IN PARTNERSHIP WITH:
Institut polytechnique de Grenoble

Activity Report 2017

Project-Team MORPHEO

Capture and Analysis of Shapes in Motion

IN COLLABORATION WITH: Laboratoire Jean Kuntzmann (LJK)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Vision, perception and multimedia interpretation

Table of contents

Project-Team MORPHEO

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

Keywords:

Computer Science and Digital Science:

A5.1.8. - 3D User Interfaces
A5.4. - Computer vision
A5.4.4. - 3D and spatio-temporal reconstruction
A5.4.5. - Object tracking and motion analysis
A5.5.1. - Geometrical modeling
A5.5.4. - Animation
A5.6. - Virtual reality, augmented reality
A6.2.8. - Computational geometry and meshes

Other Research Topics and Application Domains:

B2.6.3. - Biological Imaging
B2.8. - Sports, performance, motor skills
B9.2.2. - Cinema, Television
B9.2.3. - Video games
B9.3. - Sports

1. Personnel

Research Scientists

Edmond Boyer [Team leader, Inria, Senior Researcher, HDR]
Julien Pansiot [Inria, Starting Research Position]
Stefanie Wuhrer [Inria, Researcher]

Faculty Members

Jean-Sébastien Franco [Institut polytechnique de Grenoble, Associate Professor]
Franck Hétroy-Wheeler [Institut polytechnique de Grenoble, Associate Professor, until Aug 2017, HDR]

PhD Students

Adnane Boukhayma [Univ Grenoble Alpes, until Oct 2017]
Victoria Fernandez Abrevaya [Univ Grenoble Alpes]
Claude Goubet [Inria, from Oct 2017]
Roman Klakov [Inria, from Oct 2017]
Vincent Leroy [Inria]
Abdullah Haroon Rasheed [Inria, from Nov 2017]
Romain Rombourg [Institut polytechnique de Grenoble]
Nitika Verma [Univ Grenoble Alpes, from Sep 2017]
Jinlong Yang [Inria]

Interns

Ganapathy Ram Krishnakumar [Univ Grenoble Alpes, from Feb 2017 until Jul 2017]
Gwendal Le Quellenec [Univ Grenoble Alpes, from May 2017 until Jul 2017]
Abdullah Haroon Rasheed [Inria, from Feb 2017 until Aug 2017]
Nitika Verma [Inria, from Feb 2017 until Aug 2017]

Administrative Assistant

Nathalie Gillot [Inria]

Visiting Scientist

Li Wang [until Feb 2017]

External Collaborators

Benjamin Allain [until Apr 2017]

Vagia Tsiminaki [until Jun 2017]

2. Overall Objectives

2.1. Overall Objectives

Figure 1. Dynamic Geometry Modeling

Morpheo's main objective is the ability to perceive and to interpret moving shapes using systems of multiple cameras for the analysis of animal motion, animation synthesis and immersive and interactive environments. Multiple camera systems allow dense information on both shapes and their motion to be recovered from visual cues. Such ability to perceive shapes in motion brings a rich domain for research investigations on how to model, understand and animate real dynamic shapes. In order to reach this objective, several scientific and technological challenges must be faced:

A first challenge is to be able to recover shape information from videos. Multiple camera setups allow to acquire shapes as well as their appearances with a reasonable level of precision. However most effective current approaches estimate static 3D shapes and the recovery of temporal information, such as motion, remains a challenging task. Another challenge in the acquisition process is the ability to handle heterogeneous sensors with different modalities as available nowadays: color cameras, time of flight cameras, stereo cameras and structured light scanners, etc.

A second challenge is the analysis of shapes. Few tools have been proposed for that purpose and recovering the intrinsic nature of shapes is an actual and active research domain. Of particular interest is the study of animal shapes and of their associated articulated structures. An important task is to automatically infer such properties from temporal sequences of 3D models as obtained with the previously mentioned acquisition systems. Another task is to build models for classes of shapes, such as animal species, that allow for both shape and pose variations.

A third challenge concerns the analysis of the motion of shapes that move and evolve, typically humans. This has been an area of interest for decades and the challenging innovation is to consider for this purpose dense motion fields, obtained from temporally consistent 3D models, instead of traditional sparse point trajectories obtained by tracking particular features on shapes, e.g. motion capture systems. The interest is to provide full information on both motions and shapes and the ability to correlate these information.The main tasks that arise in this context are first to find relevant indices to describe the dynamic evolutions of shapes and second to build compact representations for classes of movements.

A fourth challenge tackled by Morpheo is immersive and interactive systems. Such systems rely on real time modeling, either for shapes, motion or actions. Most methods of shape and motion retrieval turn out to be fairly complex, and quickly topple hardware processing or bandwidth limitations, even with a limited number of cameras. Achieving interactivity thus calls for scalable methods and research of specific distribution and parallelization strategies.

