombardo, and A. Pizzo. The ontology of drama. Applied Ontology, 14(1):79–118, 2019.

[18] M. F. Deering. Holosketch: A virtual reality sketching/animation tool. ACM Transactions in Computer-Human Interaction, 2(3), Sept. 1995.

[19] J. Delanoy, M. Aubry, P. Isola, A. Efros, and A. Bousseau. 3d sketching using multi-view deep volumetric prediction. Proceedings of the ACM on Computer Graphics and Interactive Techniques, 1(21), may 2018.

[20] F. Devillers and S. Donikian. A scenario language to orchestrate virtual world evolution. In Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer animation, pages 265–275. Eurographics Association, 2003.

[21] C. Ding and L. Liu. A survey of sketch based modeling systems. Front. Comput. Sci., 10(6):985–999, Dec. 2016.

[22] M. Eger and K. W. Mathewson. dairector: Automatic story beat generation through knowledge synthesis. In Proceedings of the Joint Workshop on Intelligent Narrative Technologies and Workshop on Intelligent Cinematography and Editing, 2018.

[23] M. S. et al. Thespian : An architecture for interactive pedagogical drama. Artificial Intelligence in Education, 125:595–602, 2005.

[24] M. Firmin and M. Panne. Controller design for multi-skilled bipedal characters. Comput. Graph. Forum, 34(8), Dec. 2015.

[25] A. Fondevilla. Reverse-Engineering Fashion Products: From a single-view Sketch to a 3D Model. PhD thesis, December 2019.

[26] A. Fondevilla, A. Bousseau, D. Rohmer, S. Hahmann, and M.-P. Cani. Patterns from Photograph: Reverse-Engineering Developable Products. Computers and Graphics, 66:4–13, Aug. 2017.

[27] Q. Galvane, M. Christie, C. Lino, and R. Ronfard. Camera-on-rails: Automated Computation of Constrained Camera Paths. In ACM SIGGRAPH Conference on Motion in Games, pages 151–157, Paris, France, Nov. 2015. ACM.

[28] Q. Galvane, R. Ronfard, C. Lino, and M. Christie. Continuity Editing for 3D Animation. In AAAI Conference on Artificial Intelligence, pages 753–761, Austin, Texas, United States, Jan. 2015. AAAI Press.

[29] V. Gandhi, R. Ronfard, and M. Gleicher. Multi-Clip Video Editing from a Single Viewpoint. In European Conference on Visual Media Production, London, United Kingdom, Nov. 2014. ACM.

[30] M. Garcia. Performance transfer: animating virtual charaters by playing and acting. PhD thesis, December 2019.

[31] M. Garcia, M.-P. Cani, R. Ronfard, C. Gout, and C. Perrenoud. Automatic Generation of Geological Stories from a Single Sketch. In Expressive, pages 17–19. ACM, Aug. 2018.

[32] M. Garcia, R. Ronfard, and M.-P. Cani. Spatial Motion Doodles: Sketching Animation in VR Using Hand Gestures and Laban Motion Analysis. In Motion, Interaction and Games, Oct. 2019.

[33] P. Gebhard, G. Mehlmann, and M. Kipp. Visual scenemaker — a tool for authoring interactive virtual characters. Journal on Multimodal User Interfaces, 6:3–11, 2011.

[34] Y. Gingold, T. Igarashi, and D. Zorin. Structured annotations for 2d-to-3d modeling. In ACM SIGGRAPH Asia 2009 Papers, SIGGRAPH Asia '09, 2009.

[35] D. Gochfeld, C. Brenner, K. Layng, S. Herscher, C. DeFanti, M. Olko, D. Shinn, S. Riggs, C. Fernández-Vara, and K. Perlin. Holojam in wonderland: Immersive mixed reality theater. In ACM SIGGRAPH 2018 Art Gallery, SIGGRAPH '18, 2018.

[36] C. Grimm and P. Joshi. Just drawit: A 3d sketching system. In Proceedings of the International Symposium on Sketch-Based Interfaces and Modeling, SBIM '12, pages 121–130, 2012.

[37] M. Guay, R. Ronfard, M. Gleicher, and M.-P. Cani. Adding dynamics to sketch-based character animations. In Sketch-Based Interfaces and Modeling (SBIM), pages 27–34, June 2015.

[38] M. Guay, R. Ronfard, M. Gleicher, and M.-P. Cani. Space-time sketching of character animation. ACM Transactions on Graphics, 34(4):Article No. 118, Aug. 2015.

[39] D. Ha and D. Eck. A neural representation of sketch drawings. In ICLR, 2018.

[40] B. Hayes-Roth and R. V. Gent. Improvisational puppets, actors, and avatars. In Proc Comp Game Dev Conf, 1996.

[41] A. Hertzmann. Can computers create art? Arts, 7(18), 2018.

[42] F. Hoenig. Defining computational aesthetics. In Proceedings of the First Eurographics Conference on Computational Aesthetics in Graphics, Visualization and Imaging, Computational Aesthetics'05, 2005.

[43] D. Holden, I. Habibie, I. Kusajima, and T. Komura. Fast neural style transfer for motion data. IEEE Computer Graphics and Applications, 37(4):42–49, 2017.

[44] K. Hyun, K. Lee, and J. Lee. Motion grammars for character animation. Comput. Graph. Forum, 35(2), May 2016.

[45] T. Igarashi, S. Matsuoka, and H. Tanaka. Teddy: A sketching interface for 3d freeform design. In Proceedings of the 26th Annual Conference on Computer Graphics and Interactive Techniques, SIGGRAPH '99, pages 409–416, New York, NY, USA, 1999. ACM Press/Addison-Wesley Publishing Co.

