



IN PARTNERSHIP WITH:
CNRS

Université de Lorraine

Activity Report 2018

Project-Team MAGRIT

Visual Augmentation of Complex Environments

IN COLLABORATION WITH: Laboratoire lorrain de recherche en informatique et ses applications (LORIA)

RESEARCH CENTER
Nancy - Grand Est

THEME
**Vision, perception and multimedia
interpretation**

Table of contents

1. Team, Visitors, External Collaborators	1
2. Overall Objectives	2
3. Research Program	2
3.1. Matching and 3D tracking	2
3.2. Image-based Modeling	3
3.3. Parameter estimation	4
4. Application Domains	4
4.1. Augmented reality	4
4.2. Medical Imaging	5
4.3. Experimental mechanics	5
5. Highlights of the Year	5
6. New Software and Platforms	5
6.1. PoLAR	5
6.2. Fast>VP	5
6.3. NoLoDuDoCT	6
6.4. BSpeckleRender	6
7. New Results	6
7.1. Matching and localization	6
7.2. Handling non-rigid deformations	8
7.3. Image processing	9
8. Partnerships and Cooperations	10
8.1. Regional Initiatives	10
8.2. National Initiatives	10
8.2.1. Projet RAPID EVORA	10
8.2.2. AEN Inria SOFA-InterMedS	11
8.3. International Initiatives	11
8.3.1.1. CURATIVE	11
8.3.1.2. Informal International Partners	11
8.4. International Research Visitors	12
8.4.1. Visits of International Scientists	12
8.4.2. Visits to International Teams	12
9. Dissemination	12
9.1. Promoting Scientific Activities	12
9.1.1. Scientific Events Organisation	12
9.1.2. Scientific Events Selection	12
9.1.3. Journal	12
9.1.4. Invited Talks	13
9.1.5. Scientific Expertise	13
9.1.6. Research Administration	13
9.2. Teaching - Supervision - Juries	13
9.2.1. Teaching	13
9.2.2. Supervision	14
9.2.3. Juries	14
9.3. Popularization	14
9.3.1. Internal or external Inria responsibilities	14
9.3.2. Articles and contents	14
9.3.3. Education	15
9.3.4. Interventions	15
10. Bibliography	15

Project-Team MAGRIT

Creation of the Project-Team: 2006 April 03, end of the Project-Team: 2018 December 31

Keywords:

Computer Science and Digital Science:

- A5.3. - Image processing and analysis
- A5.4. - Computer vision
 - A5.4.1. - Object recognition
 - A5.4.5. - Object tracking and motion analysis
 - A5.4.6. - Object localization
- A5.6. - Virtual reality, augmented reality
- A5.10.2. - Perception

Other Research Topics and Application Domains:

- B2.6. - Biological and medical imaging
- B5.9. - Industrial maintenance
 - B9.5.3. - Physics

1. Team, Visitors, External Collaborators

Research Scientists

- Marie-Odile Berger [Team leader, Inria, Senior Researcher, HDR]
- Erwan Kerrien [Inria, Researcher, HDR]

Faculty Members

- Fabien Pierre [Univ de Lorraine, Associate Professor]
- Gilles Simon [Univ de Lorraine, Associate Professor]
- Frédéric Sur [Univ de Lorraine, Associate Professor, until Aug 2018, HDR]
- Frédéric Sur [Univ de Lorraine, Professor, from Sep 2018, HDR]
- Pierre-Frédéric Villard [Univ de Lorraine, Associate Professor]
- Brigitte Wrobel-Dautcourt [Univ de Lorraine, Associate Professor]

PhD Students

- Antoine Fond [Inria, until Jun 2018]
- Jaime Garcia Guevara [Inria]
- Vincent Gaudilliere [Inria]
- Daryna Panicheva [Univ de Lorraine]
- Raffaella Trivisonne [Inria]

Interns

- Thomas Mouzon [Univ de Lorraine, from May 2018 until Jul 2018]
- Juan Rocha Ferreira [Inria, from Apr 2018 until Oct 2018]

Administrative Assistants

- Isabelle Blanchard [Inria]
- Annick Jacquot [CNRS, from Jul 2018]
- Virginie Priester [CNRS]

2. Overall Objectives

2.1. Augmented Reality

The basic concept of Augmented Reality (AR) is to place information correctly registered with the environment into the user's perception. What makes AR stand out is that this new technology offers the potential for big changes in many application fields such as industrial maintenance, creative technologies, image guided medical gestures, entertainment...

Augmented reality technologies have made major advances recently, both in terms of capability, mobile development and integration into current mobile devices. Most applications are dedicated to multimedia and entertainment, games, lifestyle and healthcare and use rough localization information provided by the sensors of the mobile phones. Cutting-edge augmented reality applications which take place in complex environments and require high accuracy in augmentation are less prevalent. There are indeed still technological barriers that prevent applications from reaching the robustness and the accuracy required by such applications.

The aim of the MAGRIT project is to develop vision-based methods which allow significant progress of AR technologies in terms of ease of implementation, reliability and robustness. An expected consequence is the widening of the current application field of AR.

The team is active in both medical and classical applications of augmented reality for which accurate integration of the virtual objects within the scene is essential. Key requirements of AR systems are the availability of registration techniques, both rigid and elastic, that allow the virtual objects to be correctly aligned with the environment, as well as means to build 3D models which are appropriate for pose computation and for handling interactions between the virtual objects and the real scene. Considering the common needs for tracking, navigation, advanced modeling and visualization technologies in both medical and industrial applications, the team focuses on three main objectives: matching, localization and modeling. Methods are developed with a view to meet the expected robustness and accuracy over time and to provide the user with a realistic perception of the augmented scene, while satisfying the real-time achievements required by these procedures.

3. Research Program

3.1. Matching and 3D tracking

One of the most basic problems currently limiting AR applications is the registration problem. The objects in the real and virtual worlds must be properly aligned with respect to each other, or the illusion that the two worlds coexist will be compromised.

As a large number of potential AR applications are interactive, real time pose computation is required. Although the registration problem has received a lot of attention in the computer vision community, the problem of real-time registration is still far from being a solved problem, especially for unstructured environments. Ideally, an AR system should work in all environments, without the need to prepare the scene ahead of time, independently of the variations in experimental conditions (lighting, weather condition,...)

For several years, the MAGRIT project has been aiming at developing on-line and marker-less methods for camera pose computation. The main difficulty with on-line tracking is to ensure robustness of the process over time. For off-line processes, robustness is achieved by using spatial and temporal coherence of the considered sequence through move-matching techniques. To get robust open-loop systems, we have investigated various methods, ranging from statistical methods to the use of hybrid camera/sensor systems. Many of these methods are dedicated to piecewise-planar scenes and combine the advantage of move-matching methods and model-based methods. In order to reduce statistical fluctuations in viewpoint computation, which lead to unpleasant jittering or sliding effects, we have also developed model selection techniques which allow us to noticeably improve the visual impression and to reduce drift over time. Another line of research which has been considered in the team to improve the reliability and the robustness of pose algorithms is to combine the camera with another form of sensor in order to compensate for the shortcomings of each technology.