3. Research Program

3.1. Shape Acquisition

Multiple camera setups allow to acquire shapes, i.e. geometry, as well as their appearances, i.e. photometry, with a reasonable level of precision. However fundamental limitations still exist, in particular today's state-of-the-art approaches do not fully exploit the redundancy of information over temporal sequences of visual observations. Despite an increasing interest of the computer vision communities in the past years, the problem is still far from solved other than in specific situations with restrictive assumptions and configurations. Our goal in this research axis is to fully leverage temporal aspects of the acquisition process and to open the acquisition process to different modalities, in particular Xrays.

3.2. Generative / discriminative inference

Acquisition of 4D Models can often be conveniently formulated as an estimation or learning problem. Various generative models can be proposed for the problems of shape and appearance modeling over time sequences, and motion segmentation. The idea of these generative models is to predict the noisy measurements (e.g. pixel values, measured 3D points or speed quantities) from a set of parameters describing the unobserved scene state (e.g. shape and appearance), which in turn can be inverted with various inference algorithms. The advantages of this type of modeling are numerous to deal with noisy measurements, explicitly model dependencies between model parameters, hidden variables and observed quantities, and relevant priors over parameters; sensor models for different modalities can also easily be seamlessly integrated and jointly used, which remains central to our goals. A limitation of such algorithms is that classical algorithms to solve them rely on local iterative convergence schemes subject to local minima, or global restart schemes which avert this problem but with a significant computational penalty. This is why we also consider discriminative and deep learning approaches, which allow to formulate the parameter estimation as a direct regression from input quantities or pixel values, whose parameters are learned given a training set. This has the advantage of directly computing a solution from inputs, with robustness and speed benefits, as a standalone estimation algorithm or to initialize local convergence schemes based on generative modeling. A number of the approaches we propose thus leverage the advantages of both generative and such discriminative approaches.

3.3. Shape Analysis

Shape analysis has received much attention from the scientific community and recovering the intrinsic nature of shapes is currently an active research domain. Of particular interest is the study of human and animal shapes and their associated articulated underlying structures, i.e. skeletons, since applications are numerous, either in the entertainment industry or for medical applications, among others. Our main goals in this research axis are : the understanding of a shape's global structure, and a pose-independent classification of shapes.

3.4. Shape Tracking

Recovering the temporal evolution of a deformable surface is a fundamental task in computer vision, with a large variety of applications ranging from the motion capture of articulated shapes, such as human bodies, to the deformation of complex surfaces such as clothes. Methods that solve for this problem usually infer surface evolutions from motion or geometric cues. This information can be provided by motion capture systems or one of the numerous available static 3D acquisition modalities. In this inference, methods are faced with the challenging estimation of the time-consistent deformation of a surface from cues that can be sparse and noisy. Such an estimation is an ill posed problem that requires prior knowledge on the deformation to be introduced in order to limit the range of possible solutions. Our goal is to devise robust and accurate solutions based on new deformation models that fully exploit the geometric and photometric information available.

3.5. Dynamic Motion Modeling

Multiple views systems can significantly change the paradigm of motion capture. Traditional motion capture systems provide 3D trajectories of a sparse set of markers fixed on the subject. These trajectories can be transformed into motion parameters on articulated limbs with the help of prior models of the skeletal structure. However, such skeletal models are mainly robotical abstractions that do not describe the true morphology and anatomical motions of humans and animals. On the other hand, 4D models (temporally consistent mesh sequences) provide dense motion information on body's shape while requiring less prior assumption. They represent therefore a new rich source of information on human and animal shape movements. The analysis of such data has already received some attention but most existing works model motion through static poses and do not consider yet dynamic information. Such information (e.g. trajectories and speed) is anyway required to analyse walking or running sequences. We will investigate this research direction with the aim to propose and study new dynamic models.

3.6. Shape Animation

3D animation is a crucial part of digital media production with numerous applications, in particular in the game and motion picture industry. Recent evolutions in computer animation consider real videos for both the creation and the animation of characters. The advantage of this strategy is twofold: it reduces the creation cost and increases realism by considering only real data. Furthermore, it allows to create new motions, for real characters, by recombining recorded elementary movements. In addition to enable new media contents to be produced, it also allows to automatically extend moving shape datasets with fully controllable new motions. This ability appears to be of great importance with the recent advent of deep learning techniques and the associated need for large learning datasets. In this research direction, we will investigate how to create new dynamic scenes using recorded events.

4. Application Domains

4.1. 4D modeling

Modeling shapes that evolve over time, analyzing and interpreting their motion has been a subject of increasing interest of many research communities including the computer vision, the computer graphics and the medical imaging communities. Recent evolutions in acquisition technologies including 3D depth cameras (Time-of-Flight and Kinect), multi-camera systems, marker based motion capture systems, ultrasound and CT scans have made those communities consider capturing the real scene and their dynamics, create 4D spatio-temporal models, analyze and interpret them. A number of applications including dense motion capture, dynamic shape modeling and animation, temporally consistent 3D reconstruction, motion analyzes and interpretation have therefore emerged.

4.2. Shape Analysis

Most existing shape analysis tools are local, in the sense that they give local insight about an object's geometry or purpose. The use of both geometry and motion cues makes it possible to recover more global information, in order to get extensive knowledge about a shape. For instance, motion can help to decompose a 3D model of a character into semantically significant parts, such as legs, arms, torso and head. Possible applications of such high-level shape understanding include accurate feature computation, comparison between models to detect defects or medical pathologies, and the design of new biometric models.