[46] B. Jackson and D. F. Keefe. Lift-off: Using reference imagery and freehand sketching to create 3d models in vr. IEEE Transactions on Visualization and Computer Graphics, 22(4):1442–1451, Apr. 2016.

[47] Y. Jing, Y. Yang, Z. Feng, J. Ye, and M. Song. Neural style transfer: A review. CoRR, abs/1705.04058, 2017.

[48] A. Jung, S. Hahmann, D. Rohmer, A. Begault, L. Boissieux, and M.-P. Cani. Sketching Folds: Developable Surfaces from Non-Planar Silhouettes. ACM Transactions on Graphics, 34(5):155:1–155:12, Oct. 2015.

[49] M. Kallmann and D. Thalmann. Modeling objects for interaction tasks. In Computer Animation and Simulation, 1998.

[50] V. Kokotovich and T. Purcell. Mental synthesis and creativity in design: an experimental examination. Design Studies, 21(5):437 – 449, 2000.

[51] M. Konaković, K. Crane, B. Deng, S. Bouaziz, D. Piker, and M. Pauly. Beyond developable: Computational design and fabrication with auxetic materials. ACM Trans. Graph., 35(4), July 2016.

[52] N. Krishnaswamy and J. Pustejovsky. Voxsim: A visual platform for modeling motion lan- guage. In Proceedings of COLING 2016, the 26th International Conference on Computational Lin- guistics, 2016.

[53] K. Layng, K. Perlin, S. Herscher, C. Brenner, and T. Meduri. Cave: Making collective virtual narrative. In ACM SIGGRAPH 2019 Art Gallery, SIGGRAPH '19, 2019.

[54] M. Leake, A. Davis, A. Truong, and M. Agrawala. Computational video editing for dialogue-driven scenes. ACM Trans. Graph., 36(4), July 2017.

[55] S. J. Lee and Z. Popovic. Learning behavior styles with inverse reinforcement learning. ACM Trans. Graph., 29(4), 2010.

[56] A. Louarn, M. Christie, and F. Lamarche. Automated Staging for Virtual Cinematography. In MIG 2018 - 11th annual conference on Motion, Interaction and Games, pages 1–10, Limassol, Cyprus, Nov. 2018. ACM.

[57] Z. Lun, E. Kalogerakis, R. Wang, and A. Sheffer. Functionality preserving shape style transfer. ACM Transactions on Graphics, 35(6), 2016.

[58] B. Magerko, W. Manzoul, M. Riedl, A. Baumer, D. Fuller, K. Luther, and C. Pearce. An empirical study of cognition and theatrical improvisation. Creativity and Cognition, 2009.

[59] M. Mahzoon, M. L. Maher, K. Grace, L. Locurto, and B. Outcault. The willful marionette: Modeling social cognition using gesture-gesture interaction dialogue. In International Conference on Foundations of Augmented Cognition: Neuroergonomics and Operational Neuroscience, volume volume 9744, 2016.

[60] L. Malomo, J. Pérez, E. Iarussi, N. Pietroni, E. Miguel, P. Cignoni, and B. Bickel. Flexmaps: Computational design of flat flexible shells for shaping 3d objects. ACM Trans. Graph., 37(6), Dec. 2018.

[61] M. Marti, J. Vieli, W. Witoń, R. Sanghrajka, D. Inversini, D. Wotruba, I. Simo, S. Schriber, M. Kapadia, and M. Gross. Cardinal: Computer assisted authoring of movie scripts. In 23rd International Conference on Intelligent User Interfaces, IUI '18, 2018.

[62] S. Martin, B. Thomaszewski, E. Grinspun, and M. Gross. Example-based elastic materials. ACM Trans. Graph., 30(4):72:1–72:8, July 2011.

[63] M. Mateas and A. Stern. A behavior language for story-based believable agents. IEEE Intelligent Systems, 17(4):39–47, July 2002.

[64] A. McNamara, A. Treuille, Z. Popović, and J. Stam. Fluid control using the adjoint method. ACM Trans. Graph., 23(3):449–456, Aug. 2004.

[65] Y. Mori and T. Igarashi. Plushie: An interactive design system for plush toys. ACM Trans. Graph., 26(3), July 2007.

[66] T. D. Murphey and M. Egerstedt. Choreography for marionettes: Imitation, planning, and control. In IEEE Conference on Intelligent and Robotic Systems: Workshop on Art and Robotics, 2007.

[67] J. H. Murray. Hamlet on the Holodeck, The Future of Narrative in Cyberspace, Updated Edition. MIT Press, 2017.

[68] V. A. Murukutla, E. Cattan, O. Palombi, and R. Ronfard. Text-to-Movie Authoring of Anatomy Lessons. In Artificial Intelligence in Medicine.

[69] R. J. Neagle, K. Ng, and R. A. Ruddle. Developing a virtual ballet dancer to visualise choreography. In Artificial Intelligence and Simulation of Behavior, 2004.

[70] W. H. Organization. International Classification of Functioning, Disability and Health. World Health Organization, 2001.

[71] O. Palombi, G. Bousquet, D. Jospin, S. Hassan, L. Revéret, and F. Faure. My corporis fabrica: A unified ontological, geometrical and mechanical view of human anatomy. In Proceedings of the 2009 International Conference on Modelling the Physiological Human, 3DPH'09, pages 209–219, 2009.

[72] X. B. Peng, P. Abbeel, S. Levine, and M. van de Panne. Deepmimic: Example-guided deep reinforcement learning of physics-based character skills. ACM Trans. Graph., 37(4), July 2018.

