# 2025 *Activity Report*

RESEARCH CENTRE: **Inria Centre at Université de Lorraine**

IN PARTNERSHIP WITH: **Université de Lorraine, CNRS**

**Project-Team**

# TANGRAM

## Visual Registration with Physically Coherent Models

*In collaboration with* Laboratoire lorrain de recherche en informatique et ses applications (LORIA)

# Project-Team TANGRAM

*Creation of the Project-Team: 2020 December 01*

Each year, Inria research teams publish an Activity Report presenting their work and results over the reporting period. These reports follow a common structure, with some optional sections depending on the specific team. They typically begin by outlining the overall objectives and research programme, including the main research themes, goals, and methodological approaches. They also describe the application domains targeted by the team, highlighting the scientific or societal contexts in which their work is situated. The reports then present the highlights of the year, covering major scientific achievements, software developments, or teaching contributions. When relevant, they include sections on software, platforms, and open data, detailing the tools developed and how they are shared. A substantial part is dedicated to new results, where scientific contributions are described in detail, often with subsections specifying participants and associated keywords. Finally, the Activity Report addresses funding, contracts, partnerships, and collaborations at various levels, from industrial agreements to international cooperations. It also covers dissemination and teaching activities, such as participation in scientific events, outreach, and supervision. The document concludes with a presentation of scientific production, including major publications and those produced during the year.

# Keywords


## Computer sciences and digital sciences

A5.3. – Image processing and analysis

A5.6. – Virtual reality, augmented reality

A5.10.2. – Perception

A9.12. – Computer vision

A9.12.1. – Object recognition

A9.12.5. – Object tracking and motion analysis

A9.12.6. – Object localization

## Other research topics and application domains

B2.6. – Biological and medical imaging

B5.9. – Industrial maintenance

B9.5.3. – Physics

# Contents

# 1 Team members, visitors, external collaborators

## Research Scientists

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

## Faculty Members

- Vincent Gaudilliere [UL, Associate Professor]
- Fabien Pierre [UL, Associate Professor]
- Gilles Simon [UL, Professor, HDR]
- Frédéric Sur [UL, Professor, HDR]
- Pierre-Fredéric Villard [UL, Associate Professor, HDR]

## Post-Doctoral Fellow

- Fateme Ghayyem [UL, Post-Doctoral Fellow, from Sep 2025]

## PhD Students

- Nathan Boulangeot [UL, until Jan 2025]
- Radhouane Jilani [INRIA, until Jun 2025]
- Vaishnavi Kanagasabapathi [UNIV BOURGOGNE]
- Alexander Koch [UL (ENACT grant), from Nov 2025, Co-supervision with IADI]
- Hugo Leblond [UL]
- Liang Liao [CHRU NANCY]
- Nicolas Maignan [UL]
- Insaf Mellakh [UL, Co-supervision with IADI]
- Pengru Zhao [UL, Co-supervision with LEM3]

## Interns and Apprentices

- Dinojan David Anton [UL, Intern, from Nov 2025]
- Hugo Hayma [MINES NANCY, Intern, until Aug 2025]
- Tristan Quétin [UL, Intern, from Apr 2025 until Aug 2025]

## Administrative Assistant

- Emmanuelle Deschamps [INRIA]

## Visiting Scientists

- Hao Gao [University of Glasgow, from Sep 2025 until Oct 2025]
- Oleksii Nasypanyi [UNIV SUNY, until Feb 2025]

### External Collaborators

- Cédric Demonceaux [UNIV BOURGOGNE, HDR]
- Renato Martins [UNIV BOURGOGNE]

# 2 Overall objectives

Visual registration is a research topic with a rich history in computer vision. Though a plethora of methods have been developed and can be used for general situations, there are still many open problems which originate in the nature of the scene (poorly textured or specular environments), in the type of motion undergone by the object (tiny motions which hardly emerge from the noise floor, or in contrast, highly deformable objects) and in dissimilarities which may occur in the scene between the time the modeling stage occurs and the application time.

Registration is in practice tightly linked to the choice of the model which represents the scene and the desirable physical properties of the objects. Handling complex —possibly dynamic— scenes thus requires a tradeoff between physical realism of the model, convergence issues and robustness of the registration or tracking tasks.

Recent years have seen a surge in research at the intersection of image and deep learning which has impacted many topics of computer vision. Besides our continued exploration of modeling and registration with traditional approaches derived from signal processing, geometry, and robust estimation, one of the team's aims is to integrate machine learning methods, either as end-to-end methods or as components, into these 2D or 3D geometric tasks.

Targeted trans-disciplinary applications are mixed and augmented reality, computational photomechanics and minimally invasive medical interventions.

# 3 Research program

## 3.1 Localization and geometric reasoning with high level features

Our goal is to push forward vision-based scene understanding and localization through the joint use of learning-based methods with geometrical reasoning. Our hypothesis is that the use of intermediate representations instead or in addition to the classical point feature will lead to increased capacity in terms of scale and robustness to changing conditions. These intermediate representations can be concrete objects which are recognized and used directly in the global pose computation, in the continuity of our works on ellipsoid modeling of objects, or conceptual objects such as vanishing points (VP) or horizon lines that are of specific interest both for localization and modeling of urban or industrial scenes.

A first goal is to improve our method for localization from sets of ellipse/ellipsoid correspondences [4, 9]. Besides the need to have more accurate prediction of ellipses, another objective is to elaborate robust strategies and associated numerical schemes for refining the initial pose from a set of objects. This requires us to develop appropriate metrics for characterizing good reprojection of 3D objects onto 2D ones and study their impact on minimization issues in localization. Another goal is to define strategies to integrate into the localization procedure various features such as points, objects and VPs, which each bring information at different levels. We especially want to investigate how predictive uncertainty and explainability mechanisms can be used to select and weight these various features in the estimation process.

Finally, with the recent emergence of Gaussian Splatting and neural radiance field models, we aim at investingating methods for camera localization from such models.

## 3.2 Building dedicated models

In this line of research, our goal is to build physically coherent models with a good accuracy vs. efficiency compromise despite the interactive time constraint set in some targeted applications. Though general purpose solutions exist for building models, such techniques are still greatly challenged in more complex cases when specific constraints on the shape or its deformation must be met. This is especially the case in medical imaging of thin deformable organs, such as the diaphragm, the mitral valve or blood vessels, but also for classical scene modeling where constraints, such as ellipsoidal abstraction of objects, must be introduced. The use of mechanical models has become increasingly important in the team's activities in medical imaging, especially for handling organs with large deformations. We want to push forward the development of such models with image-guided procedures or predictive simulation in view.