4.3. Human Motion Analysis

The recovery of dense motion information enables the combined analyses of shapes and their motions. Typical examples include the estimation of mean shapes given a set of 3D models or the identification of abnormal deformations of a shape given its typical evolutions. The interest arises in several application domains where temporal surface deformations need to be captured and analysed. It includes human body analyses for which potential applications are anyway numerous and important, from the identification of pathologies to the design of new prostheses.

4.4. Interaction

The ability to build models of humans in real time allows to develop interactive applications where users interact with virtual worlds. For instance, Kinect proposed by Microsoft illustrates this principle with game applications using human inputs perceived with a depth camera. Other examples include gesture interfaces using visual inputs. A challenging issue in this domain is the ability to capture complex scenes in natural environments. Multi-modal visual perception, e.g. depth and color cameras, is one objective in that respect.

5. Highlights of the Year

5.1. Highlights of the Year

Figure 2. The president Macron's visit of the Kinovis platform in May 2017

6. New Software and Platforms

6.1. 4D repository

KEYWORDS: 4D - Dynamic scene
FUNCTIONAL DESCRIPTION: This website hosts dynamic mesh sequences reconstructed from images captured using a multi-camera set up. Such mesh-sequences offer a new promising vision of virtual reality, by capturing real actors and their interactions. The texture information is trivially mapped to the reconstructed geometry, by back-projecting from the images. These sequences can be seen from arbitrary viewing angles as the user navigates in 4D (3D geometry + time) . Different sequences of human / non-human interaction can be browsed and downloaded from the data section.

- Contact: Edmond Boyer
- URL: http://4drepository.inrialpes.fr/

6.2. Lucy Viewer

KEYWORDS: Data visualization - 4D - Multi-Cameras
SCIENTIFIC DESCRIPTION: Lucy Viewer is an interactive viewing software for 4D models, i.e, dynamic three-dimensional scenes that evolve over time. Each 4D model is a sequence of meshes with associated texture information, in terms of images captured from multiple cameras at each frame. Such data is available from the 4D repository website hosted by Inria Grenoble.

With Lucy Viewer, the user can use the mouse to zoom in onto the 4D models, zoom out, rotate, translate and view from an arbitrary angle as the 4D sequence is being played. The texture information is read from the images at each frame in the sequence and applied onto the meshes. This helps the user visualize the 3D scene in a realistic manner. The user can also freeze the motion at a particular frame and inspect a mesh in detail. Lucy Viewer lets the user to also select a subset of cameras from which to apply texture information onto the meshes. The supported formats are meshes in .OFF format and associated images in .PNG or .JPG format.
FUNCTIONAL DESCRIPTION: Lucy Viewer is an interactive viewing software for 4D models, i.e, dynamic three-dimensional scenes that evolve over time. Each 4D model is a sequence of meshes with associated texture information, in terms of images captured from multiple cameras at each frame.

- Participants: Edmond Boyer, Jean-Sébastien Franco and Matthieu Armando
- Contact: Edmond Boyer
- URL: https://kinovis.inria.fr/lucyviewer/

6.3. Shape Tracking

FUNCTIONAL DESCRIPTION: We are developing a software suite to track shapes over temporal sequences. The motivation is to provide temporally coherent 4D Models, i.e. 3D models and their evolutions over time , as required by motion related applications such as motion analysis. This software takes as input a temporal sequence of 3D models in addition to a template and estimate the template deformations over the sequence that fit the observed 3D models.

- Contact: Edmond Boyer

6.4. QuickCSG V2

KEYWORDS: 3D modeling - CAD - 3D reconstruction - Geometric algorithms
SCIENTIFIC DESCRIPTION: See the technical report "QuickCSG: Arbitrary and Faster Boolean Combinations of N Solids", Douze, Franco, Raffin.

The extension of the algorithm to self-intersecting meshes is described in "QuickCSG with self-intersections", a document inside the package.

FUNCTIONAL DESCRIPTION: QuickCSG is a library and command-line application that computes Boolean operations between polyhedra. The basic algorithm is described in the research report "QuickCSG: Arbitrary and Faster Boolean Combinations of N Solids", Douze, Franco, Raffin. The input and output polyhedra are defined as indexed meshes. In version 2, that was developed for Pixologic, the meshes can be self-intersecting, in which case the inside and outside are defined by the non-zero winding rule. The operation can be any arbitrary Boolean function, including one that is defined as a CSG tree. The focus of QuickCSG is speed. Robustness to degeneracies is obtained by carefully applied random perturbations.

- Authors: Matthys Douze, Jean-Sébastien Franco and Bruno Raffin
- Contact: Jean-Sébastien Franco
- URL: https://kinovis.inria.fr/quickcsg/

6.5. CVTGenerator

KEYWORDS: Mesh - Centroidal Voronoi tessellation - Implicit surface

FUNCTIONAL DESCRIPTION: CVTGenerator is a program to build Centroidal Voronoi Tessellations of any 3D meshes and implicit surfaces.