[73] K. Perlin and A. Goldberg. Improv: A system for scripting interactive actors in virtual worlds. In Proceedings of the 23rd Annual Conference on Computer Graphics and Interactive Techniques, SIGGRAPH '96, 1996.

[74] S. Poulakos, M. Kapadia, A. Schupfer, F. Zund, R. Sumner, and M. Gross. Towards an accessible interface for story world building. In AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, 2015.

[75] A. T. Purcell and J. S. Gero. Drawings and the design process: A review of protocol studies in design and other disciplines and related research in cognitive psychology. Design Studies, 19(4):389 – 430, 1998.

[76] R. Ronfard, V. Gandhi, L. Boiron, and V. A. Murukutla. The prose storyboard language: A tool for annotating and directing movies. CoRR, arXiv:1508.07593v3, 2019.

[77] R. Ronfard and N. Szilas. Where story and media meet: Computer generation of narrative discourse. In 2014 Workshop on Computational Models of Narrative, CMN 2014, July 31 - August 2, 2014, Quebec City, Canada, pages 164–176, 2014.

[78] E. Rosales, J. Rodriguez, and A. Sheffer. Surfacebrush: From virtual reality drawings to manifold surfaces. ACM transactions on Graphics, Proceedings of SIGGRAPH, 2019.

[79] C. Rosse and J. Mejino. A reference ontology for biomedical informatics: the foundational model of anatomy. Journal of Biomedical Informatics, 36(6):478 – 500, 2003.

[80] O. Sbai, M. Elhoseiny, A. Bordes, Y. LeCun, and C. Couprie. Design inspiration from generative networks. CoRR, abs/1804.00921, 2018.

[81] C. Schreck, D. Rohmer, S. Hahmann, M.-P. Cani, S. Jin, C. C. Wang, and J.-F. Bloch. Non-smooth developable geometry for interactively animating paper crumpling. ACM Transactions on Graphics, 35(1):10:1–10:18, Dec. 2015.

[82] C. Schumacher, S. Marschner, M. Cross, and B. Thomaszewski. Mechanical characterization of structured sheet materials. ACM Trans. Graph., 37(4):148:1–148:15, July 2018.

[83] M. Skouras, B. Thomaszewski, S. Coros, B. Bickel, and M. Gross. Computational design of actuated deformable characters. ACM Trans. Graph., 32(4), July 2013.

[84] M. Svanera, M. Savardi, A. Signoroni, A. B. Kovács, and S. Benini. Who is the director of this movie? automatic style recognition based on shot features. CoRR, abs/1807.09560, 2018.

[85] N. Szilas. Idtension – highly interactive drama. In Proceedings of the Fourth Artificial Intelligence and Interactive Digital Entertainment Conference, 2008.

[86] J. O. Talton, Y. Lou, S. Lesser, J. Duke, R. Měch, and V. Koltun. Metropolis procedural modeling. ACM Trans. Graph., 30(2), Apr. 2011.

[87] C. Thomas and A. Kovashka. Seeing behind the camera: Identifying the authorship of a photograph. In 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 3494–3502, 2016.

[88] F. Ulliana, J.-C. Léon, O. Palombi, M.-C. Rousset, and F. Faure. Combining 3D Models and Functions through Ontologies to Describe Man-made Products and Virtual Humans: Toward a Common Framework. Computer-Aided Design and Applications, 12(2):166–180, 2015.

[89] B. Wang, L. Wu, K. Yin, U. Ascher, L. Liu, and H. Huang. Deformation capture and modeling of soft objects. ACM Trans. Graph., 34(4):94:1–94:12, July 2015.

[90] T. Y. Wang, D. Ceylan, J. Popović, and N. J. Mitra. Learning a shared shape space for multimodal garment design. ACM Trans. Graph., 37(6), Dec. 2018.

[91] C.-Y. Weng, B. Curless, and I. Kemelmacher-Shlizerman. Photo wake-up: 3d character animation from a single photo. In CVPR, 2019.

[92] L. Wilke, T. Calvert, R. Ryman, and I. Fox. From dance notation to human animation: The labandancer project: Motion capture and retrieval. Comput. Animat. Virtual Worlds, 16(3-4):201–211, July 2005.

[93] A. Witkin and M. Kass. Spacetime constraints. SIGGRAPH Comput. Graph., 22(4):159–168, June 1988.

[94] C. Wright, J. Allnut, R. Campbell, M. Evans, S. Jolly, L. Kerlin, J. Gibson, G. Phillipson, and M. Shotton. Ai in production: Video analysis and machine learning for expanded live events coverage. In International Broadcasting Convention, 2018.

[95] H.-Y. Wu, F. Palù, R. Ranon, and M. Christie. Thinking Like a Director: Film Editing Patterns for Virtual Cinematographic Storytelling. ACM Transactions on Multimedia Computing, Communications and Applications, 14(4):1–23, 2018.

[96] B. Xu, W. Chang, A. Sheffer, A. Bousseau, J. McCrae, and K. Singh. True2form: 3d curve networks from 2d sketches via selective regularization. ACM Trans. Graph., 33(4):131:1–131:13, July 2014.

[97] K. Yamane, J. K. Hodgins, and H. B. Brown. Controlling a marionette with human motion capture data. In IEEE International Conference on Robotics and Automation, volume 3, 2003.

[98] J. Yaniv, Y. Newman, and A. Shamir. The face of art: Landmark detection and geometric style in portraits. ACM Trans. Graph., 38(4), July 2019.

