RESEARCH CENTRE

Inria Centre at Université Grenoble Alpes

IN PARTNERSHIP WITH:

Université de Grenoble Alpes

2023

ACTIVITY REPORT

Project-Team

ANIMA

Authoring and directing animated story worlds

IN COLLABORATION WITH: Laboratoire Jean Kuntzmann (LJK)

DOMAIN

Perception, Cognition and Interaction

THEME

Interaction and visualization

Inria

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Project-Team ANIMA

Creation of the Project-Team: 2020 July 01

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Computer sciences and digital sciences

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1 Team members, visitors, external collaborators

Research Scientists

- Remi Ronfard [Team leader, INRIA, Senior Researcher, HDR]
- Melina Skouras [INRIA, Researcher]

Faculty Members

- Stefanie Hahmann [GRENOBLE INP, Professor, HDR]
- Olivier Palombi [UGA, Professor, HDR]

Post-Doctoral Fellow

- Thibault Tricard [INRIA, Post-Doctoral Fellow, until Aug 2023]

PhD Students

- Sandrine Barbois [Hospices Civils de Lyon]
- Siyuan He [ENPC]
- Emmanuel Rodriguez [INRIA]
- Anandhu Sureshkumar [Telecom-Paris, IPParis]

Interns and Apprentices

- Karlotta Kilias [INRIA, Intern, from May 2023 until Jul 2023]
- Mengran Wu [UGA, Intern, from May 2023 until Jul 2023]

Administrative Assistant

- Marion Ponsot [INRIA]

2 Overall objectives

ANIMA focuses 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.

2.1 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 is 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 reverse engineer existing screenplays and storyboards, which are well suited for generating animation in traditional formats. We 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.

2.2 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 is to propose methods for quickly authoring shapes and animations that can be used to tell stories visually. We devise new methods for generating shapes and shape families, understanding their functions, styles, material properties and affordances, authoring animations for a large repertoire of actions, and printing and fabricating articulated and deformable shapes suitable for creating physical story worlds with tangible interaction.

2.3 Directing story worlds

Lastly, we 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 create 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 explore new areas, including the automatic generation of storyboards from movie scripts for use by domain experts, rather than graphic artists.

3 Research program

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.

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 Space-time modeling

The first new direction of research in this theme is 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.

3.1.2 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.

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 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.

3.2.2 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.

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 [17] while their geometric and material properties are not yet defined. Another important aspect of this research direction 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 direction is 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 [31]. 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 Story world ontologies

We will extend our previous work on ontology modeling of anatomy [30, 33] 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.

3.3.2 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 [25, 15, 28, 29, 24, 19, 26]. 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.

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 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 [27].

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.

3.4.2 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 [16] and hand puppeteering [23].

3.4.3 Learning and transfering film styles

In recent years, we have proposed new methods for automatically composing cinematographic shots in live action video [22] or 3D animation [20] and to edit them together into aesthetically pleasing movies [21]. 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 [32] from photographic style to cinematographic style. The pioneering work of Cutting and colleagues [18] 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.

4 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.

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 Social and environmental responsibility

5.1 Footprint of research activities

ANIMA is a small team of four permanent researchers and three PhD students, so our footprint is limited. We estimate that we run approximately twelve computers, including laptops, desktops and shared servers, at any given time.

Research in computer graphics is not (yet) data intensive. We mostly devise procedural algorithms, which require limited amounts of data. One notable exception is our work on computational editing of live performances, which produces large amounts of ultra high definition video files. We have opted for a centralized video server architecture (KinoAI) so that at least the videos are never duplicated and always reside on a single server.

On the other hand, our research requires prowerful graphics processing units (GPU) which significantly increase the power consumption of our most powerful desktops.

The COVID19 crisis has changed our working habits heavily. We have learned to work from home most of the week, and to abandon international travel entirely. This holds the promise of a vastly reduced footprint. But it is too early to say whether this is sustainable. While the team as a whole has been able to function in adverse conditions, it has become increasingly difficult to welcome interns and Masters students.