The success of pose computation over time largely depends on the quality of the matching at the initialization stage. Indeed, the current image may be very different from the appearances described in the model both on the geometrical and the photometric sides. Research is thus conducted in the team on the use of probabilistic methods to establish robust correspondences of features. The use of *a contrario* methods has been investigated to achieve this aim [9]. We especially addressed the complex case of matching in scenes with repeated patterns which are common in urban scenes. We are also investigating the problem of matching images taken from very different viewpoints which is central for the re-localization issue in AR. Within the context of a scene model acquired with structure from motion techniques, we are currently investigating the use of viewpoint simulation in order to allow successful pose computation even if the considered image is far from the positions used to build the model [4].

Recently, the issue of tracking deformable objects has gained importance in the team. This topic is mainly addressed in the context of medical applications through the design of bio-mechanical models guided by visual features [1]. We have successfully investigated the use of such models in laparoscopy, with a vascularized model of the liver and with a hyper-elastic model for tongue tracking in ultrasound images. However, these results have been obtained so far in relatively controlled environments, with non-pathological cases. When clinical routine applications are to be considered, many parameters and considerations need to be taken into account. Among the problems that need to be addressed are more realistic model representations, the specification of the range of physical parameters and the need to enforce the robustness of the tracking with respect to outliers, which are common in the interventional context.

3.2. Image-based Modeling

Modeling the scene is a fundamental issue in AR for many reasons. First, pose computation algorithms often use a model of the scene or at least some 3D knowledge on the scene. Second, effective AR systems require a model of the scene to support interactions between the virtual and the real objects such as occlusions, lighting reflections, contacts...in real-time. Unlike pose computation which has to be performed in a sequential way, scene modeling can be considered as an off-line or an on-line problem depending on the requirements of the targeted application. Interactive in-situ modeling techniques have thus been developed with the aim to enable the user to define what is relevant at the time the model is being built during the application. On the other hand, we also proposed off-line multimodal techniques, mainly dedicated to AR medical applications, with the aim of obtaining realistic and possibly dynamic models of organs suitable for real-time simulation [2].

In-situ modeling

In-situ modeling allows a user to directly build a 3D model of his/her surrounding environment and verify the geometry against the physical world in real-time. This is of particular interest when using AR in unprepared environments or building scenes that either have an ephemeral existence (e.g., a film set) or cannot be accessed frequently (e.g., a nuclear power plant). We have especially investigated two systems, one based on the image content only and the other based on multiple data coming from different sensors (camera, inertial measurement unit, laser rangefinder). Both systems use the camera-mouse principle [7] (i.e., interactions are performed by aiming at the scene through a video camera) and both systems have been designed to acquire polygonal textured models, which are particularly useful for camera tracking and object insertion in AR.

Multimodal modeling for real-time simulation

With respect to classical AR applications, AR in medical context differs in the nature and the size of the data which are available: a large amount of multimodal data is acquired on the patient or possibly on the operating room through sensing technologies or various image acquisitions [3]. The challenge is to analyze these data, to extract interesting features, to fuse and to visualize this information in a proper way. Within the MAGRIT team, we address several key problems related to medical augmented environments. Being able to acquire multimodal data which are temporally synchronized and spatially registered is the first difficulty we face when considering medical AR. Another key requirement of AR medical systems is the availability of 3D (+t) models of the organ/patient built from images, to be overlaid onto the users' view of the environment.

Methods for multimodal modeling are strongly dependent on the imaging modalities and the organ specificities. We thus only address a restricted number of medical applications –interventional neuro-radiology, laparoscopic surgery– for which we have a strong expertise and close relationships with motivated clinicians. In these applications, our aim is to produce realistic models and then realistic simulations of the patient to be used for the training of surgeons or the re-education of patients.

One of our main applications is about neuroradiology. For the last 20 years, we have been working in close collaboration with the neuroradiology laboratory (CHU-University Hospital of Nancy) and GE Healthcare. As several imaging modalities are now available in an intraoperative context (2D and 3D angiography, MRI, ...), our aim is to develop a multi-modality framework to help therapeutic decision and treatment.

We have mainly been interested in the effective use of a multimodality framework in the treatment of arteriovenous malformations (AVM) and aneurysms in the context of interventional neuroradiology. The goal of interventional gestures is to guide endoscopic tools towards the pathology with the aim to perform embolization of the AVM or to fill the aneurysmal cavity by placing coils. We have proposed and developed multimodality and augmented reality tools which make various image modalities (2D and 3D angiography, fluoroscopic images, MRI, ...) cooperate in order to help physicians in clinical routine. One of the successes of this collaboration is the implementation of the concept of *augmented fluoroscopy*, which helps the surgeon to guide endoscopic tools towards the pathology. Lately, in cooperation with the team MIMESIS, we have proposed new methods for implicit modeling of the vasculature with the aim of obtaining near real-time simulation of the coil deployment in the aneurysm [2]. These works open the way towards near real-time patient-based simulations of interventional gestures both for training and for planning.

3.3. Parameter estimation

Many problems in computer vision or image analysis can be formulated in terms of parameter estimation from image-based measurements. This is the case of many problems addressed in the team such as pose computation or image-guided estimation of 3D deformable models. Often traditional robust techniques which take into account the covariance on the measurements are sufficient to achieve reliable parameter estimation. However, depending on their number, their spatial distribution and the uncertainty on these measurements, some problems are very sensitive to noise and there is a considerable interest in considering how parameter estimation could be improved if additional information on the noise were available. Another common problem in our field of research is the need to estimate constitutive parameters of the models, such as (bio)-mechanical parameters for instance. Direct measurement methods are destructive, and elaborating image-based methods is thus highly desirable. Besides designing appropriate estimation algorithms, a fundamental question is to understand what group of parameters under study can be reliably estimated from a given experimental setup.

This line of research is relatively new in the team. One of the challenges is to improve image-based parameter estimation techniques considering sensor noise and specific image formation models. In a collaboration with the Pascal Institute (Clermont Ferrand), metrological performance enhancement for experimental solid mechanics has been addressed through the development of dedicated signal processing methods [8]. In the medical field, specific methods based on an adaptive evolutionary optimization strategy have been designed for estimating respiratory parameters [10]. In the context of designing realistic simulators for neuroradiology, we are now considering how parameters involved in the simulation could be adapted to fit real images.

4. Application Domains

4.1. Augmented reality

We have a significant experience in AR that allowed good progress in building usable, reliable and robust AR systems. Our contributions cover the entire process of AR: matching, pose initialization, 3D tracking, in-situ modeling, handling interaction between real and virtual objects....