[99] Y. Zhang, E. Tsipidi, S. Schriber, M. Kapadia, M. H. Gross, and A. Modi. Generating animations from screenplays. CoRR, abs/1904.05440, 2019.

[100] S. Zimmermann, R. Poranne, J. Bern, and S. Coros. Puppetmaster: Robotic animation of marionettes. ACM Trans. Graph., 2019.

A Presentation of the research scientists

Rémi Ronfard

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Education

1986 Msc in Engineering, Mines Paris Tech.

1991 PhD thesis in Computer Science, Mines Paris Tech: Variational principles for tracking color object contours in video.

2009 Habilitation thesis at Univ. Grenoble Alpes: Automatic film analysis – from image sequences to action sequences.

Current position(s)

Since 2016 Research Director and Team Leader at Inria

Since 2018 Associate Researcher at ENSADLAB, Paris

Previous positions

1991 – 1992 Research Engineer at Dassault Systèmes, Suresnes, France. Non manifold topology for boolean operations in CATIA.

1992 – 1994 Post-doc at IBM T.J. Watson Research Center, Yorktow, New York, USA. Large-scale mesh triangulation and simplification methods (Eurographics 1994 and 1996).

1994 – 2000 Senior Researcher at Institut National de l'Audiovisuel, Bry-sur-Marne, France. Storyboard and layout animation, content-based video indexing, MPEG expert group.

2000 – 2001 Visiting Scientist at IBM T.J. Watson Research Center, Yorktow, New York, USA. Rapid prototyping of subdivision surfaces in CATIA (with Denis Zorin, NYU).

2001 – 2016 Permanent Researcher at Inria. Computer vision with MOVI and LEAR teams, computer graphics with IMAGINE team.

2007 – 2008 Team leader at Xtranormal Technologies, Montreal, Canada, on leave from Inria. Patented virtual cinematography system Magicam for Xtranormal Text-to-Movie technology.

Supervision of graduate students and postdoctoral fellows

2001-2016 Supervised 8 PhD Students, 2 Post-Docs and 30 Master Students.

Since 2016 Currently supervising 5 PhD students.

Teaching activities

1990-1991 Remote Sensing, Masters, Imperial College, London.

1992-2000 Introduction to algorithms, Masters, ENSAE, Paris.

2002-2007 Computer Vision, Masters, Univ. Grenoble Alpes.

2012-2018 Advanced Computer Graphics, Masters, Univ. Grenoble Alpes.

2012-2018 Game Engine Programming, Masters, University of Montpellier.

2014-2016 Computational Modeling of Narrative, PhD, Univ. Grenoble Alpes.

Institutional responsibilities

2005-2006 Leader of international team VAMP with Brown University.

2012-2016 Director of the Geometry and Image Department, LJK, Univ. Grenoble Alpes.

Melina Skouras

http://team.inria.fr/imagine/

Education
2014 PhD in Computer Science, ETH Zurich, Switzerland.
2004 Diploôme d'Ingeénieur (Master 's Degree), ENSIMAG, Grenoble, France.

Current position(s)

Since 2017 Researcher (Chargée de recherche) at INRIA Grenoble-Rhône-Alpes.

Previous positions

2015 – 2017 Postdoctoral Associate at MIT, Cambridge, MA, USA.
2010 – 2014 Research Assistant at ETH Zurich, Switzerland.
2005 – 2009 Software developer at Dassault Systèmes, Vélizy, France.

Supervision of graduate students and postdoctoral fellows

2017 – 2019 Supervised 3 Master Students.
2019 Currently supervising 2 PhD students and 1 Master Student.

Teaching activities

2019-2020 MSc2 Surface Modeling (9 hours), MSc2 Numerical Mechanics (9 hours)
2018 MSc2 Surface Modeling (9 hours)
2016 MSc2 Computational Fabrication (4 hours)
2010 – 2014 Teaching assistant at level BSc1 and MSc2 (1h-2h per week during 7 semesters of 12 weeks) in Computer Graphics and Computer Vision, Geometric Modeling and Introduction to Computer Science.

Stefanie Hahmann

http://team.inria.fr/imagine/

Education

1990 Diplom Mathematics, TU Braunschweig, Germany.
1989 M.Sc. Applied Mathematics ENS Cachan and University Paris VI, France.
1994 Dr. rer. nat. (PhD) Computer Science, TU Kaiserslautern, Germany
2001 Habilitation Computer Science, Institut National Polytechnique de Grenoble.

Current position(s)

2006 Professor Grenoble INP (2016 promotion PREX, 2011 promotion PR1)

Previous positions

1995 – 2006 Assistant Professor, Institut National Polytechnique de Grenoble
1991 – 1995 Research Assistant, Computer Science Department, TU Kaiserslautern, Germany.

Supervision of graduate students and postdoctoral fellows

1997 - 2017 Supervised 10 PhD Students, 4 Post-Docs and 26 Master Students.
2019 Currently supervising 3 PhD students.

Teaching activities

Since 1995 4700 hours teached at ENSIMAG at level BSc3, MSc1, MSc2 Numerical analysis, Algorithms and data structures, Geometric Modeling, 3D Shape modeling, Scientific visualization, projects supervisor.