5.2 Impact of research results

Our research does not directly address social and environmental issues. Our work on 3D printing may have positive effects by allowing the more efficient use of materials in the production of prototypes. Our work on virtual medical simulation and training may provide an alternative in some cases to animal experiments and costly robotic simulations.

Our most important application domain is arts and culture, including computer animation and computer games. Globally, those sectors are creating jobs, rather than destroying them, in France and in Europe. The impact of our discipline is therefore positive at least in this respect.

We are more concerned with the impact of the software industry as a whole, i.e. private companies who implement our research papers and include them in their products. We note a tendency to increase the memory requirements of software. While much effort in software engineering is devoted to improving the execution speed of graphics programs, there is not enough effort in optimizing their footprint. This is an area that may be worth investigating in our future work.

6 Highlights of the year

6.1 Sabbaticals

Stefanie Hahmann spent 10 months abroad within the framework of a CRCT granted by INP and a delegation granted by INRIA.

She visited during 5 months the University of Leipzig, where was was a guest of Professor Gerik Scheuermann. The main reserach project was on geometric design of auxetic metamatriels.

She spent the other 5 month at the FU Berlin as a guest of Professor Konrad Polthier. Research includes topics on approximation of freeform surface by developable ribbons. Within this period, she was invited to give talks at TU Freiberg, TU Dortmund and Univ. Leipzig,TU Berlin and FU Berlin.

7 New results

7.1 The Hitchcock Experience - a Spatial Montage project.

Participants: Rémi Ronfard.

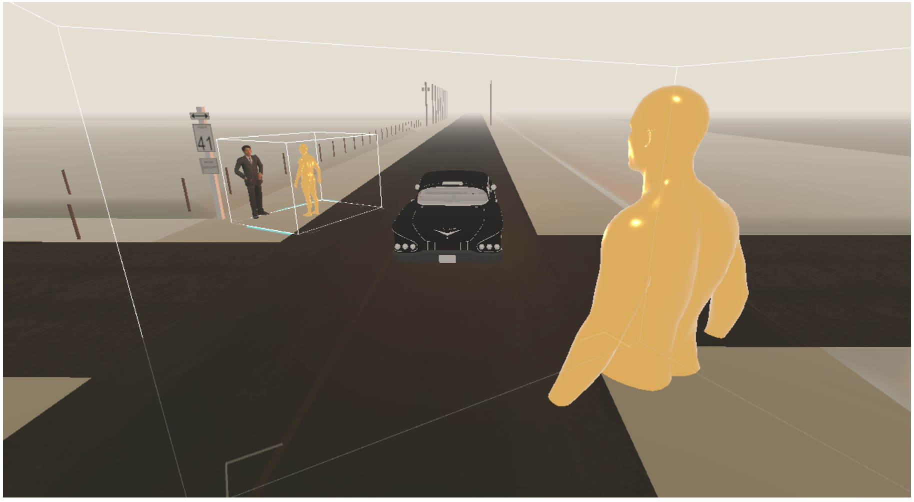

Figure 1: Two successive action frames in the 3D scene.

As a result of a successful collaboration between Phd Student Rémi Sagot-Duvauroux at EnsadLab and master student Nils Quaetaerts at Ecole Polytechnique, we published a new paper in the "spatila montage" series exploring the generalization of classical montage theory to the emerging technology of "room scale VR" [10]. We take the emblematic plane sequence in Alfred Hitchcock's "North by Northwest" and invite the spectator to experiment it "from the inside". This raises interesting research issues. How to inhabit this cinematic story world? How can the traditional tools of cinematography and montage be used to direct the audience in this new kind of experience? How can the rhythm of the spectator's body be matched to the rhythm of Hitchcock's fast pace editing? And what form can this montage take and for what aesthetic and dramaturgical effects? To answer these questions, we propose the experiment of a montage that adapts in real time to the displacements of the body and the gaze of the spectator, engaging a dialectic between narrative rhythm and bodily rhythm. We propose new algorithmic tools to transport the audience into the story as originally planned by Hitchcock while at the same time respecting the bodily rhythm of the audience to guide the experience. In doing so, we seek to create a new form of relationship between the author of a narrative experience in virtual reality and the spectator who explores and activates the experience with his own body.