4.2. Medical Imaging

For 15 years, we have been working in close collaboration with University Hospital of Nancy and GE Healthcare in interventional neuroradiology. Our common aim is to develop a multimodality framework to help therapeutic decisions and interventional gestures. Contributions of the team focus on the developments of AR tools for neuro-navigation as well as the development of simulation tools for training or planning. Laparoscopic surgery is another field of interest with the development of methods for tracking deformable organs based on bio-mechanical models. Some of these projects are developed in collaboration with the MIMESIS project team.

4.3. Experimental mechanics

In experimental solid mechanics, an important problem is to characterize properties of specimen subject to mechanical constraints, which makes it necessary to measure tiny strains. Contactless measurement techniques have emerged in the last few years and are spreading quickly. They are mainly based on images of the surface of the specimen on which a regular grid or a random speckle has been deposited. We are engaged since June 2012 in a transdisciplinary collaboration with Institut Pascal (Clermont-Ferrand Université). The aim is to characterize the metrological performances of these techniques limited by, e.g., the sensor noise, and to improve them by several dedicated image processing tools.

5. Highlights of the Year

5.1. Highlights of the Year

Vanishing point detection is an old problem of computer vision. We introduced this year a new method based on the a contrario methodology to solve this problem. By fractioning the 2-D search of meaningful vanishing points into three 1-D searches of meaningful events (Zenith line, Horizon line, and Vanishing points), we not only achieve state-of-the-art performance w.r.t. computation times and accuracy of the horizon line, but also yields more relevant vanishing points than the previous top-ranked methods. This work was presented at ECCV 2018 [23] and the associated code is freely distributed.

6. New Software and Platforms

6.1. PoLAR

Portable Library for Augmented Reality

FUNCTIONAL DESCRIPTION: PoLAR (Portable Library for Augmented Reality) is a framework which aims to help creating graphical applications for augmented reality, image visualization and medical imaging. PoLAR was designed to offer powerful visualization functionalities without the need to be a specialist in Computer Graphics. The framework provides an API to state-of-the-art libraries: Qt to build GUIs and OpenSceneGraph for high-end visualization, for researchers and engineers with a background in Computer Vision to be able to create beautiful AR applications, with little programming effort. The framework is written in C++ and published under the GNU GPL license

- Contact: Erwan Kerrien
- URL: <http://polar.inria.fr>

6.2. Fast>VP

KEYWORDS: Vanishing points - Image rectification

FUNCTIONAL DESCRIPTION: Fast>VP is a fast and effective tool to detect vanishing points in uncalibrated images of urban or indoor scenes.

This tool also allows automatic rectification of the vertical planes in the scene, namely generating images where these planes appear as if they were observed from a fronto-parallel view.

It is the Matlab implementation of the algorithm described in [6].

- Contact: Gilles Simon
- URL: <https://members.loria.fr/GSimon/fastvp/>

6.3. NoLoDuDoCT

A non-local dual-domain cartoon and texture decomposition

KEYWORDS: Image analysis - Cartoon and texture decomposition

FUNCTIONAL DESCRIPTION: This is an algorithm decomposing images into cartoon and texture components. Spectrum components of textures are detected on the basis of a statistical hypothesis test, the null hypothesis modeling a purely cartoon patch. Statistics are estimated in a non-local way.

- Contact: Frédéric Sur
- URL: <https://members.loria.fr/FSur/software/NoLoDuDoCT/>

6.4. BSpeckleRender

A Boolean model for deformed speckle rendering

KEYWORDS: Boolean model - Monte Carlo estimation - Experimental mechanics - Displacement fields

FUNCTIONAL DESCRIPTION: This library implements a new method for synthesizing speckle images deformed by an arbitrary deformation field set by the user. Such images are very useful for assessing the different methods based on digital image correlation (DIC) for estimating displacement fields in experimental mechanics. Since the deformations are very small, it is necessary to ensure that no additional bias is introduced by the image synthesis algorithm. The proposed method is based on the Monte Carlo evaluation of images generated by a Boolean model.

- Contact: Frédéric Sur
- URL: <https://members.loria.fr/FSur/software/BSpeckleRender/>

7. New Results

7.1. Matching and localization

Participants: Marie-Odile Berger, Vincent Gaudilliere, Antoine Fond, Gilles Simon.

Vanishing point detection

Accurate detection of vanishing points (VPs) is a prerequisite for many computer vision problems such as camera self-calibration, single view structure recovery, video compass, robot navigation and augmented reality, among many others. More specifically, knowing three orthogonal VPs aligned with the buildings of a scene (the Manhattan directions) allows computing the intrinsic parameters of the camera as well as warped images where the buildings' facades are orthorectified, facilitating their detection and registration. VPs are also used in our work on epipolar geometry estimation to help matching line segments, a particularly difficult task in low-textured environments.

We introduced an *a-contrario* method to solve this problem. Our key contribution was to show that, as soon as the horizon line (HL) is inside the image boundaries, this line can usually be detected as an alignment of oriented line segments. This comes from a simple geometric property, that any horizontal line segment at the height of the camera's optical center projects to the HL regardless of its 3-D direction. This property generally yields statistically meaningful events, detectable from *a-contrario* analysis. Additional candidate HLs are sampled around these events using a Gaussian Mixture Model (GMM), and scored according to the strongest of the VPs hypothesized along them. VP hypotheses are also obtained from an *a-contrario* method, using integral geometry to accurately model the background noise. Experiments made on three urban datasets showed that our method, not only achieves state-of-the-art performance w.r.t. computation times and accuracy of the HL, but also yields much less spurious VPs than the previous top-ranked methods. This work was published at ECCV'2018 [23] and an article is in preparation for submission in a peer-reviewed journal. In this article, we show that our method also outperforms state-of-the-art methods on a new industrial dataset that we built and will make publicly available. We also establish a relation between the Number of False Alarms (NFA) obtained for the meaningful events and the spreads of the GMM. In addition, the Matlab code implementing our method has been made publicly available.

Urban AR

Urban localization plays a major role in many applications including navigation aid, labeling of local touristic landmarks, and robot localization. The outdoor accuracy of mobile phone GPS is only 12.5 meters and can be worse in urban areas where the street is flanked by buildings on both sides. By contrast, buildings' facades are meaningful landmarks to rely on for large-scale localization. Last year, we proposed a method to automatically detect facades in an image, based on image cues that measure facade characteristics such as shape, color, contours, semantic structure and symmetry. Matching the detected facade with a facade database using a metric learned through a siamese neural network allowed us to estimate a first initialization of the registration parameters by solving the least-square problem that maps the four transformed corners of the reference to the four corners of the detection.

This year, we attempted to rely on semantic segmentation to improve the accuracy of that initial registration [11]. Simultaneously, we aimed to iteratively improve the quality of the semantic segmentation through registration. Registration and semantic segmentation were jointly solved in a Expectation-Maximization framework. We especially introduced a Bayesian model that uses prior semantic segmentation as well as geometric structure of the facade reference modeled by Generalized Gaussian Mixtures. We showed the advantages of our method in terms of robustness to clutter and change of illumination on urban images from various databases. We currently are assessing the relevance of the method using the large scale dataset SFM Aachen, in order to compare it with state-of-the-art SFM-based localization.