Institutional responsibilities

Since 2013 Head of Masters Program (2 years) in Mathematical Modeling and Images (MMIS department) at ENSIMAG (150 students)
Since 2011 Graduate School of Mathematics and Computer Science Grenoble, member of steering office
2007 - 2019 CNRS, GDR IM, GDR IGRV: Head of Geometric Modeling group (GTMG)
2009 - 2012 SIAM - Society for Industrial and Applied Mathematics, vice-Chair of SIAG/GD (2 years), Program Director of SIAG/GD (2 years)
2003 - 2006 Scientific Board of INP Grenoble, Member
1998 - 2006 Board of Directors, Ensimag-INPG, Member

Olivier Palombi

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Education

2002 : Doctorat en Médecine, UJF : Bases anatomiques l'invasivité ostéo-durale des méningiomes
2006 : Doctorat en Informatique graphique, INP de Grenoble : Modélisation anatomique par surfaces implicites
2010 : Habilitation à diriger des recherches (HDR), Faculté de Médecine de Grenoble

Current position(s)

Since 2011 Professeur des Universités (Anatomie) et Praticien Hospitalier (Neurochirurgie) - PUPH
Since 2007 Membre permanent du laboratoire Jean Kuntzmann LJK (UMR 5224, CNRS)

Previous positions

1997 – 2002 Interne de Neurochirurgie, CHU de Grenoble
1998 – 2002 Moniteur d'Anatomie (Travaux Pratiques PCEM2), Laboratoire d'Anatomie, UJF, Grenoble
1998 – 1999 Aspirant Médecin dans le Service de Neurochirurgie du Val de Grâce (Pr Desgeorges), Paris
2002 – 2004 Assistant Hospitalo-Universitaire (Laboratoire d'Anatomie UJF, Neurochirurgie CHU de Grenoble)
2004 – 2005 Honorary Senior Research Associate of Prince of Wales Medical Research Institute, University of New South Wales, Sydney Australia, (Pr. G. Paxinos).
2005 – 2006 Assistant Hospitalo-Universitaire (Laboratoire d'Anatomie UJF, Neurochirurgie CHU de Grenoble)
2006 – 2007 Praticien Hospitalier Universitaire (Anatomie / Neurochirurgie)
2007 – 2011 Maître de Conférence des Universités et Praticien Hospitalier (Anatomie, Neurochirurgie)

Supervision of graduate students and postdoctoral fellows

2010- 2018 Supervised 4 PhD Students, 3 Post-Docs and 12 Master Students.
2019 Currently supervising 3 PhD students.

Teaching activities

2004-2008 Cours à l'École d'Ingénieurs de Polytech 'Grenoble
Since 2004 Cours d'Anatomie à la faculté de médecine de Grenoble (1er cycle)
Since 2004 Cours dans le master ISM
Since 2006 DIU de prise en charge des traumatisés sévères, DU de pédagogie de Grenoble.

Institutional responsibilities

Since 2014 Conseillé scientifique pour le numérique du Conseil scientifique du CNCI (MESR)
Since 2015 Membre élu du Conseil et membre du bureau de l'UFR de Grenoble
Since 2016 Chargé de mission sur le numérique pour la conférence des Doyens de Médecine
Since 2017 Vice-Doyen de la faculté de médecine de Grenoble

B Publications of team members 2015-2019

References

[1] N. Aboubakr, J. L. Crowley, and R. Ronfard. Recognizing Manipulation Actions from State-Transformations. In Fourth International Workshop on Egocentric Perception Interaction and Computing, pages 1–4, June 2019.

[2] N. Aboubakr, R. Ronfard, and J. L. Crowley. Recognition and Localization of Food in Cooking Videos. In Multimedia for Cooking and Eating Activities, pages 21–24. ACM, July 2018.

[3] L. Allemand-Giorgis, G.-P. Bonneau, and S. Hahmann. Piecewise polynomial Reconstruction of Scalar Fields from Simplified Morse-Smale Complexes. In H. Carr, C. Garth, and T. Weinkauf, editors, Topological Methods in Data Analysis and Visualization, Mathematics and Visualization, pages 151–168. Springer, 2017.

[4] A. Barbulescu, G. Bailly, R. Ronfard, and M. Pouget. Audiovisual Generation of Social Attitudes from Neutral Stimuli. In Facial Analysis, Animation and Auditory-Visual Speech Processing, pages 34–39. ISCA, Sept. 2015.

[5] A. Barbulescu, A. Begault, L. Boissieux, M.-P. Cani, M. Garcia, M. Portaz, A. Viand, P. Heinish, R. Dulery, R. Ronfard, and D. Vaufreydaz. Making Movies from Make-Believe Games. In 6th Workshop on Intelligent Cinematography and Editing (WICED 2017), Lyon, France, Apr. 2017. The Eurographics Association.

[6] A. Barbulescu, M. Garcia, A. Begault, L. Boissieux, M.-P. Cani, M. Portaz, A. Viand, R. Dulery, P. Heinish, R. Ronfard, and D. Vaufreydaz. A system for creating virtual reality content from make-believe games. In IEEE Virtual Reality 2017, pages 207–208, Los Angeles, United States, Mar. 2017. IEEE.

[7] A. Barbulescu, R. Ronfard, and G. Bailly. Characterization of Audiovisual Dramatic Attitudes. In Interspeech, pages 585–589, Sept. 2016.

[8] A. Barbulescu, R. Ronfard, and G. Bailly. A Generative Audio-Visual Prosodic Model for Virtual Actors. IEEE Computer Graphics and Applications, 37(6):40–51, Nov. 2017.

[9] A. Barbulescu, R. Ronfard, and G. Bailly. Which prosodic features contribute to the recognition of dramatic attitudes? Speech Communication, 95:78–86, Dec. 2017.