Facing difficulties of meshing complex geometries, especially thin ones, we want to promote mesh free methods such as implicit models. In the continuity of past works [5], automatic adaptation of node locations and sizes to the image will be investigated to improve compactness, and computational efficiency of implicit models. As the fidelity of a mechanical model is often impaired by approximations required to solve its dynamical system equations at interactive frame rates, a second objective is to take advantage of our implicit models to improve contact and deformation resolution.

Another topic of interest is the investigation of shape-aware methods either for shape segmentation or shape recognition, in order to be able to enforce global shape constraints or geometric shape priors on the output of CNNs.

### 3.3 Estimation and inverse problems

Most aforementioned tasks lead to image-based inverse, possibly ill-posed, problems. While some of them can be solved with well-established estimation techniques, others necessitate the design of new strategies. In this perspective, we consider in this research axis several fundamental aspects of estimation, common to our problems, such as sampling methods, traditional optimization methods, or end-to-end learning methods for pose estimation.

#### 3.3.1 Optimization, variational calculus and numerical schemes

We are interested in non-convex optimization problems, especially those raised by variational calculus. While the convergence of numerical schemes is well established for convex problems, this is not always the case for non-convex functionals. Our aim is to continue the work already carried out in the biconvex framework [8], and extend it to primal-dual algorithms. We especially want to address energy minimization problems where the energy is convex with respect to each variable, but non-convex with respect to the pair of variables.

Another research topic is to investigate new neural architectures adapted to non-Euclidean data, and also to plug variational methods into deep learning approaches to regularize the results. The obtained theoretical results will be applied to image colorization, with the idea to reduce artefacts caused both by a lack of regularization and by the non-Euclidean structure of color information as perceived by the human visual system.

#### 3.3.2 Machine learning for physical problems

We aim at continuing our efforts towards supervised and unsupervised learning for estimation problems. Concerning supervised learning, we intend to investigate further the opportunities offered by neural network estimation of displacement and strain fields in experimental mechanics that we have recently introduced with colleagues in mechanics and signal processing [2]. Besides, we also aim at developing unsupervised learning in problems where a quantity has to be estimated over a spatio-temporal domain, which is a recent trend in several application domains. Neural networks are indeed universal approximators whose derivative can be exactly computed with the backpropagation algorithm, which is supposed to make them robust to acquisition noise.

## 4 Application domains

Applications on which our program is expected to have an impact are mixed reality, computational photomechanics and minimally invasive medical interventions. These fields correspond to areas where we have established trans-disciplinary collaborations with academic or industrial experts of the applicative fields. Common to these applications are the need for finely characterizing the acquisition context of vision-based applications and the need for accurate registration procedures. Another common point is the availability of a limited amount of data for characterizing the variability of the observed phenomena.

**Mixed reality** Being able to perform reliable and accurate registration under large viewpoint variations, seasonal or lighting changes opens the way towards challenging mixed reality applications. Urban AR and industrial maintenance in large and cluttered environments are examples of application fields that would successfully capitalize on more robust localization solutions. Improved robustness of camera localization is especially expected for poorly textured, specular environments and in the presence of repeated patterns that are common in industrial contexts

**Photomechanics** Photomechanics is the field of experimental mechanics which is dedicated to mechanical measurement from images. In particular, we are interested in contactless image-based methods for extensometry, that is the estimation of displacement and strain fields on the surface of materials subjected to different types of mechanical loads. Full-field extensometry is a challenging task since strains often have tiny values and result in gray level changes at the limit of the sensor noise floor. The economic stakes are high and concern for example the automotive and aeronautics industries, or civil engineering. In order for these methods to be adopted by industry, it is, however, necessary to quantify their metrological performance, which is limited by the registration process or by the image acquisition chain, and especially by sensor noise. This topic is the subject of a long-term trans-disciplinary collaboration with Institut Pascal (Clermont-Ferrand Université).

**Minimally invasive medical interventions** The trend towards the design and performance of minimally invasive procedures will increase in the near future. But the benefit for the patient is at the expense of the surgeon who can only sense the surgical scene through intra-operative imaging. Commercial solutions now exist to teach this increasingly difficult surgical gesture with interactive simulation technologies. However, challenges remain to fill the gap between the learning environment, where qualitative correctness of the setup is sufficient, and the surgical theater, where accuracy and predictability are required. In this context, we aim at addressing the key problem of modeling the geometry and dynamics of deformable organs and surgical devices, in order to make progress towards a faithful 3D rendition of the surgical scene. To circumscribe practical and experimental difficulties, three specific applications will be addressed with our clinical partners: intra-operative guidance in interventional neuroradiology, augmented reality for laparoscopic liver surgery, and simulation of the mitral valve behaviour.

# 5 Highlights of the year

## 5.1 Transdisciplinary work between computer vision and art history

In collaboration with historian Ludovic Balavoine, Gilles Simon has just published a book [30] on the works of the Van Eyck brothers and Rogier van der Weyden, Flemish painters from the first half of the $15^{th}$ century. The book reveals unexpected correspondences between geometric structures and iconographic narration.

## 5.2 Awards

- Pierre-Frédéric Villard is one of the authors of the paper "X-ray simulations with gVirtualXray in medicine and life sciences" which was awarded 3rd place at the Dirk Bartz Prize for Visual Computing in Medicine and Life Sciences 2025, and was presented at EuroVis 2025 [23].
- Erwan Kerrien received an Outstanding Reviewer award at the MIDL 2025 conference (Medical Imaging With Deep Learning)

# 6 Latest software developments, platforms, open data

## 6.1 Latest software developments

### 6.1.1 OA-SLAM

**Name:** Object-aided SLAM

**Keywords:** Localization, 3D reconstruction, Object detection

**Scientific Description:** Details on the method can be found in the paper published in ISMAR 2022 [9].

**Functional Description:** OA-SLAM uses objects as landmarks to improve the relocalization capabilities of SLAM systems. OA-SLAM builds on the point-based ORB-SLAM2. It allows online reconstruction of 3D objects modeled as ellipsoids from their detections in 2D images. OA-SLAM dramatically improves the relocalization capabilities of SLAM.

**News of the Year:** Various software updates. A docker is now available. Several object recognition systems can now be incorporated in OA-SLAM.