AR in industrial environments

Industrial environments are normally inundated with textureless objects, specular surfaces, repetitive objects and artificial lights, etc. which may fail traditional 2D/3D matching-based approaches. Line segments are numerous in industrial environments, but contrary to what happens in urban scenes, matching is a tough issue since most segments are silhouette contours whose appearance is viewpoint dependant. The combinatorial of segment matches is thus very high, making impossible in practice the use of RANSAC algorithms for pose computation.

Within V. Gaudilliere's PhD thesis [21], [25], we took advantage of global properties of the environment, both geometric - such as the presence of numerous vertical planes - and contextual to guide matching. First, sub-image correspondences based on high level ConvNet features are used as prior for vertical planes detection and matching. Then, local homographies are detected between matched regions. To ensure efficient estimations, we have developed a dedicated RANSAC framework in which model hypotheses are first generated based on vanishing point and visual keypoint correspondences, and then validated on key points and line segments. This potential set of matched features are finally filtered with a robust fundamental matrix estimation. That scheme enables us to circumvent problems encountered in poorly-textured images (sparsity of visual keypoints and difficulties to match segments) while taking advantage of the abundance of segments and vanishing points characteristic of industrial environments

7.2. Handling non-rigid deformations

Participants: Marie-Odile Berger, Jaime Garcia Guevara, Daryna Panicheva, Pierre-Frédéric Villard.

Elastic multi-modal registration

Our previous works about 3D tracking for deformable objects [1] are template-based methods and thus need to carefully register the model onto the image in the first image. In practice this task is performed manually and is especially difficult for deformable organs. Within J. Guevara's PhD thesis, we have proposed an automatic method for registering pre and per-operative imagery which exploits the matching of the vascular trees, visible in most pre and intra-operative images. Although methods dedicated to non-rigid graph registration exist, they are not efficient when large intra-operative deformations of tissues occur. Our contribution is an extension of the graph-matching algorithm based on Gaussian process regression (GPR) proposed in [28]. Our idea is to combine GPR with a biomechanical model of the organ. Indeed, GPR allows for rigorous and fast error propagation but is extremely versatile and may thus produce non physically coherent registration, while biomechanical transformations are slower to compute but are capable of handling non linear deformation while preserving their physical nature. They thus allow earlier incoherent matching hypotheses to be removed. Integrating the two approaches allows us to significantly improve the quality of the registration while reducing computation times. These contributions have been published in the IPCAI conference [20] and in the International Journal of Computer Assisted Radiology and Surgery [13].

Individual-specific heart valve modeling

We first finished up a feasibility study aiming at providing fast image-based mitral valve mechanical simulation from individualized geometry [19]. The method was demonstrated on one dataset which was interactively segmented. In order to extend the pipeline to any data, robust methods to segment the valve components are required. Within the context of D. Panicheva's PhD thesis, we are currently working on means allowing to automatically segment the chordae. Valve chordae are generalized cylinders: Instead of being limited to a line, the central axis is a continuous curve. Instead of a constant radius, the radius varies along the axis. Most of the time, chordae sections are flattened ellipses and classical model-based methods commonly used for vessel enhancement or vessel segmentation fail. In this contribution, we exploit the fact that there are no other generalized cylinders than the chordae in the CT scan and we propose a topology-based method for chordae extraction. This approach is flexible and only requires the knowledge of an upper bound of the maximum radius of the chordae. The method has been tested on three CT scans. Overall, non-chordae structures are correctly identified and detected chordae ending points match up with actual chordae attachment points.

INVIVE: The Individual Virtual Ventilator: Image-based biomechanical simulation of the diaphragm during mechanical ventilation

When intensive care patients are subjected to mechanical ventilation, the ventilator causes damage to the muscles that govern the normal breathing, leading to Ventilator Induced Diaphragmatic Dysfunction (VIDD). The INVIVE project aims to study the mechanics of respiration through numerical simulation in order to learn more about the onset of VIDD. We propose to use a meshfree RBF method. During this year, we have worked on building an implicit representation of the surface of the diaphragm based on the topology coming from last year researches. It has been associated with a linear elasticity model and the boundary conditions have been measured on landmark points extracted by medical experts.

3D catheter navigation from monocular images

In interventional radiology, the 3D shape of the micro-tool (guidewire, micro-catheter or micro-coil) can be very difficult, if not impossible to infer from fluoroscopy images, which may have an impact on the clinical outcome of the procedure. This question is considered as a single view 3D curve reconstruction problem. We follow a constrained non-rigid shape from motion approach, using a physics-based model as a prior for the object shape. The navigation model is implemented through interactive simulation that provides a prediction of the device, taking into account non-linear effects such as friction during contacts.

Raffaella Trivisonne started her PhD thesis in November 2015 (co-supervised by Stéphane Cotin, from MIMESIS team in Strasbourg) to address this research topic. An unscented kalman filter is used as a fusion mechanism of the model with image data (opaque markers placed along the device). Progress has been made this year towards an effective formulation of the filter. In particular, a good estimate is recovered for the device shape in the case of ambiguous views (overlapping anatomy, bifurcations).

The method has been implemented in Sofa simulation software platform. Validation has been performed on porcine in-vivo data, acquired in accordance with UE norms, in collaboration with Pr. Mario Gimenez and Dr. Alain Garcia from IHU-Strasbourg.

In-vivo procedures will be performed under ethical approval of MSER (reference to ethic protocol *APAFIS #15433-2018060815283960*).

Markerless similarity metrics were investigated during Juan Rocha's Master's thesis. The update equations of the filter were generalized to tackle curve to image similarity metrics, traditionally used in multi-view reconstruction methods.

7.3. Image processing

Participants: Gilles Simon, Fabien Pierre, Frédéric Sur.

Variational methods for image processing

In the previous decade, variational methods in image processing have been widely used with a huge number of applications. The convex hypothesis generally makes the proof of convergence easier, whereas it is not fulfilled by the most interesting problems in imaging. The non-convexity may appear in some applications such as image colorization with multiple candidates selection [27] or in the case of M-estimators computation, in particular with an assumption of Cauchy noise [16]. These two points of view of the non-convex variational methods bring two different mathematical challenges to ensure the convergence of the numerical scheme. The choice of one candidate among a collection of possible ones implies bi-convex functions (functions with multiple variables, convex with respect to each ones). The computation of M-estimators with Cauchy noise hypothesis implies smooth but non-convex functions.

Our contributions concern both types of non-convexity. For bi-convex functions, we have demonstrated in [27] the convergence of alternate gradient descent numerical scheme with inertial relaxation of the iterates. Moreover, an application to image colorization has been proposed. In [16], a fixed-point algorithm has been studied to solve the problem of the Myriad filters. The particularity of this work is the convergence of the numerical scheme to a local minimum with probability 1, which is, up to our best knowledge, a novelty in the optimization community.