[10] A. Bauer, A.-H. Dicko, F. Faure, O. Palombi, and J. Troccaz. Anatomical Mirroring: Real-time User-specific Anatomy in Motion Using a Commodity Depth Camera. In ACM SIGGRAPH Conference on Motion in Games, pages 113–122, San Francisco, United States, Oct. 2016. ACM.

[11] A. Bauer, A. H. Dicko, O. Palombi, F. Faure, and J. Troccaz. Living Book of Anatomy Project: See your Insides in Motion! In SA '15 SIGGRAPH Asia 2015 Emerging Technologies , page Article No. 16, Kobe, Japan, Nov. 2015. ACM.

[12] A. Bauer, D. R. Neog, A.-H. Dicko, D. K. Pai, F. Faure, O. Palombi, and J. Troccaz. Anatomical augmented reality with 3D commodity tracking and image-space alignment. Computers and Graphics, 69:140 – 153, Dec. 2017.

[13] T. Blanc-Beyne, G. Morin, K. Leonard, S. Hahmann, and A. Carlier. A Salience Measure for 3D Shape Decomposition and Sub-parts Classification. Graphical Models, 99:22–30, Sept. 2018.

[14] F. Boussuge, J.-C. Léon, S. Hahmann, and L. Fine. Idealized Models for FEA Derived from Generative Modeling Processes Based on Extrusion Primitives. Engineering with Computers, 31:513–527, 2015.

[15] A. Carlier, K. Leonard, S. Hahmann, G. Morin, and M. Collins. The 2D shape structure dataset: A user annotated open access database. Computers and Graphics, 58:23–30, 2016.

[16] M. Carrière, M. Skouras, and S. Hahmann. 3D Design Of Ancient Garments. In Graphics and Cultural Heritage, Nov. 2019.

[17] P. Casati, R. Ronfard, and S. Hahmann. Approximate Reconstruction of 3D Scenes From Bas-Reliefs. In Graphics and Cultural Heritage, Nov. 2019.

[18] D. Chen, M. Skouras, B. Zhu, and W. Matusik. Computational discovery of extremal microstructure families. Science Advances, 4(1), 2018.

[19] M. Cherdieu, O. Palombi, S. Gerber, J. Troccaz, and A. Rochet-Capellan. Make Gestures to Learn: Reproducing Gestures Improves the Learning of Anatomical Knowledge More than Just Seeing Gestures . Frontiers in Psychology, 8:1689:1–15, Oct. 2017.

[20] B. Dalstein, R. Ronfard, and M. Van De Panne. Vector Graphics Animation with Time-Varying Topology. ACM Transactions on Graphics, 34(4):Article No. 145, 12 p, July 2015.

[21] A. H. Dicko, N. Tong-Yette, B. Gilles, F. Faure, and O. Palombi. Construction and Validation of a Hybrid Lumbar Spine Model For the Fast Evaluation of Intradiscal Pressure and Mobility. International Science Index, Medical and Health Science, 9(2):134–145, Feb. 2015.

[22] A. Fondevilla, A. Bousseau, D. Rohmer, S. Hahmann, and M.-P. Cani. Modeling Symmetric Developable Surfaces from a Single Photo. In Journées Françaises d'Informatique Graphique, Grenoble, France, Nov. 2016.

[23] A. Fondevilla, A. Bousseau, D. Rohmer, S. Hahmann, and M.-P. Cani. Patterns from Photograph: Reverse-Engineering Developable Products. Computers and Graphics, 66:4–13, Aug. 2017.

[24] A. Fondevilla, A. Bousseau, D. Rohmer, S. Hahmann, and M.-P. Cani. Towards developable products from a sketch. EUROGRAPHICS Poster Proceedings, Apr. 2017. Poster.

[25] G. Gagneré, R. Ronfard, and M. Desainte-Catherine. La simulation du travail théâtral et sa " notation " informatique. In M. Martinez and S. Proust, editors, La notation du travail théâtral : du manuscrit au numérique. Lansman, Oct. 2016.

[26] Q. Galvane, M. Christie, C. Lino, and R. Ronfard. Camera-on-rails: Automated Computation of Constrained Camera Paths. In ACM SIGGRAPH Conference on Motion in Games, pages 151–157, Paris, France, Nov. 2015. ACM.

[27] Q. Galvane and R. Ronfard. Implementing Hitchcock - the Role of Focalization and Viewpoint. In Eurographics Workshop on Intelligent Cinematography and Editing, number 5-12 in Eurographics Workshop on Intelligent Cinematography and Editing, Lyon, France, Apr. 2017. Eurographics Association, The Eurographics Association.

[28] Q. Galvane, R. Ronfard, and M. Christie. Comparing film-editing. In Eurographics Workshop on Intelligent Cinematography and Editing, WICED '15 , pages 5–12, Zurich, Switzerland, May 2015. Eurographics Association.

[29] Q. Galvane, R. Ronfard, C. Lino, and M. Christie. Continuity Editing for 3D Animation. In AAAI Conference on Artificial Intelligence, pages 753–761, Austin, Texas, United States, Jan. 2015. AAAI Press.

[30] V. Gandhi and R. Ronfard. A Computational Framework for Vertical Video Editing. In 4th Workshop on Intelligent Camera Control, Cinematography and Editing, pages 31–37, Zurich, Switzerland, May 2015. Eurographics, Eurographics Association.

[31] M. Garcia, M.-P. Cani, R. Ronfard, C. Gout, and C. Perrenoud. Automatic Generation of Geological Stories from a Single Sketch. In Expressive, pages 17–19. ACM, Aug. 2018.

[32] M. Garcia, R. Ronfard, and M.-P. Cani. Spatial Motion Doodles: Sketching Animation in VR Using Hand Gestures and Laban Motion Analysis. In Motion, Interaction and Games, Oct. 2019.