7.2 Supporting Perception of Spatiality in Dance in Augmented Reality

Participant: Mélina Skouras.

This work, done in collaboration with the PhD student Manon Vialle, the researcher Sarah Fdili Alaoui (Ex-Situ Inria team) and the dancer Elisabeth Schwartz, presents how we co-designed with a connoisseur a system that visualizes a star-like ribbon joining at the solar plexus and animated it from

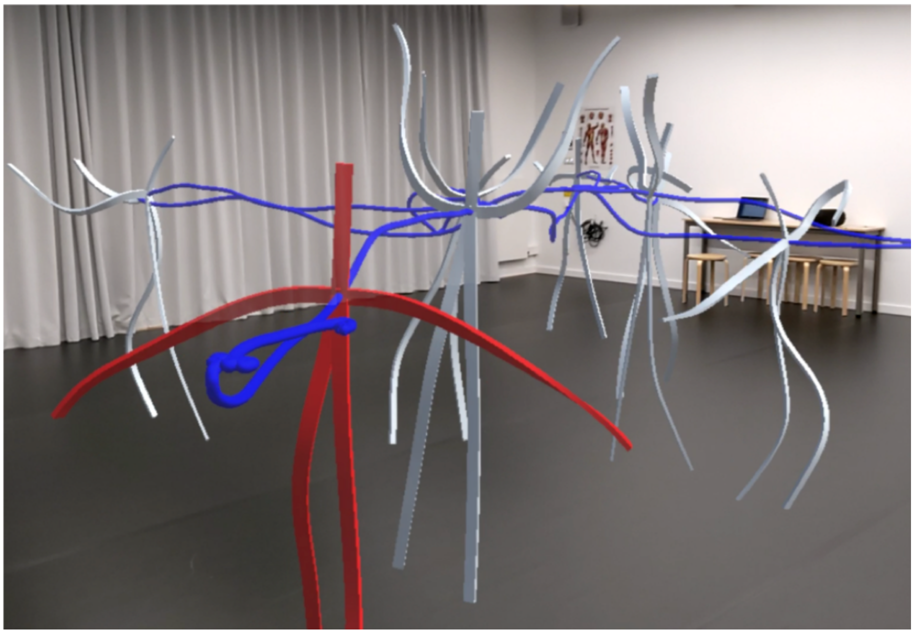

Figure 2: View of the prototype “all keyframes” in the Hololens 2 headset aiming at helping the user to understand and learn Duncan’s qualities and choreographic style.

motion capture data to perform Isadora Duncan’s dances. Additionally, the system visualizes the trace of the solar plexus and specific keyframes of the choreography as key poses placed in the 3D space. We display the visualization in a Hololens headset and provide features that allow to manipulate it in order to understand and learn Duncan’s qualities and choreographic style. Through a workshop with dancers, we ran a structured observation where we compared qualitatively how the dancers were able to perceive Duncan’s qualities and embody them using the system set according to two different conditions: displaying all the future keyframes or displaying a limited number of keyframes. We discuss the results of our workshop and the use of augmented reality in the studio for pedagogical purposes.

7.3 Complex Wrinkle Field Evolution

Participant: Mélina Skouras.

This work results of a collaboration with the PhD student Zhen Chen (UT Austin) and the researchers Etienne Vouga (UT Austin) and Danny Kaufman (Adobe research). It proposes a new approach for representing wrinkles, designed to cap- ture complex and detailed wrinkle behavior on coarse triangle meshes, called Complex Wrinkle Fields. Complex Wrinkle Fields consist of an almost- everywhere-unit complex-valued phase function over the surface; a fre- quency one-form; and an amplitude scalar, with a soft compatibility condition coupling the frequency and phase. We develop algorithms for interpolating between two such wrinkle fields, for visualizing them as displacements of a Loop-subdivided refinement of the base mesh, and for making smooth local edits to the wrinkle amplitude, frequency, and/or orientation. These algorithms make it possible, for the first time, to create and edit animations of wrinkles on triangle meshes that are smooth in space, evolve smoothly through time, include singularities along with their complex interactions, and that represent frequencies far finer than the surface resolution.