Computational photomechanics

In computational photomechanics, mainly two methods are available for estimating displacement and strain fields on the surface of a material specimen subjected to a mechanical test, namely digital image correlation (DIC) and localized spectrum analysis (LSA). With both methods, a contrasted pattern marks the surface of the specimen: either a random speckle pattern for DIC or a regular pattern for LSA, this latter method being based on Fourier analysis. It is a challenging problem since strains are tiny quantities giving deformations often not visible to the naked eye. This year's outcomes of our collaboration with Institut Pascal (Clermont-Ferrand) focus on three areas.

We have proposed an algorithm to render synthetic speckle images deformed under a predetermined deformation fixed by the user [17]. The goal is to generate ground truth datasets in order to assess the performance of the numerous variants of DIC and also the influence of extrinsic factors such as the noise or the marking pattern. It is required to carefully design the rendering algorithm in order to ensure that any measurement bias is caused by DIC estimation and not by the rendering algorithm itself. We have proposed to render speckle images based on a Boolean model, a standard model of stochastic geometry, a Monte Carlo estimation giving the gray level at any pixel. A software library and datasets are publicly available.

We have also investigated the optimization of the pattern marking the specimen [15], which is the topic of various recent papers. Checkerboard is the optimized pattern in terms of sensor noise propagation when the signal is correctly sampled, but its periodicity causes convergence issues with DIC. The consequence is that checkerboards are not used in DIC applications although they are optimal in terms of sensor noise propagation. We have shown that it is possible to use LSA to estimate displacement and strain fields from checkerboard images, although LSA was originally designed to process 2D grid images. A comparative study of checkerboards and grids shows that, under similar lighting conditions, the noise level in displacement and strain maps obtained with checkerboards is lower than that obtained with classic 2D grids.

Another scientific contribution concerns the restoration of displacement and strain maps. DIC and LSA both provide displacement fields equal to the actual one convolved by a kernel known a priori. The kernel indeed corresponds to the Savitzky-Golay filter in DIC, and to the analysis window of the windowed Fourier transform used in LSA. While convolution reduces noise level, it also gives a systematic measurement error. We have proposed a deconvolution method to retrieve the actual displacement and strain fields from the output of DIC or LSA [14]. The proposed algorithm can be considered as a variant of Van Cittert deconvolution, based on the small strain assumption. It is demonstrated that it allows enhancing fine details in displacement and strain maps, while improving the spatial resolution.

Cartoon-texture image decomposition

Decomposing an image as the sum of geometric and textural components is a popular problem of image analysis. In this problem, known as cartoon and texture decomposition, the cartoon component is piecewise smooth, made of the geometric shapes of the images, and the texture component is made of stationary or quasi-stationary oscillatory patterns filling the shapes. Microtextures being characterized by their power spectrum, we propose to extract cartoon and texture components from the information provided by the power spectrum of image patches. The contribution of texture to the spectrum of a patch is detected as statistically significant spectral components with respect to a null hypothesis modeling the power spectrum of a non-textured patch. The null-hypothesis model is built upon a coarse cartoon representation obtained by a basic yet fast filtering algorithm of the literature. The coarse decomposition is obtained in the spatial domain and is an input of the proposed spectral approach. We thus design a “dual domain” method. The statistical model is also built upon the power spectrum of patches with similar textures across the image. The proposed approach therefore falls within the family of non-local methods. Compared to variational methods or fast filters, the proposed non-local dual-domain approach [18] is shown to achieve a good compromise between computation time and accuracy. Matlab code is publicly available.

8. Partnerships and Cooperations

8.1. Regional Initiatives

- The project *Imagerie et Robotique Médicale Grand Est (IRMGE)* started in early January 2018. Clinical and interventional imagery is a major public health issue. Teams from the Grand-Est region involved in medical imaging have thus proposed a research project to broaden and strengthen cooperation. The three axes of the project are about optic imagery, nuclear imagery and medical image processing. The Magrit team is especially involved in the third axis, with the aim to improve interventional procedures.
- Lorraine regional project about AR for liver surgery (2015-2018). The MAGRIT and the MIMESIS teams have been working for several years on the use of augmented reality for deformable organs and especially on liver surgery. The PhD of Jaime Garcia Guevara started in October 2015 and is funded by the Région Lorraine. It follows on from our past works and aims at improving the reliability and the robustness of AR-based clinical procedures.

8.2. National Initiatives

8.2.1. Projet RAPID EVORA

Participants: M.-O. Berger, V. Gaudillère, G. Simon.

This 3-year project is supported by DGA/DGE and led by the SBS-Interactive company. The objective is to develop a prototype for location and object recognition in large-scale industrial environments (factories, ships...), with the aim to enrich the operator's field of view with digital information and media. The main issues concern the size of the environment, the nature of the objects (often non textured, highly specular...) and the presence of repeated patterns. Use cases will be provided by industrial partners such as DCNS and Areva. A class of officer cadets and professors of the Merchant Marine School will also be associated to judge the pedagogical interest of such a tool. A PhD student, Vincent Gaudillière, has been recruited to work on this project and his contract started in December 2016.

8.2.2. AEN Inria SOFA-InterMedS

Participants: R. Anxionnat (CHU Nancy), M.-O. Berger, E. Kerrien.

The SOFA-InterMedS large-scale Inria initiative is a research-oriented collaboration across several Inria project-teams, international research groups and clinical partners. Its main objective is to leverage specific competences available in each team to further develop the multidisciplinary field of Medical Simulation research. Our action within the initiative takes place in close collaboration with both the MIMESIS team and the Department of diagnostic and therapeutic interventional neuroradiology of Nancy University Hospital. Two PhD students - R. Trivisonne and J. Guarcia Guevara- are currently co-supervised by the Magrit and the MIMESIS teams.

8.3. International Initiatives

8.3.1. Inria International Labs

Inria@EastCoast

Associate Team involved in the International Lab:

8.3.1.1. CURATIVE

Title: CompUteR-based simulAtion Tool for mItral Valve rEpair

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Harvard Biorobotics Lab (HBL) - Robert Howe

Start year: 2017

See also: <https://team.inria.fr/curative/>

The mitral valve of the heart ensures one-way flow of oxygenated blood from the left atrium to the left ventricle. However, many pathologies damage the valve anatomy producing undesired backflow, or regurgitation, decreasing cardiac efficiency and potentially leading to heart failure if left untreated. Such cases could be treated by surgical repair of the valve. However, it is technically difficult and outcomes are highly dependent upon the experience of the surgeon.

One way to facilitate the repair is to simulate the mechanical behavior of the pathological valve with subject-specific data. Our main goal is to provide surgeons with a tool to study solutions of mitral valve repairs. This tool would be a computer-based model that can simulate a potential surgical repair procedure in order to evaluate its success. The surgeons would be able to customize the simulation to a patient and to a technique of valve repair. Our methodology will be to realistically simulate valve closure based on segmentation methods faithful enough to capture subject-specific anatomy and based on a biomechanical model that can accurately model the range of properties exhibited by pathological valves.