- Partner: INP Grenoble
- Contact: Li Wang
- URL: http://cvt.gforge.inria.fr/

6.6. Platforms

6.6.1. Platform Kinovis

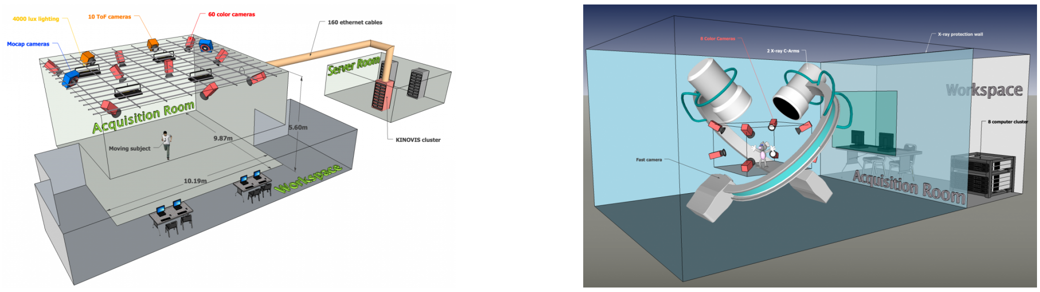

Figure 3. Kinovis platforms: on the left the Inria platform; on the right Grenoble Hospital platform.

Kinovis (http://kinovis.inrialpes.fr/) is a multi-camera acquisition project that was was selected within the call for proposals ”Equipements d’Excellence” of the program “Investissement d’Avenir˝ funded by the French government. The project involves 2 institutes: the Inria Grenoble Rhône-Alpes, the université Joseph Fourier and 4 laboratories: the LJK (laboratoire Jean Kuntzmann - applied mathematics), the LIG (laboratoire d’informatique de Grenoble - Computer Science), the Gipsa lab (Signal, Speech and Image processing) and the LADAF (Grenoble Hospitals - Anatomy). The Kinovis environment is composed of 2 complementary platforms (see Figure3). A first platform located at Inria Grenoble with a 10mx10m acquisition surface is equipped with 68 color cameras and 20 IR motion capture (mocap) cameras. It is the evolution of the Grimage platform towards the production of better models of more complex dynamic scenes. A second platform located at Grenoble Hospitals, within the LADAF anatomy laboratory, is equipped with 10 color and 2 X-ray cameras to enable combined analysis of internal and external shape structures, typically skeleton and bodies of animals. Both platforms have already demonstrated their potential through a range of projects lead by the team and externally. Members of Morpheo are highly involved in this project. Edmond Boyer is coordinating this project, and Julien Pansiot is managing the technical resources of both platforms.

7. New Results

7.1. Multi-View Dynamic Shape Refinement Using Local Temporal Integration

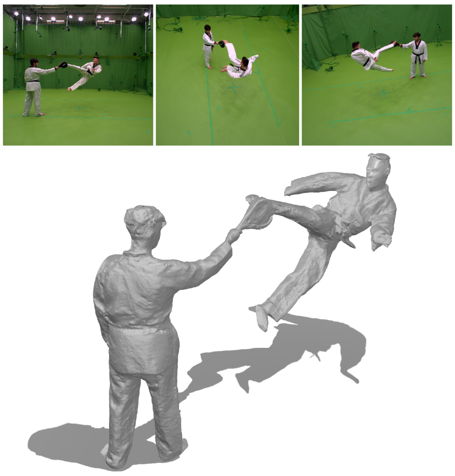

Figure 4. 3D Shape Model Refinement

We consider 4D shape reconstructions in multi-view environments and investigate how to exploit temporal redundancy for precision refinement (see Figure 4). In addition to being beneficial to many dynamic multi-view scenarios this also enables larger scenes where such increased precision can compensate for the reduced spatial resolution per image frame. With precision and scalability in mind, we propose a symmetric (non-causal) local time-window geometric integration scheme over temporal sequences, where shape reconstructions are refined framewise by warping local and reliable geometric regions of neighboring frames to them. This is in contrast to recent comparable approaches targeting a different context with more compact scenes and real-time applications. These usually use a single dense volumetric update space or geometric template, which they causally track and update globally frame by frame, with limitations in scalability for larger scenes and in topology and precision with a template based strategy. Our templateless and local approach is a first step towards temporal shape super-resolution. We show that it improves reconstruction accuracy by considering multiple frames. To this purpose, and in addition to real data examples, we introduce a multi-camera synthetic dataset that provides ground-truth data for mid-scale dynamic scenes.

This work was presented at the International Conference on Computer Vision [8].