**URL:** `https://gitlab.inria.fr/tangram/oa-slam`

**Publication:** hal-03837883

**Contact:** Gilles Simon

**Participants:** Matthieu Zins, Vincent Gaudilliere, Gilles Simon, Marie-Odile Berger, Dinojan David Anton

### 6.1.2 DeepAnePose

**Name:** Pose estimation of brain aneurysms using deep learning

**Keywords:** Deep learning, Anomaly detection, Medical imaging, Brain MRI, Brain aneurysm, Pose estimation

**Functional Description:** DeepAnePose is a deep convolution network for the detection and pose estimation of intracranial aneurysms from 3D TOF-MRI images. It is a YOLOv3-inspired anchor-free detection model in 3D, extended with a pose estimation head, coupled with an original strategy for small patch generation that combines data augmentation and data synthesis.

**News of the Year:** The code has been generalized to enable more flexible choice of patch size. The reproducibility section was also updated to use a data format easier to reuse.

**URL:** `https://gitlab.INRIA.fr/yassis/DeepAnePose`

**Publications:** hal-04207337, hal-03391884, hal-03897642

**Contact:** Erwan Kerrien

**Participants:** Youssef Assis, Erwan Kerrien

**Partner:** Loria

## 6.2 Open data

The PreSPIN database was built and curated to support the work on algorithm development and evaluation within the PreSPIN PRC ANR project [27]. This database collects 210 3D TOF MRI data (*Time-of-Flight Magnetic Resonance Imaging*) involving 161 patients, with a subset presenting with both D0 and D1 data (Day-0 at patient arrival, and Day-1 the day after the intervention). Additionally, 54 D0 MR perfusion datasets were identified, among which 26 patients had corresponding D1 data included. These data are made available on Archimed platform from CIC-IT Nancy, with global descriptive characteristics and each 3D TOF data comes with a vascular segmentation produced by the deep learning model developed during the project.

# 7 New results

## 7.1 Visual localization

### 7.1.1 Depth-Aware 2-Point Consensus Maximization for Absolute Pose Estimation

**Participants:** Marie-Odile Berger, Oleksii Nasypanyi, Gilles Simon.

Accurately estimating the position of a camera within a known 3D map is essential for reconstruction and localisation. This is typically solved using the Perspective-n-Point (PnP) algorithm with RANSAC, which requires a minimum of three 2D–3D correspondences. Reducing the number of correspondences required can significantly lower the computational cost. To this end, several approaches have successfully exploited additional information, such as affine descriptors, surface normals or gravity direction, to constrain the pose estimation problem. Unfortunately, such information is not always available, and it often requires dedicated preprocessing of the map data. To address these limitations, we propose a depth-aware, two-point method that requires no such prior information and can be used with any standard 3D map. Our approach uses dense depth information from sensors or neural networks to provide geometric constraints directly from the query image. Using two correspondences with depth from at least one point, we estimate a partial pose that constrains five degrees of freedom, leaving only the rotation around the two-point axis undetermined. This constraint restricts 3D points to circular trajectories that project as conics in the image, providing a geometric test for outlier rejection before the final rotation is recovered through voting. Experiments on indoor and outdoor datasets demonstrate that our method achieves comparable or better accuracy than existing techniques, without the need for IMUs or specialised feature descriptors. This work is currently submitted to CVPR 2026.

### 7.1.2 Gaussian splatting and Visual localization

**Participants:** Marie-Odile Berger, Cédric Demonceaux, Hugo Leblond, Renato Martins, Gilles Simon.

Gaussian Splatting (GS) is a promising method of representing scenes for visual localisation and SLAM. Recent studies have examined loop closure detection using Gaussian registration to enhance map consistency and precision. However, reliably registering two GS representations from different acquisitions remains challenging.

Within the context of H. Leblond's PhD thesis, we have proposed a complete pipeline to perform the matching and registration given two GS maps. The method is grounded in generating orthographic bird's-eye views (BEVs) of optimized Gaussian models. The proposed approach leverages photometric and geometric information extracted directly from the GS to provide a trade-off of accuracy and invariance to different viewing changes (as types of GS maps, seasons, or illumination). Unlike existing 3D registration methods, which become inefficient as the number of Gaussians grows, our approach leverages 2D orthographic renders thus considerably reducing the registration complexity.

Experiments on two public datasets demonstrate that our method achieves higher accuracy than several existing baselines, while also maintaining better registration results when dealing with GS maps learned by different techniques (from 3DGS to LightGaussian), or GS maps presenting viewing changes such as varying illumination conditions. This work has been publisehd in a preliminary version at [25] and is accepted for publication at WACV 2026 [22].

### 7.1.3 Vanishing point computation and applications

**Participants:** Marie-Odile Berger, Cedric Demonceaux, Vaishnavi Kanagasabapathi, Renato Martins, Gilles Simon.

V. Kanagasabapathi's PhD thesis started in october 2024. Her thesis addresses the problem of visual feature learning on videos for scene understanding. Our goal is to design strategies that are capable of leveraging temporal consistency and physical constraints when a sequence of images is available. We are interested notably in designing strategies for vanishing point estimation from a sequence of images.

Vanishing points' detection applied to research in the history of art was the subject of a book co-authored by Gilles Simon and historian Ludovic Balavoine, published in December 2025 by Brepols [30]. Whether painters mastered perspective during the early Renaissance, as well as the ways in which it is employed in their works, proves to be a decisive criterion for attributing artworks and, more broadly, for understanding how perspective may have emerged at the beginning of the fifteenth century–both in Florence and, as this book demonstrates, in Flanders. Determining the presence of vanishing points in a painting is more complicated than it might appear, and analyses by art historians, who often disagree on key works, are not free from a degree of subjectivity. An *a-contrario* algorithm, introduced in [31] and described in the book's appendix, allows for an objective approach to these questions.

### 7.1.4 Object-based localization

**Participant:** Vincent Gaudillière, Gilles Simon, Marie-Odile Berger, Tristan Quétin, Dinojan David Anton, Hugo Hayma
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High-level landmarks such as objects present in the scene have proven to offer key advantages over low-level landmarks (i.e., points or lines) for localization such as lower multiplicity, higher detection repeatability across viewpoints, and possibly lower ambiguity compared to their local counterparts. However, existing solutions require the prior intervention of an expert to identify the object landmarks that can be used for localization in a given environment. Moreover, object detectors used in these methods must be finetuned to recognize objects beyond standard categories. The recent emergence of « zero-shot » and « open-vocabulary » object detectors based on vision-only and vision-language foundation models represents a promise of lower human intervention and easier deployment, but the consistency of their predictions under camera movements and their geometric accuracy are still to demonstrate.