7.4 3D auxetic meso-structures for turbine blade

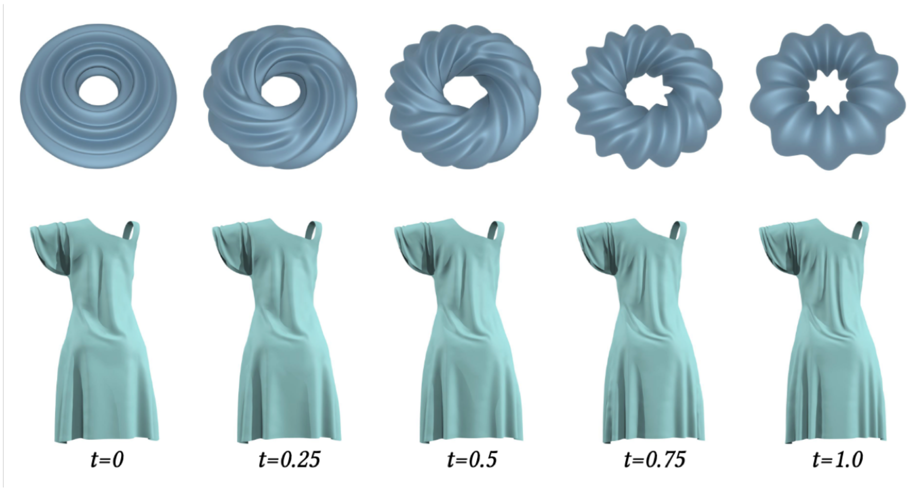

Figure 3: Two examples of complex wrinkle field interpolation between keyframes specified at t = 0 and 1.

Participant: Stefanie Hahmann.

In the framework of the FET Open European Project ADAM2 we are working on producing geometric meso-structures with specific mechanical properties, that can be used for the conception of lightweight object. As a central testcase for which all the ADAM2 partners expertise is required, the conception of a turbine blade was addressed. Together with the Technion group, we were responsible of designing the geometry of the meso-structures, while our partners in applied mathematics at TU Wien and EPFL were focusing on the analysis of the mechanical properties, our partners at BCAM and UPV were fabricating the prototypes with 5-axis CNC machining and metal laser power bed fusion, and UPV and Trimek were doing experimental measurements on the fabricated prototypes. We are currently writing a common publication with all partners, describing the work on the turbine blade conception.

8 Partnerships and cooperations

8.1 International research visitors

8.1.1 Visits to international teams

Research stays abroad Stefanie Hahmann spent five months, from September 2022 to January 2023, as a guest of Professor Gerik Scheuermann, visiting the Computer Science department at the University of Leipzig. From February to June 2023, Stefanie Hahmann served was visiting the Computational Geometry group within the Mathematics department at Freie Universität Berlin, hosted by Professor Konrad Polthier.

8.2 European initiatives

8.2.1 H2020 projects

ADAM2 (Analysis, Design, And Manufacturing using Microstructures) is an ongoing project funded by the H2020 Horizon programme of the European Union (Start date: 1 January 2020 - End date: 31 December 2023). Offical web site: www.adam2.eu. Participating project teams : ANIMA and MAVERICK. The project has provided funding for the PhD thesis of Emmanuel Rodriguez (2020-2024) and the post-doc position of Thibault Tricart (2023).