[33] M. Guay, R. Ronfard, M. Gleicher, and M.-P. Cani. Adding dynamics to sketch-based character animations. In Sketch-Based Interfaces and Modeling (SBIM), pages 27–34, June 2015.

[34] M. Guay, R. Ronfard, M. Gleicher, and M.-P. Cani. Space-time sketching of character animation. ACM Transactions on Graphics, 34(4):Article No. 118, Aug. 2015.

[35] A. Jung, S. Hahmann, D. Rohmer, A. Begault, L. Boissieux, and M.-P. Cani. Sketching Folds: Developable Surfaces from Non-Planar Silhouettes. ACM Transactions on Graphics, 34(5):155:1–155:12, Oct. 2015.

[36] M. Kumar, V. Gandhi, R. Ronfard, and M. Gleicher. Zooming On All Actors: Automatic Focus+Context Split Screen Video Generation. Computer Graphics Forum, 36(2):455–465, May 2017.

[37] K. Leonard, G. Morin, S. Hahmann, and A. Carlier. A 2D Shape Structure for Decomposition and Part Similarity. In ICPR 2016 - 23rd International Conference on Pattern Recognition, pages 3216–3221, Cancun, Mexico, Dec. 2016. IEEE.

[38] H. Liu, U. Vimont, M. Wand, M.-P. Cani, S. Hahmann, D. Rohmer, and N. J. Mitra. Replaceable Substructures for Efficient Part-Based Modeling. Computer Graphics Forum, 34(2):503 – 513, 2015.

[39] M. Ly, R. Casati, F. Bertails-Descoubes, M. Skouras, and L. Boissieux. Inverse Elastic Shell Design with Contact and Friction. ACM Transactions on Graphics, 37(6):1–16, Nov. 2018.

[40] J. Martínez, M. Skouras, C. Schumacher, S. Hornus, S. Lefebvre, and B. Thomaszewski. Star-Shaped Metrics for Mechanical Metamaterial Design. ACM Transactions on Graphics, 38(4):13, July 2019. Special issue, SIGGRAPH 2019.

[41] F. Morin, H. Courtecuisse, I. Reinertsen, F. Le Lann, O. Palombi, Y. Payan, and M. Chabanas. Brain-shift compensation using intraoperative ultrasound and constraint-based biomechanical simulation. Medical Image Analysis, 40:133 – 153, 2017.

[42] F. Morin, H. Courtecuisse, I. Reinertsen, F. Le Lann, O. Palombi, Y. Payan, and M. Chabanas. Intraoperative brain-shift compensation using MR/US elastic registration by means of a constraint-based biomechanical simulation. In Biomechanics and computer assisted surgery meets medical reality, 2017.

[43] F. Morin, H. Courtecuisse, I. Reinertsen, F. Le Lann, O. Palombi, Y. Payan, and M. Chabanas. Resection-induced brain-shift compensation using vessel-based methods. In SPIE Medical Imaging, volume 10576. International Society for Optics and Photonics, Feb. 2018.

[44] F. Morin, I. Reinertsen, H. Courtecuisse, O. Palombi, B. Munkvold, H. K. Bø, Y. Payan, and M. Chabanas. Vessel-based brain-shift compensation using elastic registration driven by a patient-specific finite element model. In Information Processing in Computer-Assisted Interventions, June 2016.

[45] V. A. Murukutla, E. Cattan, O. Palombi, and R. Ronfard. Text-to-Movie Authoring of Anatomy Lessons. In Artificial Intelligence in Medicine.

[46] G. Nucha, G.-P. Bonneau, S. Hahmann, and V. Natarajan. Computing Contour Trees for 2D Piecewise Polynomial Functions. Computer Graphics Forum, 36(3):23–33, June 2017.

[47] J. Ou, M. Skouras, N. Vlavianos, F. Heibeck, C.-Y. Cheng, J. Peters, and H. Ishii. aeromorph - heat-sealing inflatable shape-change materials for interaction design. In Proceedings of the 29th Annual Symposium on User Interface Software and Technology, UIST '16, pages 121–132, New York, NY, USA, 2016. ACM.

[48] O. Palombi, F. Jouanot, N. Nziengam, B. Omidvar-Tehrani, M.-C. Rousset, and A. Sanchez. OntoSIDES: Ontology-based student progress monitoring on the national evaluation system of French Medical Schools. Artificial Intelligence in Medicine, 96:59–67, May 2019.

[49] M. Portaz, M. Garcia, A. Barbulescu, A. Begault, L. Boissieux, M.-P. Cani, R. Ronfard, and D. Vaufreydaz. Figurines, a multimodal framework for tangible storytelling. In Child Computer Interaction, pages 52–57, Nov. 2017. Author version.

[50] S. Pujades, F. Devernay, L. Boiron, and R. Ronfard. The Stereoscopic Zoom. In Computation Cameras and Displays, The IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, pages 1295–1304, Honolulu, United States, July 2017. IEEE.

[51] P.-Y. Rabattu, B. Massé, F. Ulliana, M.-C. Rousset, D. Rohmer, J.-C. Léon, and O. Palombi. My Corporis Fabrica Embryo: An ontology-based 3D spatio-temporal modeling of human embryo development. Journal of Biomedical Semantics, 6:36:1–15, 2015.

[52] D. Rohmer, S. Hahmann, and M.-P. Cani. Real-Time Continuous Self-Replicating Details for Shape Deformation. Computers and Graphics, 51:67–73, Oct. 2015.