8.3.1.2. Informal International Partners

- Pierre-Frédéric Villard is a co-investigator in the INVIVE project (http://www.it.uu.se/research/scientific_computing/project/rbf/biomech) funded by the Swedish Research Council and realized within a collaboration with Uppsala University and Karolinska Institute. Within this project, he is the co-supervisor of Igor Tominec (Uppsala University) with Elisabeth Larsson (Uppsala University) as the Main advisor.

- With Gabriele Steidl (Technische Universität Kaiserslautern, Germany), we have worked about the removal of Cauchy noise in natural images. This work has led with a publication in *Journal of Mathematical Imaging and Vision* in 2018. The extension of this technique for structured data (on Riemannian variety for instance) will be considered in future works.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Pete Hammer, a senior researcher at Harvard University (<http://www.childrenshospital.org/researchers/peter-e-hammer>), visited the MAGRIT team from 06/04/18 to 06/10/18. He gave a talk to the Department 1 in Loria, he helped out with mechanical modeling of the mitral valve and he provided advice to Daryna Panicheva supervision during one week.
- Rob Howe, a full professor at Harvard University (<http://people.seas.harvard.edu/~howe/>), visited the MAGRIT team from 06/16/18 to 06/20/18. He gave a talk to the Department 1 in Loria, he helped out with science understanding of the valve and he helped Daryna Panicheva supervision during one week.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Pierre-Frederic Villard spent one month (May 2018) at Uppsala University working on the INVIVE project. His work there includes supervising PhD student Igor Tominec, meeting with a physiologist expert in respiration muscles and working on an implicit surface representation of the diaphragm.

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. Member of the Organizing Committees

- Fabien Pierre co-organized an ICPR satellite Workshop on Reproducible Research in Pattern Recognition (RRPR 2018, Beijing, China).

9.1.2. Scientific Events Selection

9.1.2.1. Member of the Conference Program Committees

- M.-O. Berger was a member of the program committee of: International Conference on Robotic and automation (ICRA 2018), International Conference on Information Processing in Computer assisted interventions (IPCAI 2018), International Conference on Robotics and Automation (IROS 2018), International Symposium on Mixed and Augmented Reality (ISMAR 2018), International Conference on Pattern Recognition (ICPR 2018).
- Erwan Kerrien was a member of the program committee of MICCAI 2018.
- G. Simon was a member of the program committee of IEEE VR 2019 and IEEE ISMAR 2018
- F. Sur was a member of the program committee of RFIAP 2018 (Reconnaissance des formes, image, apprentissage et perception)

9.1.3. Journal

9.1.3.1. Reviewer - Reviewing Activities

The members of the team reviewed articles in IEEE Transactions on Visualization and Computer Graphics, IEEE Transaction on Image Processing, MDPI Journal of Imaging, Image Processing On Line, Computer Methods and Programms in Biomedicine, Medical Image Analysis.

9.1.4. Invited Talks

- Fabien Pierre gave a talk during a one-day workshop organized in Paris in november 2018 by GDR ISIS. Title : *Géométrie et représentation de la couleur*.
- Pierre-Frederic gave a seminar at the department of information technology of Uppsala University on May 30th. Title: ' Mitral Valve Biomechanical Model Construction ' http://user.it.uu.se/~maya/seminar_abstracts/sem_spring18/PFVillard.html.
- Daryna Pancheva gave a talk at the Harvard Biorobotics Lab on November 19th. Title: 'Automatic Segmentation of Mitral Valve Chordae'.
- Pierre-Frederic Villard gave a talk at the Harvard Biorobotics Lab on November 26th. Title: 'Mitral Valve modeling: from CT scan to FEM model'.

9.1.5. Scientific Expertise

- Marie-Odile Berger is the president of the Association française pour la reconnaissance et l'interprétation des formes (AFRIF).
- Gilles Simon was reviewers for two CIFRE grant proposals (ANR).

9.1.6. Research Administration

- Marie-Odile Berger is a member of the Inria evaluation committee. She was scientific referent for the Evaluation Seminar "Vision, perception and multimedia interpretation".
- Gilles Simon is Chargé de Mission Loria to take part in an EIT's KIC (Knowledge and Innovation Communities) proposal in the thematic of manufacturing (KIC Added-value Manufacturing).

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

The assistant professors of the MAGRIT team actively teach at Université de Lorraine with an annual number of around 200 teaching hours in computer sciences, some of them being accomplished in the field of image processing. Inria researchers have punctual teaching activities in computer vision and shape recognition mainly in the computer science Master of Nancy and in several Engineering Schools near Nancy (ENSMN Nancy, SUPELEC Metz, ENSG). Our goal is to attract Master students with good skills in applied mathematics towards the field of computer vision.

The list of courses given by staff members which are related to image processing and computer vision is detailed below:

- M.-O. Berger
 - Master : Shape recognition, 15 h, Université de Lorraine.
 - Master : Introduction to image processing, 12 h, École des Mines de Nancy .
 - Master : Image processing for Geosciences, ENSG, 12h.
- E. Kerrien
 - Master : Introduction to image processing, 15 h, École des Mines de Nancy.
- Fabien Pierre
 - Licence: Introduction to image processing and compression, 30h, IUT Saint-Dié des Vosges.
- G. Simon
 - Master: Augmented reality, 24 h, Télécom-Nancy.
 - Master : Augmented reality, 24h, M2 IHM Metz.
 - Master : Augmented reality, 3 h, SUPELEC Metz.
- F. Sur

- Master: Introduction to machine learning, 50 h, Université de Lorraine.
- Master : Introduction to signal processing and applications, 21 h, Ecole des Mines de Nancy.
- P.-F. Villard
 - Licence: 3D programming, 16h, IUT Saint-Dié des Vosges.
 - Licence: Game design with Unity3D , 15h, IUT Saint-Dié des Vosges.
 - Licence: Introduction to augmented reality, 4h, IUT Saint-Dié des Vosges.
 - Master : Augmented and Virtual Reality, 16h, M2 Cognitive Sciences and Applications, Institut des Sciences du Digital, Université de Lorraine.

Frédéric Sur was the head of the Industrial Engineering and Applied Mathematics department at Mines Nancy until August 2018.

9.2.2. Supervision

PhD: Antoine Fond, Introduction de sémantique dans la modélisation urbaine dans un contexte de calcul du point de vue, octobre 2014, Marie-Odile Berger, Gilles Simon. PhD defended in avril 2018.

PhD in progress: Jaime Garcia Guevara, Vers une utilisation clinique de la réalité agmentée pour la chirurgie hépatique, octobre 2015, Marie-Odile Berger, Stéphane Cotin (MIMESIS).

PhD in progress: Raffaella Trivisonne, Image-guided real-time simulation using stochastic filtering, novembre 2015, Erwan Kerrien, Stéphane Cotin (MIMESIS).