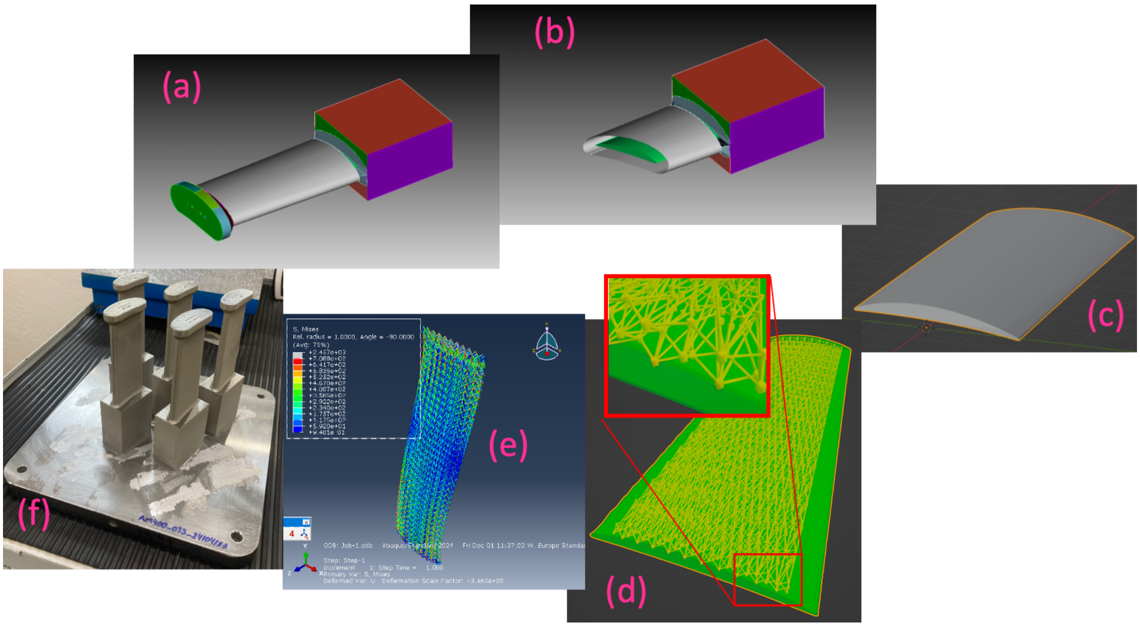

Figure 4: Blade CAO (a), cut-off to reveal central part (b), triangulation of central part (c), auxetic fill-in (d), numerical analysis (e), fabrication (f)

8.3 National initiatives

8.3.1 ANR SIDES-LAB

Participants: Olivier Palombi.

SIDES is a learning digital platform common to all French medical schools, used for official exams (tests) in faculties and for the training of students for the National Ranking Exam (ECN) which is fully computerized since 2016 (ECNi).

As part of this platform, Olivier Palombi is taking part in the SIDES LAB project (start date February 2022, end date January 2026) under the leadership of Franck Ramus, Laboratoire de Sciences Cognitives et Psycholinguistique, ENS, Paris.

Official web sites: anr.fr/Projet-ANR-21-CE28-0030and www.uness.fr/projets/recherche/sides-lab.

9 Dissemination

Participants: Stefanie Hahmann, Rémi Ronfard, Mélina Skouras, Olivier Palombi.

9.1 Promoting scientific activities

9.1.1 Scientific events: organisation

Member of the organizing committees Rémi Ronfard was a member of the organizing committee for the International Symposium on Eletronic Art (ISEA) 2023.

9.1.2 Scientific events: selection

Chair of conference program committees Mélina Skouras was a chair for Eurographics short papers 2023.

Member of the conference program committees Stefanie Hahmann was a program committee member for the Symposiumon Solid and PhysicalModeling (SPM'23).

Mélina Skouras was a program committee member for ACM Siggraph Full Papers, for the Symposium on Computer Animation (SCA) 2023 and for Eurographics State-of-the-art reports.

9.1.3 Journal

Member of the editorial boards Stefanie Hahmann is an associate editor of the Elsevier journals Computer Aided Design (CAD) and Computers & Graphics (CAG) since 2015.

Reviewer - reviewing activities Mélina Skouras was a reviewer for ACM Transactions on Graphics, Pacific Graphics and Computer-Aided Design.