To start assessing the advantages and limitations of foundation models in object-based localization, one Master project and two Master internships were conducted within the team.

- Hugo Hayma (Sept. 2024 - May 2025), second year civil engineering student at Mines Nancy, conducted a preliminary study on the use of a vision-language alignment model for object re-identification across different viewpoints. This work was carried out as part of a research initiation project.
- Tristan Quétin (April - Aug. 2025), first year Master student at Université Paris-Saclay, studied different visual and text prompting strategies for detecting uncommon objects (*e.g.*, valves, manometers, safety pictograms) inside images of industrial environments. The results of this internship will serve as a basis for proposing object-based localization methods suitable for deployment in uncommon types of environments.
- Dinojan David Anton (Nov. 2025 - Jan. 2026), third year civil engineering student at Mines Nancy, is working on integrating different open-vocabulary object detectors within an object-aided visual SLAM sofware previously developed within the team 6.1.1.

### 7.1.5 Anomaly detection

**Participant:** Vincent Gaudillière.

When performing object-based localization, one might need to discard certain unexpected objects possibly observed in the environment. Without a comprehensive list of such objects, they can still be identified as anomalies by observing differences with well-known expected objects. Indeed, one-class anomaly detection aims to detect objects that do not belong to a predefined normal class. However, in practice training data lack those anomalous samples; hence state-of-the-art methods are trained to discriminate between normal and synthetically-generated pseudo-anomalous data. Most methods use data augmentation techniques on normal images to simulate anomalies. However the best-performing ones implicitly leverage a geometric bias present in the benchmarking datasets. This limits their usability in more general conditions. Others are relying on basic noising schemes that may be suboptimal in capturing the underlying structure of normal data. To overcome these limitations, [20] considers frozen yet rich feature spaces given by pretrained models and create pseudo-anomalous features with a novel adaptive linear feature perturbation technique. It adapts the noise distribution to each sample applies decaying linear perturbations to feature vectors and further guides the classification process using a contrastive learning objective. Experimental evaluation conducted on both standard and geometric bias-free datasets demonstrates the superiority of our proposed approach with respect to comparable baselines.

#### 7.1.6 Multispectral information fusion

**Participant:** Vincent Gaudillière.

Visual localization may need to be performed under adversarial illumination conditions. To address such challenges, the combination of thermal and visible images has demonstrated major advantages. However, existing fusion methods rely on the critical assumption that the RGB-Thermal (RGB-T) image pairs are fully overlapping. These assumptions often do not hold in real-world applications, where only partial overlap between images can occur due to sensors configuration. Moreover, sensor failure can cause loss of information in one modality. In [16], we proposed a novel module called the Hybrid Attention (HA) mechanism as our main contribution to mitigate performance degradation caused by partial modality overlap and sensor failure, i.e. when at least part of the scene is acquired by only one sensor. We proposed an improved RGB-T fusion algorithm, robust against partial overlap and sensor failure encountered during inference in real-world applications. We also leveraged a mobile-friendly backbone to cope with resource constraints in embedded systems. We conducted experiments on the pedestrian detection problem, by simulating various partial overlap and sensor failure scenarios to evaluate the performance of our proposed method. The results demonstrate that our approach outperforms state-of-the-art methods, showcasing its superiority in handling real-world challenges.

### 7.2 Handling non rigid deformation

#### 7.2.1 Individual mitral valve modeling

**Participants:** Marie-Odile Berger, Nariman Khaledian, Pierre-Frédéric Villard, Hao Gao.

We continued our work on simulating mitral valve closure by incorporating the interaction between the leaflets and blood, while taking into account an anisotropic constitutive law and patient-specific data. This year, we have shifted our focus to scaling up the approach by testing it on multiple patient datasets [14]. To achieve this, we have adapted the biomechanical model to mitigate the impact of less smooth geometries on numerical accuracy. The model also considers the influence of modeling the left ventricle with a cylinder fitted to the valve dimensions or a large one as well as the influence of the fiber orientation in the anisotropic modeling of the leaflet.

In collaboration with the university of Glasgow, we introduced a parameterized framework for modeling the mitral valve, incorporating a universal coordinate system to standardize geometry across datasets. We demonstrated the initial feasibility study of this framework through dynamic mitral valve simulations using an immersed boundary method [24]. We intend to use this parameterization approach to generate data for deep learning applications or to enhance segmentation, particularly in cases involving incomplete or noisy data.

### 7.2.2 Image-based biomechanical simulation of the diaphragm during mechanical ventilation

**Participant:** Pierre-Frédéric Villard.

The ultimate goal of this project is to perform high-fidelity, real-time simulations of a critical care patient's respiratory function. The focus is on the respiratory muscles, the main one being the diaphragm. The first step is to create a realistic tissue model that enables us to simulate the muscle's passive deformation. This work is being carried out within the INVIVE project, in collaboration with the University of Uppsala. This year, we are working on generating feasible rib rotations using the existing medical data acquired in the project. These results will be used to generate boundary conditions for the diaphragm. The rib motions have been validated by our medical collaborator on the project.

## 7.3 Evaluation of X-ray simulations

**Participant:** Pierre-Frédéric Villard.

This year we worked on the evaluation of our tool gVXR that was developped in collaboration with the university of Bangor to generate X-rays on deformable meshes. It was initially developped for use in respiratory motion. We evaluated its potential in other applications both medical medical [23] and non-medical[18].

## 7.4 Interventional radiology

### 7.4.1 Detection of brain aneurysms using deep learning

**Participants:** Erwan Kerrien, Liang Liao, Fateme Ghayyem.

We collaborate with the department of Interventional Neuroradiology at CHRU Nancy, with René Anxionnat to further evaluate the performance or our deep neural network model to detect unruptured brain aneurysms from 3D TOF MRI data (Time-of-Flight Magnetic Resonance Imaging). In the context of Liang Liao's PhD thesis, our DeepAneDet algorithm was evaluated together with a second reference algorithm (nnDetection) with a focus on the impact of AI on clinical performance based on annotations of public database with 270 patients from a team of 5 annotators with varying experience in neuroimaging: experts (2), non-experts (2) and intermediate-level (1). We found that human observers are very good at removing false positive detection, but at the expense of many true positive when they lack expertise. Experts were the only one to not degrade, and even slighly improve, their sensibility. Our conclusion was that AI cannot replace experts, but can help improve non-experts performance if used in a very conservative way (remove only obvious false detections) [15].