[53] R. Ronfard. Notation et reconnaissance des actions scéniques par ordinateur. In M. Martinez and S. Proust, editors, La notation du travail théâtral : du manuscrit au numérique. Lansman, Oct. 2016.

[54] R. Ronfard. Five Challenges for Intelligent Cinematography and Editing. In Eurographics Workshop on Intelligent Cinematography and Editing, Eurographics Workshop on Intelligent Cinematography and Editing, Lyon, France, Apr. 2017. Eurographics Association.

[55] R. Ronfard, B. Encelle, N. Sauret, P.-A. Champin, T. Steiner, V. Gandhi, C. Migniot, and F. Thiery. Capturing and Indexing Rehearsals: The Design and Usage of a Digital Archive of Performing Arts. In Digital Heritage, pages 533–540, Grenade, Spain, Sept. 2015. IEEE.

[56] R. Ronfard, V. Gandhi, L. Boiron, and V. A. Murukutla. The prose storyboard language: A tool for annotating and directing movies. CoRR, arXiv:1508.07593v3, 2019.

[57] M.-C. Rousset, M. Atencia, J. David, F. Jouanot, O. Palombi, and F. Ulliana. Datalog revisited for reasoning in linked data. In G. Ianni, D. Lembo, L. Bertossi, W. Faber, B. Glimm, G. Gottlob, and S. Staab, editors, Reasoning Web. Semantic Interoperability on the Web. Reasoning Web 2017, volume LNCS of Reasoning Web International Summer School, pages 121–166. Springer Verlag, 2017.

[58] C. Schreck, D. Rohmer, and S. Hahmann. Interactive paper tearing. Computer Graphics Forum, 36(2):95–106, May 2017.

[59] C. Schreck, D. Rohmer, S. Hahmann, and M.-P. Cani. Interactively animating crumpling paper. In womEncourage 2015, Uppsala, Sweden, Sept. 2015.

[60] C. Schreck, D. Rohmer, S. Hahmann, M.-P. Cani, S. Jin, C. C. Wang, and J.-F. Bloch. Non-smooth developable geometry for interactively animating paper crumpling. ACM Transactions on Graphics, 35(1):10:1–10:18, Dec. 2015.

[61] C. Schreck, D. Rohmer, D. L. James, S. Hahmann, and M.-P. Cani. Real-time sound synthesis for paper material based on geometric analysis. In ACM SIGGRAPH/Eurographics Symposium on Computer Animation (SCA'16), pages 211–220, Zürich, Switzerland, July 2016. Eurographics Association.

[62] M. Skouras, S. Coros, E. Grinspun, and B. Thomaszewski. Interactive surface design with interlocking elements. ACM Trans. Graph., 34(6):224:1–224:7, Oct. 2015.

[63] T. Stanko, S. Hahmann, G.-P. Bonneau, and N. Saguin-Sprynski. Smooth Interpolation of Curve Networks with Surface Normals. In T. Bashford-Rogers and L. P. Santos, editors, Eurographics 2016 Short Papers, pages 21–24, Lisbonne, Portugal, May 2016. Eurographics Association.

[64] T. Stanko, S. Hahmann, G.-P. Bonneau, and N. Saguin-Sprynski. Surfacing Curve Networks with Normal Control. Computers and Graphics, 60:1–8, Nov. 2016.

[65] T. Stanko, S. Hahmann, G.-P. Bonneau, and N. Saguin-Sprynski. Shape from sensors: Curve networks on surfaces from 3D orientations. Computers and Graphics, 66:74–84, Aug. 2017.

[66] T. Stanko, N. Saguin-Sprynski, L. Jouanet, S. Hahmann, and G.-P. Bonneau. Morphorider: Acquisition and Reconstruction of 3D Curves with Mobile Sensors. In IEEE Sensors 2017, pages 1–3, Glasgow, United Kingdom, Oct. 2017. IEEE.

[67] T. Stanko, N. Saguin-Sprynski, L. Jouanet, S. Hahmann, and G.-P. Bonneau. Morphorider: a new way for Structural Monitoring via the shape acquisition with a mobile device equipped with an inertial node of sensors. In EWSHM 2018 - 9th European Workshop on Structural Health Monitoring, pages 1–11, Manchester, United Kingdom, July 2018.

[68] T. Steiner, R. Ronfard, P.-A. Champin, B. Encelle, and Y. Prié. Curtains Up! Lights, Camera, Action! Documenting the Creation of Theater and Opera Productions with Linked Data and Web Technologies. In International Conference on Web Engineering ICWE 2015, volume 9114 of Lecture Notes in Computer Science, page 10, Amsterdam, Netherlands, June 2015. International Society for the Web Engineering.

[69] S. Sundaram, M. Skouras, D. S. Kim, L. van den Heuvel, and W. Matusik. Topology optimization and 3d printing of multimaterial magnetic actuators and displays. Science Advances, 5(7), 2019.

[70] F. Ulliana, J.-C. Léon, O. Palombi, M.-C. Rousset, and F. Faure. Combining 3D Models and Functions through Ontologies to Describe Man-made Products and Virtual Humans: Toward a Common Framework. Computer-Aided Design and Applications, 12(2):166–180, 2015.

[71] X. Zhang, G. Fang, M. Skouras, G. Gieseler, C. C. L. Wang, and E. Whiting. Computational design of fabric formwork. ACM Trans. Graph., 38(4):109:1–109:13, July 2019.

[72] B. Zhu, M. Skouras, D. Chen, and W. Matusik. Two-scale topology optimization with microstructures. ACM Trans. Graph., 36(4), July 2017.