9.1.4 Invited talks

Stefanie Hahmann gave invited talks at University of Leibzig, TU Freiberg, TU Dortmund, TU Berlin and FU Berlin.

Mélina Skouras gave an invited talk at the Research in Robotics National Days (Journées Nationales de la Recherche en Robotique).

9.1.5 Leadership within the scientific community

Rémi Ronfard presented a review of his 2022 metaverse report during the general assembly of the computer graphics and virtual reality community (journées plénières du GDR Informatique graphique et réalité virtuelle) on May 30, 2023.

Stefanie Hahmann is a Work-package Leader and Principal Investigator for INRIA in the European FET OPEN Horizon 2020 project ADAM2 (Analysis, Design and Manufacturing of Microstructures, contract no. 862025).

Stefanie Hahmann is a member of the SMI (ShapeModeling International Association) steering committee.

9.1.6 Scientific expertise

Rémi Ronfard was auditioned by the Comité consultatif national d'éthique dans le numérique (CNPEN), on February 7, 2023.

Rémi Ronfard was auditioned by the Conseil supérieur de la propriété littéraire et artistique (CSPLA), on March 9, 2023.

9.1.7 Research administration

Stefanie Hahmann is an elected member of the European Association for Computer Graphics – chapitre français (EGFR) and serves as secretary in the steering committee. Stefanie Hahmann is an elected member of the council of Association Française d'Informatique Graphique (AFIG). Stefanie Hahmann is an elected member of the Conseil Scientifique of Grenoble INP.

9.2 Teaching - Supervision - Juries

9.2.1 Teaching

- Master: Mélina Skouras, Computer Graphics II, 36 HETD, M2, Ensimag-Grenoble INP (MoSIG).

- From September 2022 to August 2023, Stefanie Hahmann is beneficiary of a CRCT from Grenoble INP. From September 2023 to August 2024, she is in delegation Inria with a reduced teaching load of 64h. She taught 2 classes at Ensimag-Grenoble INP: Geometric Modeling (35 students, level M1 23h) and Surface Modeling (25 students, level M2, 37h). She was president of the jury for more than 10 Masters (PFE) thesis defences.
- Rémi Ronfard is an associate researcher with the SPATIAL MEDIA research group at ENSADLAB, where he teaches and supervises PhD students in art and design.

9.2.2 Supervision

PhD in progress: Rémi Sagot-Duvauroux, The body-montage: the practice of montage as a narrative, discursive and poetic vector for the creation and reception of virtual reality artworks. Since September 2020, supervised by Rémi Ronfard et de Guillaume Soulez (Univ. Sorbonne Nouvelle), SACRE Doctoral School, Univ. Paris PSL.

PhD in progress: Sandrine Barbois, Formalization of surgical procedures for the simulation of non-technical skills in surgery. Since Aprill 2020, supervised by Olivier Palombi and Rémi Ronfard, Univ. Grenoble Alpes.

PhD in progress: Emmanuel Rodriguez, Direct and inverse modeling of laser-cut meta-materials, since October 2020, supervised by Georges-Pierre Bonneau, Mélina Skouras and Stefanie Hahmann.

PhD in progress: Siyuan He, Inflatable metamaterials, since October 2022, supervised by Mélina Skouras and Arthur Lebée (Ecole des Ponts)'.

PhD in progress: Alexandre Teixeira da silva, Modeling of tight knots, since February 2021, supervised by Florence Bertails-Descoubes, Thibaut Métivet and Mélina Skouras.

PhD defense of Manon Vialle, Design and Evaluation of 3D Systems for Movement Transmission in Dance, supervised by Mélina Skouras, Sarah Fdili Alaoui (Inria Saclay) and Emmanuelle Crépeau (Laboratoire Jean Kuntzmann).

9.2.3 Juries

Stefanie Hahmann the President of the jury for the HDR of Samuel Peltier, XLIM, Univ. Poitiers 2023.

Stefanie Hahmann was an external reviewer for the PhD thesis of Nicolas Leduc, Ecole des Ponts, Paris, 2023.