Our work currently addresses the second variant, DeepAnePose 6.1.2, that is able to also infer the best orientation for the analysis of the aneurysm shape and its surrouding angioarchitecture. A database has been collected, and a team of annotators has been recruited, to compare this orientation with the actual orientation used during the intervention to treat the aneurysm.

Fateme Ghayyem started her post-doctoral work in September with the aim of improving the performance of our algorithms. A contrastive feature learning approach is currently under investigation, and is showing promise to improve the discrimination between positive (containing the center of an aneurysm) and negative grid cells, based on their embeddings.

### 7.4.2 Predictive simulation of catheter navigation

**Participants:** Radhouane Jilani, Erwan Kerrien, Pierre-Frédéric Villard.

Our main contribution to the PreSPIN ANR project consists in achieving smooth, interactive and predictive simulation of a catheter navigating in the brain vasculature.

Radhouane Jilani defended his PhD thesis this year [28]. The main results of his work were published in [13] under a solution for the quasi-static resolution of Cosserat rods in contact. A strain parametrization was employed to integrate contacts as generalized contact forces. We showed how these contact forces could be computed analytically when contact surfaces are defined by an implicit equation (e.g. using [5]), which in turn enables the use of implicit solvers. Numerical results show the stability of the proposed method in challenging contact scenarios, as well as improvements in computational time by two orders of magnitude compared to the use of explicit solvers.

Our current work investigates the use of deep neural networks to improve the accuracy and speed of our method. In particular PINNs (*Physics-Informed Neural Networks*) are considered to speed up physical computations, and Neural Implicit Surfaces to replace our current implicit surface representation.

### 7.4.3 Perfusion based on Digital Subtracted Angiography

**Participants:** Insaf Mellakh, Erwan Kerrien.

Assessing the perfusion status of the brain is paramount to evaluating the impact of an ischemic stroke on the brain function and the long term outcome of this medical emergency. Currently, perfusion imaging (CT – *Computed Tomography* – or MRI – *Magnetic Resonance Imaging*) is performed as part of the clinical assessment at onset, but clinicians have no means to evaluate it during the intervention or even during the post-operative period, and thereafter cannot assess the impact of the interventional except for clinical signs of the resoration of brain functions.

The goal of Insaf Mellakh's PhD, co-supervised with Julien Oster (IADI, INSERM), is to develop means of measuring the level of brain perfusion from Digital Subtracted Angiography sequences: X-ray images acquised at 2 to 6 frames per second during the injection of a contrat agent that highlights the blood circulation in the brain arteries, then parenchyma, then veins. The parenchyma has a very low signal which makes it difficult to isolate. We follow a source separation unsupervised approach, first blind, and more recently using gamma distribution model for each source, consistent with the dynamics of perfusion.

## 7.5 Neuro-oncology

**Participant:** Alexander Koch, , Erwan Kerrien. .

Alexander Koch started his PhD in November 2025, co-supervised by Prof. Antoine Verger (IADI, CHRU Nancy). It supports a new research project that aims to develop machine learning models based on learned features describing the complex relationships between voxels in 18F-FDOPA PET scans (Position Emission Tomography using Fluorodopa (18F), an amino acid radiotracer) in aggressive brain tumors known as gliomas. This work will develop along three axes: 1) Development of a self-supervised deep learning model to learn the representation of both healthy and pathological brains from multimodal PET and MRI images; 2) Identification of an aggressive subregion within a glioma using the previously constructed latent representation and MRI and PET images to assist in biopsy planning; and 3) Development of a classification model for differential diagnosis between radionecrosis and true progression, with evaluation in a clinical routine context.

## 7.6 Image and signal processing

### 7.6.1 Computational photomechanics

**Participant:** Frédéric Sur.

This year's work, together with Institut Pascal (Université Clermont-Auvergne), concerns several aspects of displacement and strain field measurement of a material subjected to compressive or tensile deformations. A first contribution is within the scope of the prediction of the metrological performance of full-field measurement system, which is a topical issue in the photomechanics community. Paper [11] discusses predictive equations giving the pixelwise standard deviation distribution of the noise affecting displacement and strain maps retrieved from checkerboard patterns deposited on the surface of the materials with the so-called Localised Spectrum Analysis (LSA). Noise in these maps is a consequence of sensor noise, which is modeled as a mixture of Gaussian and Poisson distributions. A second contribution [12] is an extension of the LSA method to stereo image pairs, enabling the measurement of 3D displacement fields on sample surfaces marked with optimal checkerboard patterns. A third contribution concerns the practical implementation of the checkerboard method. Paper [19] explains how to print a checkerboard pattern on a thin polymeric film and to glue the resulting laser-engraved film on the specimen surface. It also discussed the limitation of this approach.

### 7.6.2 Variational methods for image processing

**Participants:** Nicolas Maignan, Fabien Pierre, Frédéric Sur.

Image quality assessment is an essential component of research activities in image analysis and image processing. When a reference image is available, full-reference metrics such as the Peak Signal-to-Noise Ratio (PSNR) or the Structural Similarity Index (SSIM) are commonly used. However, in many application contexts, no reference image is accessible, which makes no-reference image quality assessment metrics necessary.

No-reference or 'blind' quality metrics, including BRISQUE and NIQE, estimate image quality by exploiting the statistical properties of natural images with the aim of reflecting human visual perception. Originally developed for grayscale images, these metrics do not explicitly account for chromatic information.

In the context of N. Maignan PhD thesis, a survey of these metrics, accompanied by a reference software code, has been submitted for publication in a journal, together with the extension to colour of existing referenceless metrics [26]. The work of the year involves extending BRISQUE and NIQE to colour images based on a few reference colour frames, building upon the assumption of deep video prior.

### 7.6.3 Contrast Highlighting of TV-Based Reconstructed Polarimetric Images

**Participants:** Fabien Pierre.

Using classical smoothers in restoration processes, such as total variation regularisation, while capturing well discontinuities, is known to induce an estimation bias in the final result, materialised by a loss of contrast. If the literature is prolific when dealing with standard modalities of images (grayscale or RGB images), it is more tenuous when the involved modality encodes some intrinsic geometrical properties, requiring the design of specific purpose-built algorithms. In this work, focused on such a specific modality, namely polarimetric imaging, we address the joint restoration and contrast re-enhancement (equivalently referred to as debiasing or refitting) question within an extension of the CLEAR framework (Covariant LEAst-square Refitting, [5]), emphasising the importance of preserving the Jacobian (with respect to the observed signal) of the original estimator.