7.2. Controllable Variation Synthesis for Surface Motion Capture

We address the problem of generating variations of captured 4D models automatically (see Figure 5), and we particularly focus on dynamic human shapes as observed from multi-view videos. Variation is an essential component of motion realism, however recent mesh animation datasets and tools lack such richness. Given a few 4D models representing movements of the same type, our method builds a probabilistic low dimensional embedding of shape poses using Gaussian Process Dynamical Models, and novel variants of motions are obtained by sampling trajectories from this manifold using Monte Carlo Markov Chain. We can synthesize an unlimited number of variations of any of the input movements, and also any blended version of them, without costly non-linear interpolation of input movement variations in mesh domain. The output variations are statistically similar to the input movements but yet slightly different in poses and timings. As we show

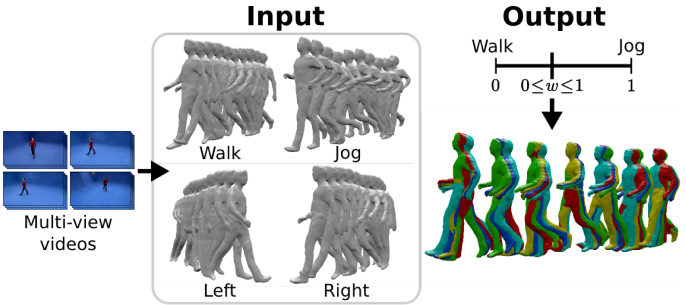

Figure 5. Animation Synthesis with Variability

through our results, the generated mesh sequences match the training examples in realism, which facilitates 4D model dataset augmentation.

This work was presented at the International Conference on 3D Vision [6].

7.3. CT from Motion: Volumetric Capture of Moving Shapes with X-rays and Videos

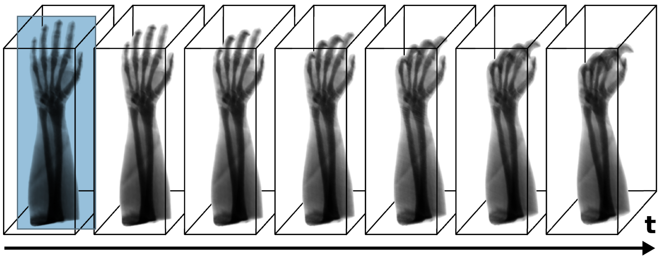

Figure 6. Volumetric Model of a Moving Arm

We consider the capture of dense volumetric X-ray attenuation models of non-rigidly moving samples (see Figure 6). Traditional 3D medical imaging apparatus, e.g. CT or MRI, do not easily adapt to shapes that deform significantly such as a moving hand. We propose an approach that simultaneously recovers dense volumetric shape and motion information by combining video and X-ray modalities. Multiple colour images are captured to track shape surfaces while a single X-ray device is used to infer inner attenuations. The approach does not assume prior models which makes it versatile and easy to generalise over different shapes. Results on synthetic and real-life data are presented that demonstrate the approach feasibility with a limited number of X-ray views. The resulting dense 4D attenuation data provides unprecedented insights for motion analysis.

This work was presented at the British Machine Vision Conference [9].

7.4. Surface Motion Capture Transfer with Gaussian Process Regression

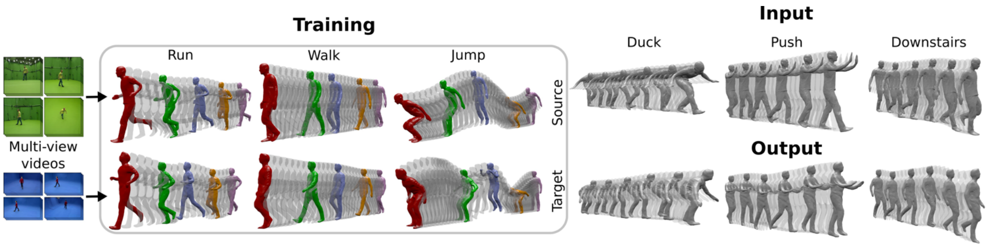

Figure 7. Motion Transfer between Captured 4D Models

We address the problem of transferring motion between captured 4D models (see Figure 7). We particularly focus on human subjects for which the ability to automatically augment 4D datasets, by propagating movements between subjects, is of interest in a great deal of recent vision applications that builds on human visual corpus. Given 4D training sets for two subjects for which a sparse set of corresponding key-poses are known, our method is able to transfer a newly captured motion from one subject to the other. With the aim to generalize transfers to input motions possibly very diverse with respect to the training sets, the method contributes with a new transfer model based on non-linear pose interpolation. Building on Gaussian process regression, this model intends to capture and preserve individual motion properties, and thereby realism, by accounting for pose inter-dependencies during motion transfers. Our experiments show visually qualitative, and quantitative, improvements over existing pose-mapping methods and confirm the generalization capabilities of our method compared to state of the art.

This work was presented at the Conference on Computer Vision and Pattern Recognition [7].