Stefanie Hahmann was a member of the jury for the PhD thesis of Axel Paris, Université Claude Bernard, Lyon, 2023.

Mélina Skouras was a member of the jury for the PhD thesis of Pierre Gilibert, Ecole des Ponts, Marne-la-Vallée, 2023, and for the PhD thesis of Guillaume Coiffier, Université de Lorraine, 2023.

Mélina Skouras was a member of the recruitment jury for the CRCN/ISFP positions at the Inria Centre at the University Grenoble Alpes.

Mélina Skouras was a member of the recruitment jury for a junior professor (Maitre de Conférence) at Ensimag, INPG.

9.3 Popularization

9.3.1 Internal or external Inria responsibilities

Rémi Ronfard co-organized (with Florent Masseglia and Franck Multon), a two-day prospective meeting with 30 Inria researchers on the topic of the metaverse and immersive reality.

9.3.2 Interventions

Rémi Ronfard was invited to present a summary of the 2022 metaverse report during the technoconference « Métavers, au-delà du buzz, quelles réalités? » organized by Images & Réseaux in Rennes on March 2nd, 2023. This hybrid conference was attended by 150 participants.

Rémi Ronfard was an invited keynote speaker at the workshop on "live performances and digital stages" (spectacle vivant scène numérique) as part of the Avignon theater festival on July 12, 2023.

Rémi Ronfard was invited by France Université in a panel discussion of the metaverse and its relation to the creative and cultural industries in Brussels on September 21, 2023.

Rémi Ronfard co-organized a meeting at the French Ministry of Economy with deputy minister Jean-Noel Barrot and Inria CEO Bruno Sportisse, to mark the anniversary of his 2022 metaverse report and review outstanding challenges and new perspectives in immersive virtual worlds. The meeting took place on November 7, 2023 and was attended by 120 invited personalities.

10 Scientific production

10.1 Major publications

[1] Z. Chen, H.-Y. Chen, D. M. Kaufman, M. Skouras and E. Vouga. 'Fine Wrinkling on Coarsely Meshed Thin Shells'. In: *ACM Transactions on Graphics* 40.5 (21st Aug. 2021), pp. 1–32. DOI: 10.1145/3462758. URL: https://hal.inria.fr/hal-03519074.

[2] A. Fondevilla, D. Rohmer, S. Hahmann, A. Bousseau and M.-P. Cani. 'Fashion Transfer: Dressing 3D Characters from Stylized Fashion Sketches'. In: *Computer Graphics Forum* 40.6 (2021), pp. 466–483. DOI: 10.1111/cgf.14390. URL: https://ut3-toulouseinp.hal.science/hal-03280215.

[3] M. Garcia and R. Ronfard. 'Recognition of Laban Effort Qualities from Hand Motion'. In: MOCO'20 - 7th International Conference on Movement and Computing. Article No.: 8. Jersey City/ Virtual, United States, 15th July 2020, pp. 1–8. DOI: 10.1145/3401956.3404227. URL: https://hal.inria.fr/hal-02899999.

[4] Y. Le Vaou, J.-C. Léon, S. Hahmann, S. Masfrand and M. Mika. 'As-Stiff-As-Needed Surface Deformation Combining ARAP Energy with an Anisotropic Material'. In: *Computer-Aided Design* 121 (Apr. 2020), pp. 1–15. DOI: 10.1016/j.cad.2019.102803. URL: https://hal.inria.fr/hal-02428505.

[5] R. Ronfard. 'Film Directing for Computer Games and Animation'. In: *Computer Graphics Forum* 40.2 (May 2021), pp. 713–730. DOI: 10.1111/cgf.142663. URL: https://hal.inria.fr/hal-03225328.

10.2 Publications of the year

International journals

[6] Z. Chen, D. M. Kaufman, M. Skouras and E. Vouga. 'Complex Wrinkle Field Evolution'. In: *ACM Transactions on Graphics* 42.4 (Aug. 2023), 72:1–19. DOI: 10.1145/3592397. URL: https://inria.hal.science/hal-04130767.