## 7.7 Application of machine learning

### 7.7.1 Inversion of downhole resistivity properties through infrared spectroscopy and whole-rock geochemistry using machine-learning

**Participants:** Mehdi Serdoun, Frédéric Sur.

The PhD thesis of Mehdi Serdoun was co-supervised with Julien Mercadier (Géoressources, Université de Lorraine). It was part of the GeoMin3D project funded by ANR and Orano Mining, with the goal to develop statistical learning models to analyze the large amount of data of diverse nature provided during the exploratory drillings in Athabasca basin, the largest known source of uranium. The ultimate goal is to develop new analysis tools to accelerate exploration and reduce its cost, in cooperation with the industrial actors.

Publication [17] concerns electrical properties of rocks, which are widely used in the geophysical exploration of natural resources, such as minerals, hydrocarbons and groundwater. In mining exploration, the primary goal is to map electrically anomalous geological features associated with different mineralization styles, such as clay alteration haloes, metal oxides and sulphides, weathered crystalline rocks or fractured zones. As such, the reconciliation of geophysical data with geological information (geochemistry, mineralogy, texture and lithology) is a critical step and can be performed based on petrophysical properties collected either on core samples or as downhole measurements. Based on data from 189 diamond drill cores collected for uranium exploration in the Athabasca Basin (Saskatchewan, Canada), [17] presents a case study of reconciliation of downhole resistivity probing with core sample geochemistry and short-wave infrared spectroscopy (350–2500 nm). Another work, submitted for publication, aims at automating the classification of rock images using deep learning architectures. The biggest issue for practitioners when applying these methods to real-world datasets generated during mineral exploration is the long time required to create and label a dataset. This study proposes a complete workflow to label and classify drill core photographs with minimal time required for labeling through five successive steps: i) using exploration drill-core photographs, rock cores are separated from wooden trays using morphological operators; ii) feature descriptors are then extracted from rock images using color histograms for colorimetric information and Gabor filters for texture information; iii) features extractors then serve as input data for self-organizing maps (SOM) for generating clusters that can be partially labeled by geologists for generating a labeled dataset with limited efforts, generating a dataset made of labeled and unlabeled images; iv) the partially labeled dataset can then be used to train either fully supervised or semi-supervised deep learning architectures for generating classifications; v) the classification model obtained can then be re-used on unseen data to automate logging process.

### 7.7.2 Neural network architectures dedicated to crystalline orientations and Electron BackScattered Diffraction (EBSD)

**Participants:** Pengru Zhao, Frédéric Sur.

We are engaged in the co-supervision of the PhD thesis of Pengru Zhao with Lionel Germain (LEM3, Université de Lorraine). The goal is to develop machine learning models to process crystal orientation maps obtained by Electron Backscattered Diffraction (EBSD). The work of this year concerns the design and comparison of neural network architectures to detect grain boundary on the surface of crystalline structures, a simpler problem than EBSD data processing. A journal paper has been submitted.

# 8 Partnerships and cooperations

## 8.1 International research visitors

### 8.1.1 Visits of international scientists

#### Other international visits to the team

**Hao Gao**

**Status** Senior Lecturer

**Institution of origin:** University of Glasgow

**Country:** United Kingdom

**Dates:** 26/09/2025 - 18/10/2025

**Context of the visit:** The goal of the visit was to continue the work on data recording the behavior of a phantom valve acquired through the CURATIVE associated team.The work focused in particular on data modelling and obtaining a suitable mesh for dynamic simulation.

**Mobility program/type of mobility:** Invited professor funded by Inria

**Sarah Donaldson**

**Status**

**Institution of origin:** University of Glasgow

**Country:** United Kingdom

**Dates:** 26/09/2025 - 10/10/2025

**Context of the visit:** The visit was linked to Hao Gao's visit. While he was focusing on the mesh, Sarah Donaldson was working on the fluid-structure interaction.

**Mobility program/type of mobility:** Springboard Programme for bilateral UK-France partnership grants

**Oleksii Nasypanyi**

**Status** PhD

**Institution of origin:** State University of New York (SUNY)

**Country:** Korea

**Dates:** 1/1/2025-10/2/2025

**Context of the visit:** In the continuity of F. Rameau's visit last year, the goal of this visit was to design new approches to decompose minimal computer vision problems into smaller sub-problems where consensus maximization techniques can be applied on a smaller subset of points.

**Mobility program/type of mobility:** research stay

### 8.1.2 Visits to international teams

**Research stays abroad**

**Pierre-Frédéric Villard**

**Visited institution:** Uppsala University

**Country:** Sweden

**Dates:** 01/05/2025 - 31/05/2025

**Context of the visit:** In the context of our collaboration with Uppsala University on the diaphragm simulation, we worked on modeling the rib cage motion during breathing based on CT data to be used as boundary conditions for our diaphragm modeling.

**Mobility program/type of mobility:** Visiting research stay funded by the Swedish Scientific Council

## 8.2 European initiatives

### 8.2.1 Other european programs/initiatives

**Springboard Programme for bilateral UK-France partnership grants**

**Title** : Building Digital Twins for Mitral Valve: from images to mathematics, models and clinical impact

**Coordinator:** Pierre-Frédéric Villard and Hao Gao

**Participants:** PF. Villard, M.-O. Berger, E. Kerrien, I. Mellakh, F. Ghayyem

**Duration:** 2025-2026

**Additionnal info/keywords:** In this project, the overarching aim is to explore an efficient framework of developing a digital twin of mitral valve using routinely available clinical data and ex vivo experiments by integrating expertise from clinical imaging, machine learning and biomechanics modelling. Specifically, we will (1) identify the existing challenges in developing digital twins of MV; (2) integrate existing models for personalized modelling; (3) proof-of-concept of workflow design combining machine learning-based imaging processing and advanced computational models.