7.5. Dynamic Filters in Graph Convolutional Networks

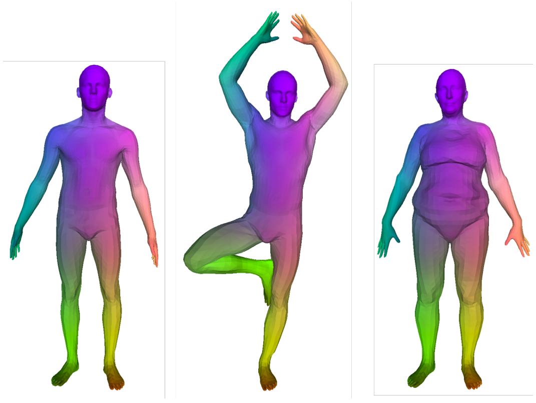

Figure 8. Shape Registration (left: reference shape, right: matched shapes) with Graph Convolutional Networks

Convolutional neural networks (CNNs) have massively impacted visual recognition in 2D images, and are now ubiquitous in state-of-the-art approaches. While CNNs naturally extend to other domains, such as audio and video, where data is also organized in rectangular grids, they do not easily generalize to other types of data such as 3D shape meshes, social network graphs or molecular graphs. To handle such data, we propose a novel graph-convolutional network architecture that builds on a generic formulation that relaxes the 1-to-1 correspondence between filter weights and data elements around the center of the convolution. The main novelty of our architecture is that the shape of the filter is a function of the features in the previous network layer, which is learned as an integral part of the neural network. Experimental evaluations on digit recognition, semi-supervised document classification, and 3D shape correspondence (see Figure 8) yield state-of-the-art results, significantly improving over previous work for shape correspondence.

This work was published as research report [11].

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Grants with Industry

The Morpheo Inria team and Microsoft research set up a collaboration on the capture and modelling of moving shapes using multiple videos. Two PhD proposals will be part of this collaboration with the objective to make contributions on 4D Modeling. The PhDs will take place at Inria Grenoble Rhône-Alpes and will involve regular visits and stays at Microsoft in Redmond (USA) and Cambridge (UK). At Microsoft, Steve Sullivan, Andrew Fitzgibbon, Jamie Shotton and Marta Wilczkowiak will be participating to the project.

8.2. Bilateral Contracts with Industry

A collaboration with the French Start up Holooh started in 2017. Holooh aims at producing high quality holograms for VR and AR applications, especially for the fashion and music domains. Holooh's objective is to set up a multi-camera studio in Paris for that purpose. Edmond Boyer is involved in the collaboration.

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Persyval-Lab exploratory project Carambole

The Carambole projects initiates a new collaboration between the Morpheo team and biophysicists from University Paris Diderot. The objectives are to develop hardware and software to help tracking feature points on a leaf of Averrhoa Carambola during its growth with a multi-camera system and to measure their 3D motion. Averrhoa carambola is of special interest because of the distinctive nutation balancing motion of a leaf during its growth.
This exploratory project was funded for 18 months in 2016 and 2017 by the Persyval-Lab LabEx.

9.1.2. ANR

9.1.2.1. ANR PRCE CaMoPi – Capture and Modelling of the Shod Foot in Motion

The main objective of the CaMoPi project is to capture and model dynamic aspects of the human foot with and without shoes. To this purpose, video and X-ray imagery will be combined to generate novel types of data from which major breakthroughs in foot motion modelling are expected. Given the complexity of the internal foot structure, little is known about the exact motion of its inner structure and the relationship with the shoe. Hence the current state-of-the art shoe conception process still relies largely on ad-hoc know-how. This project aims at better understanding the inner mechanisms of the shod foot in motion in order to rationalise and therefore speed up and improve shoe design in terms of comfort, performance, and cost. This requires the development of capture technologies that do not yet exist in order to provide full dense models of the foot in motion. To reach its goals, the CaMoPi consortium comprises complementary expertise from academic partners : Inria (combined video and X-ray capture and modeling) and Mines St Etienne (finite element modeling), as well as industrials : CTC Lyon (shoe conception and manufacturing) and Sporaltec (dissemination). The project has effectively started in October 2017 with Claude Goubet's recruitment as a PhD candidate.

9.1.2.2. ANR project Achmov – Accurate Human Modeling in Videos

The technological advancements made over the past decade now allow the acquisition of vast amounts of visual information through the use of image capturing devices like digital cameras or camcorders. A central subject of interest in video are the humans, their motions, actions or expressions, the way they collaborate and communicate. The goal of ACHMOV is to extract detailed representations of multiple interacting humans in real-world environments in an integrated fashion through a synergy between detection, figure-ground segmentation and body part labeling, accurate 3D geometric methods for kinematic and shape modeling, and large-scale statistical learning techniques. By integrating the complementary expertise of two teams (one French, MORPHEO and one Romanian, CLVP), with solid prior track records in the field, there are considerable opportunities to move towards processing complex real world scenes of multiple interacting people, and be able to extract rich semantic representations with high fidelity. This would enable interpretation, recognition and synthesis at unprecedented levels of accuracy and in considerably more realistic setups than currently considered. This project is currently ongoing with 2 PhDs on the Inria side: Vincent Leroy and Jinlong Yang.

9.1.3. Competitivity Clusters

9.1.3.1. FUI project Creamove

Creamove is a collaboration between the Morpheo team of the Inria Grenoble Rhône-Alpes, the 4D View Solution company specialized in multi-camera acquisition systems, the SIP company specialized in multi-media and interactive applications and a choreographer. The objective is to develop new interactive and artistic applications where humans can interact in 3D with virtual characters built from real videos. Dancer performances will be pre-recorded in 3D and used on-line to design new movement sequences based on inputs coming from human bodies captured in real time. Website: http://www.creamove.fr.