[7] V. A. Murukutla, E. Cattan, B. Lecouteux, R. Ronfard and O. Palombi. 'Text-to-movie authoring of anatomy lessons'. In: *Artificial Intelligence in Medicine* 146 (Dec. 2023), p. 102717. DOI: 10.1016/j.artmed.2023.102717. URL: https://hal.science/hal-04301065.

International peer-reviewed conferences

[8] E. N. Kandemir, J.-J. Vie, F. Ramus, O. Palombi and A. H. Sanchez Ayte. 'Adaptation of the Multi-Concept Multivariate Elo Rating System to Medical Students' Training Data'. In: *Proceedings of the 14th Learning Analytics and Knowledge Conference.* LAK 24 - The 14th Learning Analytics and Knowledge Conference. Kyoto, Japan, 18th Mar. 2024. DOI: 10.1145/3636555.3636858. URL: https://hal.science/hal-04371748.

[9] O. Kobryn, M. Couteau, R. Sagot-Duvauroux, S. Balcon-Fourmaux, F. Garnier, G. Soulez and R. Ronfard. 'Feeling One's Way: In Search of a Symbiotic Vocabulary of the Virtual'. In: ISEA 2023 - Internation Symposium on Electronic Art. Paris, France, 2023, pp. 1–9. URL: https://inria.hal.science/hal-04410667.

[10] R. Sagot-Duvauroux, N. Quaetaert, F. Garnier and R. Ronfard. 'The Hitchcock Experience - a Spatial Montage project'. In: International Symposium on Electronic Art (ISEA). Paris, France, 16th May 2023, pp. 1–7. URL: https://hal.science/hal-04133336.

[11] A. Teixeira da Silva, T. Métivet, V. Romero, M. Skouras and F. Bertails-Descoubes. 'Untangling the physics of self-locking in tight knots'. In: HFSS 2023 - International Conference on Highly Flexible Slender Structures. Rijeka, Croatia, 2023, pp. 1–2. URL: https://inria.hal.science/hal-04388669.

[12] M. Vialle, S. Fdili Alaoui, M. Skouras and E. Schwartz. 'Supporting Perception of Spatiality in Dance in Augmented Reality'. In: C&C 2023 - 15th ACM Conference on Creativity and Cognition. Virtual, United States: ACM, 19th June 2023, pp. 441–453. DOI: 10.1145/3591196.3593513. URL: https://inria.hal.science/hal-04135850.

Conferences without proceedings

[13] F. Garnier, E. Mahé and R. Ronfard. 'Electronic arts in the age of the metaverse: what kind of a positive symbiotic organization?' In: ISEA 2024 - 28th International Symposium on Electronic Art. Paris, France, 2023. URL: https://inria.hal.science/hal-04412582.

10.3 Other

Scientific popularization

[14] R. Ronfard. 'Theater in the age of the metaverse'. In: SVSN 2023 - Spectacle vivant, scènes numériques. Avignon (FR), France, 12th July 2023. URL: https://inria.hal.science/hal-04376157.

10.4 Cited publications

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[16] A. Barbulescu, R. Ronfard and G. Bailly. 'A Generative Audio-Visual Prosodic Model for Virtual Actors'. In: *IEEE Computer Graphics and Applications* 37.6 (Nov. 2017), pp. 40–51. DOI: 10.1109/MCG.2017.4031070. URL: https://hal.inria.fr/hal-01643334.

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[18] J. E. Cutting, J. E. DeLong and C. E. Nothelfer. 'Attention and the Evolution of Hollywood Film'. In: *Psychological Science* 21.3 (2010), pp. 432–439.

[19] 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.

[20] 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*. Paris, France: ACM, Nov. 2015, pp. 151–157. DOI: 10.1145/2822013.2822025. URL: https://hal.inria.fr/hal-01220119.

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[22] 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: ACM, Nov. 2014.

[23] 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. DOI: 10.1145/3359566.3360061. URL: https://hal.archives-ouvertes.fr/hal-02303803.

[24] 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.

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[26] 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.

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