## 8.3 National initiatives

**PEPR ICCARE**

**Title** : Cultural and Creative Industries: Action, Research, Experimentation

**Coordinator:** Gilles Simon

**Participants:** G. Simon, M.-O. Berger

**Duration:** 2025-2030

**Additionnal info/keywords:** With a budget of €25 million for a six-year period, ICCARE's aim is to bring together research communities (human and social sciences/computer sciences) in a process of co-construction, co-realization and co-valorization, in order to help the cultural and creative industry transform and adapt to digital, economic and social challenges. Gilles Simon is joint coordinator of the "Museum and Heritage" sector, along with Lise Renaud (SHS, univ. Avignon) and Thomas Sagory (Musée d'Archéologie Nationale).

**ANR Arcé**

**Title** : Colorisation automatique de vidéos

**Coordinator:** Fabien Pierre

**Participants:** F. Pierre, N. Maignan, F. Sur

**Duration:** 2022-2026

**Additionnal info/keywords:** The Arcé project aims at proposing new methods for automatic, fast and perceptually satisfying video colorization. Image colorization methods based on deep learning based have encountered a great success in recent years. These techniques are fully automatic and very fast, but they have not been adopted by colorization industry. The reason is that they do not ensure the temporal coherence of the colorization, which is particularly disturbing for the viewer. The ultimate goal is the use of our work in audiovisual production studios.

**ANR PRC PreSPIN**

**Title:** Predictive Simulation for Planning Interventional Neuroradiology procedures

**Partners:** CReSTIC (Reims), Creatis (Lyon) and CIC-IT/CHRU Nancy

**Coordinateur:** Erwan Kerrien

**Participants:** Y. Assis, R. Jilani, E. Kerrien, P.-F Villard.

**Duration:** 2020-2026

**Additionnal info/keywords:** This project is coordinated by E. Kerrien. It aims at improving the planning phase in the therapeutic management of cerebral ischemic strokes thanks to predictive simulation of both the therapeutic interventional gesture and post-interventional perfusion images. The consortium is set to address the challenges of geometrical and topological modeling of the full brain vasculature; physics-based simulation of interventional devices; simulation of MRI perfusion images; and clinical validation.

# 9 Dissemination

## 9.1 Promoting scientific activities

### 9.1.1 Scientific events: organisation

- Pierre-Frederic Villard co-organized the Workshop on Digital Twins for Mitral Valve
- Gilles Simon co-organised four workshops within the PEPR ICCARE programme:
  - 06 Feb. 2025 – *Retour aux origines : pour une fresque des projets numériques patrimoniaux*, Paris, Carrefour numérique, Cité des sciences et de l'industrie.
  - 25 Mar. 2025 – *Étendre le rôle social des musées* (with Université Paris 1 Panthéon-Sorbonne), Paris, Conservatoire national des Arts et Métiers.
  - 03 Nov. 2025 – *IA et patrimoine* (with the CNRS GdR IASIS), Musée d'Archéologie nationale, Saint-Germain-en-Laye.
  - 16 Dec. 2025 – *(Re)voir et (re)vivre pour transmettre : les technologies immersives au service des patrimoines et des musées*, Lille, Musée de l'Hospice Comtesse.

### 9.1.2 Scientific events: selection

**Member of the conference program committees**

- Marie-Odile Berger was a member of the program committee of the International Conference on Extended Reality (ICXR).
- Frédéric Sur was a member of the program committee of the International Conference on Computer Vision Theory and Applications (VISAPP)
- Erwan Kerrien was an area chair for the Medical Imaging With Deep Learning (MIDL) conference

**Reviewer**

- Marie-Odile Berger was a reviewer for IROS (International Conference on Intelligent Robots and Systems), ICRA (IEEE International Conference on Robotics and Automation) and for the French conference ORASIS (Journées Francophones des Jeunes Chercheurs en Vision par Ordinateur).

- Pierre-Frédéric Villard was a reviewer for MICCAI (Medical Image Computing and Computer Assisted Interventions), the Eurographics Workshop on Visual Computing for Biology and Medicine, the International Conference on Computer Graphics, Visualization, Computer Vision And Image Processing and the national conference IABM (Colloque Français d'Intelligence Artificielle en Imagerie Biomédicale).
- Gilles Simon was a reviewer for ICXR, IROS, 3DV (International Conference on 3D Vision) and for the French conference ORASIS.
- Vincent Gaudillière was a reviewer for CVPR (Conference on Computer Vision and Pattern Recognition), ICCV (International Conference on Computer Vision) and ICXR.
- Erwan Kerrien was a reviewer for MIDL, MICCAI, ICRA conferences, and for the French symposiums IABM and ORASIS.

### 9.1.3 Journal

**Reviewer - reviewing activities**

- Frédéric Sur was a reviewer for Pattern Recognition Letters, Optics and Lasers in Engineering, Measurement, and IEEE Transactions on Instrumentation and Measurement.
- Erwan Kerrien was a reviewer for Medical Image Analysis, Medical Physics, International Journal of Computer Assisted Radiology and Surgery, IEEE Transactions on Image Processing, and the Journal of Neuroradiology.

### 9.1.4 Invited talks

- Pierre-Frédéric Villard did a presentation at Glasgow University on Thu 2025-02-20. Title : "Modeling the Mitral Valve: From Medical Image Analysis to Fluid-Structure Interaction".
- Pierre-Frederic Villard gave a seminar at the department of information technology of Uppsala University. Title: "Catheter Modeling using the Cosserat Rod" on May 2025.
- Pierre-Frédéric Villard did a presentation at KTH Royal Institute of Technology in Stockholm on 2025-05-23. Title: "Modeling the Mitral Valve: from image acquisition and segmentation to biomechanical simulations".
- Pierre-Frédéric Villard gave a talk at King's College on Fri 2025-11-07. Title: "Mitral Valve Modeling: From Image-Based Reconstruction to Fluid–Structure Interaction".
- Frédéric Sur gave a presentation at association Mecamat event *Apprentissage et Mesures de champs* on 2025-05-27. "A deep-learning model for displacement measurement in photomechanics".
- Erwan Kerrien did a presentation at *La Folle journée de l'anévrisme* in Nantes on 2025-12-11 meeting. Title: "Détection d'anévrismes intracrâniens assisté par IA: de la conception d'un modèle profond à son évaluation pour un usage clinique" (*AI-assisted intracranial aneurysm detection: From the design of a deep model to its evaluation for clinical use*).