9.1.3.2. FUI24 SPINE PDCA – SPINE Plan-Do-Check-Act

The goal of the SPINE PDCA project is to develop a unique medical platform that will streamline the medical procedure and achieve all the steps of a minimally invasive surgery intervention with great precision through a complete integration of two complementary systems for pre-operative planning (EOS platform from EOS IMAGING) and imaging/intra-operative navigation (SGV3D system from SURGIVISIO). Innovative low-dose tracking and reconstruction algorithms will be developed by Inria, and collaboration with two hospitals (APHP Trousseau and CHU Grenoble) will ensure clinical feasibility. The medical need is particularly strong in the field of spinal deformity surgery which can, in case of incorrect positioning of the implants, result in serious musculoskeletal a high repeat rate (10 to 40% of implants are poorly positioned in spine surgery) and important care costs. In paediatric surgery (e.g. idiopathic scoliosis), the rate of exposure to X-rays is an additional major consideration in choosing the surgical approach to engage. For these interventions, advanced linkage between planning, navigation and postoperative verification is essential to ensure accurate patient assessment, appropriate surgical procedure and outcome consistent with clinical objectives.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Selection

10.1.1.1. Member of the Conference Program Committees

- Franck Hétroy-Wheeler was a PC member for the Eurographics 2017 conference (short papers track).
- Edmond Boyer was area chair for BMVC and 3DV 2017.

10.1.1.2. Reviewer

- Jean-Sébastien Franco reviewed for CVPR and ICCV 2017.

- Franck Hétroy-Wheeler reviewed for Eurographics 2017 (short papers), ACM Multimedia 2017 and 3DV 2017.
- Julien Pansiot reviewed for CVPR and MobiHealth 2017.
- Stefanie Wuhrer reviewed for CVPR and ICCV 2017.
- Edmond Boyer reviewed for CVPR, ICCV, SIGGRAPH 2017.

10.1.2. *Journal*

10.1.2.1. Member of the Editorial Boards

- Edmond Boyer is associate editor of the International Journal of Computer Vision (Springer).

10.1.2.2. Reviewer - Reviewing Activities

- Franck Hétroy-Wheeler reviewed for Frontiers in Plant Science and Journal of Mathematical Imaging and Vision.

10.1.3. *Invited Talks*

- Julien Pansiot talked at the INNOVACS Conférence "L'Innovation et la recherche pour le Sport, la Santé et le Bien-être"
- Edmond Boyer gave invited talks at: Inria Sophia Antipolis (February) , Journées scientifiques Inria (June) , ICCV Workshop on people capture (October), IPTA Montreal (December) 2017.

10.1.4. *Scientific Expertise*

- Edmond Boyer reviewed research proposals for EPSRC (UK) and KAUST (Saudi Arabia) in 2017.
- Edmond Boyer was a member of the recruiting commitee of Ecole Central Paris for a professor position in 2017.
- Edmond Boyer was a member of the Inria Grenoble Rhône-Alpes recruiting committee for postdocs and visiting researchers in 2017.

10.2. Teaching - Supervision - Juries

10.2.1. *Teaching*

Licence: Jean-Sébastien Franco, Introduction to Imperative Programming, 55h, Ensimag 1st year, Grenoble INP.

Licence: F. Hétroy-Wheeler, Algorithmics and data structures, 42h, Ensimag 1st year, Grenoble INP.

Master: Jean-Sébastien Franco, Introduction to Computer Vision, 27h, Ensimag 1st year, Grenoble INP.

Master: F. Hétroy-Wheeler, 3D graphics, 16h, Master of Science in Informatics, Université Grenoble Alpes.

Master: F. Hétroy-Wheeler, co-responsability of the Mathematical Modeling, Image and Simulation (MMIS) track of Ensimag, Grenoble INP.

Master: Edmond Boyer, 3D Modeling, 18h, M2R Mosig GVR, Grenoble INP.

Master: Edmond Boyer, Introduction to Visual Computing, 30h, M1 MoSig, Université Grenoble Alpes.

10.2.2. *Supervision*

PhD: Adnane Boukhayma, Surface Motion Capture Animation, Université de Grenoble, defended 06/12/2017, supervised by Edmond Boyer.

PhD in progress: Victoria Fernàndez Abrevaya, 3D Dynamic Human Motion Representations, Université de Grenoble Alpes, started 01/10/2016, supervised by Edmond Boyer and Stefanie Wuhrer.

PhD in progress: Claude Goubet, Modeling of 3D Foot, Université de Grenoble Alpes, started 01/10/2017, supervised by Edmond Boyer and Julien Pansiot.

PhD in progress: Roman Klakov, Deep Learning for 3D Shape Modeling Environment, Université de Grenoble Alpes, started 01/10/2017, supervised by Edmond Boyer and Jakob Verbeek.