PhD in progress: Vincent Gaudillière, Reconnaissance de lieux et d'objets pour la réalité augmentée en milieux complexes, décembre 2016, Marie-Odile Berger, Gilles Simon.

PhD in progress: Daryna Panicheva, Image-based Biomechanical Simulation of Mitral Valve Closure, octobre 2017, Marie-Odile Berger, Pierre-Frédéric Villard.

9.2.3. Juries

- Marie-Odile Berger was external reviewer of the PhD of Philippe-Antoine Gohard (Univ. Toulouse), Guillaume Cortes (Univ. Rennes), Giang Nguyen (Univ Paris-Est) and of the HdR of Céline Fouard (Univ. Grenoble). She was examiner of the PhD of Nader Mamoud (Univ. Saragosse) and Alexandre Morgand (Univ. Clermont-Ferrand).
- Erwan Kerrien was external reviewer of the PhD of Mohammad Rezza Maddah (IMT Atlantique and Wright State University).

9.3. Popularization

Members of the team participate on a regular basis, to scientific awareness and mediation actions.

9.3.1. Internal or external Inria responsibilities

Erwan Kerrien is Chargé de Mission for scientific mediation at Inria Nancy-Grand Est, and thereby is part of the Inria scientific mediation network. As such, he is a member of the steering committee of "la Maison pour la Science de Lorraine" ¹, and member of the IREM ² steering council. He also serves as the academic referent of an IREM working group aiming at introducing computer science in lower and upper secondary school curricula.

9.3.2. Articles and contents

Erwan Kerrien was interviewed for a special edition of the journal of Nancy University Hospital about AI in medicine.

¹"Houses for Science" project, see <http://maisons-pour-la-science.org/en>

²Institut de Recherche sur l'Enseignement des Mathématiques - *Research Institute for Teaching Mathematics*

9.3.3. Education

- Gilles Simon participated to the “Fête de la science 2018” at the Faculté des Sciences et Technologies of the Université de Lorraine. He presented unplugged activities of computer science.
- Pierre-Frédéric Villard participated to open days and science festival in the IUT of Saint-Dié des Vosges. He presented augmented and virtual reality demos and their link to the high school mathematics program.
- Erwan Kerrien participated in the creation of a MOOC for teachers of the new ICN option (Informatique et Création Numérique - *Computer Science and Digital Creation*) at the beginning of high school curriculum (see <https://www.fun-mooc.fr/courses/inria/41014/session01/info>). This MOOC is part of the Class'Code project (<https://pixees.fr/classcode-v2>). During the year, he took his part in the animation and participated in the evolution of this MOOC to adapt to the new SNT class (Sciences du Numérique et Technologie - *Digital Science and Technology*) that generalizes ICN, and is included in the 1st year core curriculum in upper secondary education. He also participated in the creation and teaching, of a 5-day training course for scientific animators (in a broad sense, from science club animators to science teachers). This course was funded by Région Lorraine (see <https://fan.loria.fr>).

He gave a 2-day course about the use of unplugged computer science to introduce computer science in science class, along with another researcher and 2 secondary school maths teachers. This course has been organized with Maison pour la Science since 2015, and is proposed to around 20 maths and science secondary school teachers each year.

9.3.4. Interventions

- Gilles Simon was invited to participate in a round table on geomatics as part of the Saint-Dié-des-Vosges Geography Festival.
- Erwan Kerrien was an associate researcher to a MATH.en.JEANS workshop within Loritz high school in Nancy. He was also part of the organizing committee of the MATH.en.JEANS conference that took place in Nancy, and gathered around 500 pupils and teachers from North-East France, Belgium and Romania. He also proposed computer science unplugged activities to secondary school pupils, especially when around 100 girls were welcome in the Inria Nancy-Grand Est center to celebrate the Ada Lovelace Day.

10. Bibliography

Major publications by the team in recent years

- [1] N. HAOUCHINE, S. COTIN, I. PETERLIK, J. DEQUIDT, M. SANZ-LOPEZ, E. KERRIEN, M.-O. BERGER. *Impact of Soft Tissue Heterogeneity on Augmented Reality for Liver Surgery*, in "IEEE Transactions on Visualization and Computer Graphics", 2015, vol. 21, n^o 5, pp. 584 - 597 [DOI : 10.1109/TVCG.2014.2377772], <https://hal.inria.fr/hal-01136728>
- [2] E. KERRIEN, A. YUREIDINI, J. DEQUIDT, C. DURIEZ, R. ANXIONNAT, S. COTIN. *Blood vessel modeling for interactive simulation of interventional neuroradiology procedures*, in "Medical Image Analysis", January 2017, vol. 35, pp. 685 - 698 [DOI : 10.1016/J.MEDIA.2016.10.003], <https://hal.inria.fr/hal-01390923>
- [3] N. PADOY, T. BLUM, A. AHMADI, H. FEUSSNER, M.-O. BERGER, N. NAVAB. *Statistical Modeling and Recognition of Surgical Workflow*, in "Medical Image Analysis", 2011, <http://hal.inria.fr/inria-00526493/en>

- [4] P. ROLIN, M.-O. BERGER, F. SUR. *Viewpoint simulation for camera pose estimation from an unstructured scene model*, in "International Conference on Robotics and Automation", Seattle, United States, May 2015, <https://hal.archives-ouvertes.fr/hal-01166785>
- [5] G. SIMON, M.-O. BERGER. *Interactive Building and Augmentation of Piecewise Planar Environments Using the Intersection Lines*, in "The Visual Computer", February 2011, vol. 27, n^o 9, pp. 827-841, <http://hal.inria.fr/inria-00565129/en>
- [6] G. SIMON, A. FOND, M.-O. BERGER. *A Simple and Effective Method to Detect Orthogonal Vanishing Points in Uncalibrated Images of Man-Made Environments*, in "Eurographics 2016", Lisbon, Portugal, May 2016, <https://hal.inria.fr/hal-01275628>
- [7] G. SIMON. *In-Situ 3D Sketching Using a Video Camera as an Interaction and Tracking Device*, in "31st Annual Conference of the European Association for Computer Graphics - Eurographics 2010", Suède Norrköping, May 2010
- [8] F. SUR, M. GREDIAC. *Measuring the Noise of Digital Imaging Sensors by Stacking Raw Images Affected by Vibrations and Illumination Flickering*, in "SIAM J. on Imaging Sciences", March 2015, vol. 8, n^o 1, pp. 611-643 [DOI : 10.1137/140977035], <https://hal.inria.fr/hal-01133358>
- [9] F. SUR, N. NOURY, M.-O. BERGER. *An A Contrario Model for Matching Interest Points under Geometric and Photometric Constraints*, in "SIAM Journal on Imaging Sciences", 2013, vol. 6, n^o 4, pp. 1956-1978 [DOI : 10.1137/120871766], <http://hal.inria.fr/hal-00876215>
- [10] F. P. VIDAL, P.-F. VILLARD, E. LUTTON. *Tuning of patient specific deformable models using an adaptive evolutionary optimization strategy*, in "IEEE Transactions on Biomedical Engineering", October 2012, vol. 59, n^o 10, pp. 2942 - 2949 [DOI : 10.1109/TBME.2012.2213251], <https://hal.inria.fr/hal-00731910>

Publications of the year

Doctoral Dissertations and Habilitation Theses

- [11] A. FOND. *Image-based localization in urban environment : application to augmented reality*, Université de Lorraine, April 2018, <https://tel.archives-ouvertes.fr/tel-01789709>
- [12] E. KERRIEN. *Quelques contributions à l'imagerie médicale multimodale et interventionnelle*, Université de Lorraine, January 2018, Habilitation à diriger des recherches, <https://hal.inria.fr/tel-01754699>

Articles in International Peer-Reviewed Journals

- [13] J. GARCIA GUEVARA, I. PETERLIK, M.-O. BERGER, S. COTIN. *Biomechanics-based graph matching for augmented CT-CBCT*, in "International Journal of Computer Assisted Radiology and Surgery", April 2018, vol. 13, n^o 6, pp. 805-813 [DOI : 10.1007/s11548-018-1755-1], <https://hal.inria.fr/hal-01761521>
- [14] M. GREDIAC, B. BLAYSAT, F. SUR. *A robust-to-noise deconvolution algorithm to enhance displacement and strain maps obtained with local DIC and LSA*, in "Experimental Mechanics", 2018 [DOI : 10.1007/s11340-018-00461-4], <https://hal.archives-ouvertes.fr/hal-01926058>

- [15] M. GREDIAC, B. BLAYSAT, F. SUR. *Extracting displacement and strain fields from checkerboard images with the Localized Spectrum Analysis*, in "Experimental Mechanics", 2018 [DOI : 10.1007/s11340-018-00439-2], <https://hal.archives-ouvertes.fr/hal-01926054>
- [16] F. LAUS, F. PIERRE, G. STEIDL. *Nonlocal Myriad Filters for Cauchy Noise Removal*, in "Journal of Mathematical Imaging and Vision", April 2018, pp. 1-31, <https://arxiv.org/abs/1710.03015> [DOI : 10.1007/s10851-018-0816-Y], <https://hal.archives-ouvertes.fr/hal-01814104>
- [17] F. SUR, B. BLAYSAT, M. GREDIAC. *Rendering Deformed Speckle Images with a Boolean Model*, in "Journal of Mathematical Imaging and Vision", 2018, vol. 60, n^o 5, pp. 634-650 [DOI : 10.1007/s10851-017-0779-4], <https://hal.archives-ouvertes.fr/hal-01664997>
- [18] F. SUR. *A non-local dual-domain approach to cartoon and texture decomposition*, in "IEEE Transactions on Image Processing", 2019, vol. 28, n^o 4, pp. 1882-1894 [DOI : 10.1109/TIP.2018.2881906], <https://hal.archives-ouvertes.fr/hal-01925890>
- [19] P.-F. VILLARD, P. E. HAMMER, D. P. PERRIN, P. J. DEL NIDO, R. HOWE. *Fast Image-Based Mitral Valve Simulation from Individualized Geometry*, in "The International Journal of Medical Robotics and Computer Assisted Surgery", 2018 [DOI : 10.1002/RCS.1880], <https://hal.archives-ouvertes.fr/hal-01643868>

International Conferences with Proceedings

- [20] J. GARCIA GUEVARA, I. PETERLIK, M.-O. BERGER, S. COTIN. *Biomechanics-based graph matching for augmented CT-CBCT*, in "IPCAI 2018 - 9th International Conference on Information Processing in Computer-Assisted Interventions", Berlin, Germany, June 2018, <https://hal.inria.fr/hal-01761538>
- [21] V. GAUDILLIÈRE, G. SIMON, M.-O. BERGER. *Region-based epipolar and planar geometry estimation in low-textured environment*, in "ICIP 2018 - 25th IEEE International Conference on Image Processing, Oct 2018, Athens, Greece", Athènes, Greece, October 2018, <https://hal.archives-ouvertes.fr/hal-01802596>
- [22] M. GREDIAC, B. BLAYSAT, F. SUR. *Speckles and DIC or Checkerboards and LSA?*, in "SEM Annual Conference & Exposition on Experimental and Applied Mechanics", Greenville, United States, L. LAMBERTI, M.-T. LIN, C. FURLONG, C. SCIAMMARELLA, P. L. REU, M. A. SUTTON (editors), Springer, June 2018, vol. 3, pp. 79-80 [DOI : 10.1007/978-3-319-97481-1_9], <https://hal.archives-ouvertes.fr/hal-01896817>
- [23] G. SIMON, A. FOND, M.-O. BERGER. *A-Contrario Horizon-First Vanishing Point Detection Using Second-Order Grouping Laws*, in "ECCV 2018 - European Conference on Computer Vision", Munich, Germany, September 2018, <https://hal.inria.fr/hal-01865251>
- [24] F. SUR, B. BLAYSAT, M. GREDIAC. *Speckle Image Rendering for DIC Performance Assessment*, in "SEM Annual Conference & Exposition on Experimental and Applied Mechanics", Greenville, United States, L. LAMBERTI, M.-T. LIN, C. FURLONG, C. SCIAMMARELLA, P. L. REU, M. A. SUTTON (editors), Springer, June 2018, vol. 3, pp. 75-77 [DOI : 10.1007/978-3-319-97481-1_8], <https://hal.archives-ouvertes.fr/hal-01896811>

National Conferences with Proceedings

- [25] V. GAUDILLIÈRE, G. SIMON, M.-O. BERGER. *Estimation des géométries planaire et épipolaire en environnement faiblement texturé basée sur la mise en correspondance de régions*, in "RFIAP 2018 - Congrès Recon-

naissance des Formes, Image, Apprentissage et Perception", Marne-la-Vallée, France, June 2018, <https://hal.archives-ouvertes.fr/hal-01802538>

Conferences without Proceedings

- [26] F. PIERRE. *Exemplar-based face colorization using image morphing*, in "SIAM Conference on IMAGING SCIENCE", Bologna, Italy, June 2018, <https://hal.archives-ouvertes.fr/hal-01824827>

Other Publications

- [27] P. TAN, F. PIERRE, M. NIKOLOVA. *Inertial Alternating Generalized Forward-Backward Splitting for Image Colorization*, May 2018, working paper or preprint, <https://hal.archives-ouvertes.fr/hal-01792432>

References in notes

- [28] E. SERRADELL, M. A. PINHEIRO, R. SZNITMAN, J. KYBIC, F. NOGUER, P. FUA. *Non-Rigid Graph Registration Using Active Testing Search*, in "IEEE Transactions on Pattern Analysis & Machine Intelligence", March 2015, vol. 37, n^o 3, pp. 625-638