PhD in progress: Vincent Leroy, 4D shape reconstruction from photoconsistency cues, Université de Grenoble Alpes, started 01/10/2015, supervised by Edmond Boyer and Jean-Sébastien Franco.

PhD in progress: Abdullah-Haroon Rasheed, Cloth Modeling and Simulation, Université de Grenoble Alpes, started 01/11/2017, supervised by Florence Bertails-Descoubes, Jean-Sébastien Franco and Stefanie Wuhrer.

PhD in progress: Romain Rombourg, Digital tree: from the acquisition to a high-level geometric model, Université Grenoble Alpes, started 01/10/2015, supervised by Franck Hétroy-Wheeler and Eric Casella.

PhD in progress: Nitika Verma, Deep Learning on Irregular Grids, Université de Grenoble Alpes, started 01/10/2017, supervised by Edmond Boyer and Jakob Verbeek.

PhD: Li Wang, Algorithms and criteria for volumetric Centroidal Voronoi Tessellations, Université Grenoble Alpes, defended 27/01/2017, supervised by Edmond Boyer and Franck Hétroy-Wheeler.

PhD in progress: Jinlong Yang, Learning shape spaces of dressed 3D human models in motion, Université de Grenoble Alpes, started 01/10/2015, supervised by Franck Hétroy-Wheeler and Stefanie Wuhrer.

10.2.3. Juries

- Jean-Sébastien Franco was a member of the defense commitee of Adnane Boukhayma (Univ. Grenoble Alpes).
- Franck Hétroy-Wheeler is a member of the PhD monitoring committee of Van Tho Nguyen (University of Lorraine, INRA Nancy and Office National des Forêts).
- Edmond Boyer was a member of the defense commitee of Rodrigo Ortiz Cayon.

11. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] A. Boukhayma. *Surface Motion Capture Animation*, UGA - Université Grenoble Alpes, December 2017, https://hal.inria.fr/tel-01665203

[2] L. Wang. *Algorithms and Criteria for Volumetric Centroidal Voronoi Tessellations*, UGA - Université Grenoble Alpes, January 2017, https://hal.inria.fr/tel-01455701

Articles in International Peer-Reviewed Journals

[3] C. H. Huang, B. Allain, E. Boyer, J.-S. Franco, F. Tombari, N. Navab, S. Ilic. *Tracking-by-Detection of 3D Human Shapes: from Surfaces to Volumes*, in "IEEE Transactions on Pattern Analysis and Machine Intelligence", August 2017 [*DOI :* 10.1109/TPAMI.2017.2740308], https://hal.inria.fr/hal-01588272

[4] L. Pishchulin, S. Wuhrer, T. Helten, C. Theobalt, B. Schiele. *Building Statistical Shape Spaces for 3D Human Modeling*, in "Pattern Recognition", July 2017, vol. 67, pp. 276–286, https://arxiv.org/abs/1503.05860 [*DOI :* 10.1016/j.patcog.2017.02.018], https://hal.inria.fr/hal-01136221

[5] F. VASCONCELOS, J. P. BARRETO, E. BOYER. *Automatic camera calibration using multiple sets of pairwise correspondences*, in "IEEE Transactions on Pattern Analysis and Machine Intelligence", 2017, pp. 1 - 14 [*DOI :* 10.1109/TPAMI.2017.2699648], https://hal.inria.fr/hal-01675686

International Conferences with Proceedings

[6] A. BOUKHAYMA, E. BOYER. *Controllable Variation Synthesis for Surface Motion Capture*, in "3DV 2017 - International Conference on 3D Vision", Qingdao, China, October 2017, https://hal.inria.fr/hal-01590648

[7] A. BOUKHAYMA, J.-S. FRANCO, E. BOYER. *Surface Motion Capture Transfer with Gaussian Process Regression*, in "CVPR 2017 - IEEE Conference on Computer Vision and Pattern Recognition", Honolulu, United States, July 2017, 9 p. , https://hal.inria.fr/hal-01491386

[8] V. LEROY, J.-S. FRANCO, E. BOYER. *Multi-View Dynamic Shape Refinement Using Local Temporal Integration*, in "IEEE, International Conference on Computer Vision 2017", Venice, Italy, 2017 IEEE International Conference on Computer Vision, ICCV 2017, Venice, Italy, October 22-29, 2017. IEEE Computer Society 2017, October 2017, https://hal.archives-ouvertes.fr/hal-01567758

[9] J. PANSIOT, E. BOYER. *CT from Motion: Volumetric Capture of Moving Shapes with X-rays and Videos*, in "British Machine Vision Conference (BMVC)", London, United Kingdom, September 2017, https://hal.inria.fr/hal-01585344

Research Reports

[10] M. DOUZE, J.-S. FRANCO, B. RAFFIN. *QuickCSG: Fast Arbitrary Boolean Combinations of N Solids*, ArXiv, June 2017, https://hal.inria.fr/hal-01587902

Other Publications

[11] N. VERMA, E. BOYER, J. VERBEEK. *Dynamic Filters in Graph Convolutional Networks*, June 2017, https://arxiv.org/abs/1706.05206 - working paper or preprint, https://hal.inria.fr/hal-01540389