### 9.1.5 Scientific expertise

- Marie-Odile Berger was a member of the recruitment committee for a professeur at Université de Lorraine.
- Gilles Simon served as a jury member for the recruitment of INRIA CRCN – NGE researchers.
- Gilles Simon and Erwan Kerrien served as external reviewers for an Inria Quadrant Programme (PIQ) project.
- Pierre-Frédéric Villard served as external reviewer for the Scientific Interest Group FC3R
- Frédéric Sur was a member of the recruitment committee for a professor and an associate professor, and the president for the recruitment committe for an associate professor at Université de Lorraine.

#### 9.1.6 Research administration

- Marie-Odile Berger is the head of the INRIA COMIPERS PhD and postdoctoral recruitment committee.
- Pierre-Frédéric Villard is an elected member of the Scientific Council of the Université de Lorraine
- Gilles Simon is coordinator of the "Museum and Heritage" sector of the Priority Research Programmes and Equipments (PEPR) ICCARE.
- Erwan Kerrien is the head of the Digital Health transversal axis of the Loria lab.
- Erwan Kerrien coordinates one of the 4 challenges of LIFE-TRAVEL Interdisciplinary Program for the I-Site *Initiative d'Excellence Lorraine*.
- Erwan Kerrien is a member of the steering committee of the Digital Health Community at Université de Lorraine. 2 local seminars about Cardiology and Oncology were organized and a newletter was created and launched.

### 9.2 Teaching - Supervision - Juries - Educational and pedagogical outreach

#### 9.2.1 Teaching

The professors and assistant professors of the TANGRAM 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 of Lorraine (ENSMN Nancy, SUPELEC Metz, ENSG, TELECOM Nancy). 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 is detailed below:

M.-O. Berger

Master : Shape recognition, 24 h, Université de Lorraine.

Master : Introduction to image processing, 12 h, ENSMN Nancy.

Erwan Kerrien

Master : Introduction to image processing, 15 h, ENSMN Nancy.

Master : Shape recognition, 12 h, Université de Lorraine.

Licence : Initiation to software developement, 25h, IUT St Dié-des-Vosges.

Fabien Pierre

Master: Introduction à l'apprentissage automatique, 14h, Mines Nancy.

Master: Vision artificielle et traitement des images, 12h, Polytech Nancy.

Licence: Introduction au traitement d'image, 30h, IUT Saint-Dié des Vosges.

Licence: Algorithmique et programmation, 87h, IUT Saint-Dié des Vosges

Licence: Culture scientifique et traitement de l'information, 69h, IUT Saint-Dié des Vosges

Licence: Programmation objet et évènementielle, 35h, IUT Saint-Dié des Vosges

Licence: Initiation à l'intelligence artificielle, 18h, IUT Saint-Dié des Vosges

G. Simon

Master: Augmented reality, 9 h, Télécom-Nancy.

Master: Augmented reality, 24h, M2 Informatique FST

Master: Visual data modeling, 12h, M1 Informatique FST

Master: Computer Vision, 12h, M1 Informatique FST

Licence pro: 3D modeling and augmented reality, 50h FST - CESS d'Epinal

Licence: Programming methodology, L1 informatique, 48h FST

F. Sur

Academic dean of École des Mines de Nancy.

Master: Introduction to machine learning, 40 h, Université de Lorraine (ENSMN Nancy).

Licence: Javascript programming, 100h, IUT Charlemagne

P.-F Villard

Master : Augmented and Virtual Reality, 16h, M2 Cognitive Sciences and Applications, Institut des Sciences du Digital, Université de Lorraine

Licence: Computer Graphics with webGL, 30h, IUT Saint-Dié des Vosges.

Licence: Virtual and Augmented Reality in Industrial Maintenance, 2h, Faculty of Science and Technology, Université de Lorraine

Licence: Web programming, 20h, IUT Saint-Dié des Vosges.

Licence: Graphical user interface programming, 30h, IUT Saint-Dié des Vosges.

Licence: Security and life privacy with internet, 2h, IUT Saint-Dié des Vosges.

Licence: Parallel programming, 18h, IUT Saint-Dié des Vosges.

Licence: Initiation to machine learning, 24h, IUT Saint-Dié des Vosges.

Licence: Initiation to cryptography, 12h, IUT Saint-Dié des Vosges.

V. Gaudillière

Master: Visual data representation, 6h, M1 informatique, FST.

Bachelor: Image synthesis, 16h, L3 informatique, FST.

Bachelor: Geometry for image synthesis, 30h, L2 informatique, FST.

Bachelor: Basics of object-oriented programming, 42h, L2 informatique, FST.

Bachelor: Algorithms and complexity, 18h, L2 informatique, FST.

Bachelor: Algorithmics and programming, 30h, L1 Sciences pour l'ingénieur, FST.

Bachelor: Synthesis project, 20h, L1 informatique, FST.

### 9.2.2 Supervision

- PhD completed: Radhouane Jilani, Predictive simulation for interventional neuroradiology, defended in June 2025, Erwan Kerrien, Pierre-Frédéric Villard.
- PhD completed: Nathan Boulangeot, Coupling machine learning and quantum chemistry methods to predict surface properties of intermetallic catalysts, defended in March 2025, Émilie Gaudry (Institut Jean-Lamour), Frédéric Sur.
- PhD completed: Mehdi Serdoun, Multivariate analysis of mineralogical, geochemical and physical signatures, defended in March 2025, Julien Mercadier (GéoRessources), Frédéric Sur.
- PhD in progress: Liang Liao, Detection of cerebral aneurysms from MRI images using deep learning: deep neural network creation and its clinical evaluation, November 2021, René Anxionnat (CHRU Nancy) and Erwan Kerrien.
- PhD in progress: Nicolas Maignan, Image and video colorization, October 2022, Fabien Pierre, Frédéric Sur.

- PhD in progress: Hugo Leblond, November 2023, Analyse de scènes dynamiques à partir d'une représentation neuronale implicite (NeRF) basée sur des données LiDAR-caméra, Gilles Simon, Renato Martins.
- PhD in progress: Pengru Zhao, February 2024, Neural network architectures dedicated to crystalline orientations and EBSD, Lionel Germain (LEM3), Frédéric Sur.
- PhD in progress: Insaf Mellakh, Quantitative analysis of X-ray angiography images in acute ischemic stroke, October 2024, Erwan Kerrien and Julien Oster (IADI, INSERM).
- PhD in progress: Vaishnavi Kanagabapathi, october 2024, Feature Learning with Temporal/Physical Constraints: Application to Vanishing Point Estimation on Videos, Renato Martins, Cédric Demonceaux, Gilles Simon.
- PhD in progress: François Rousseau, Inverse design of materials with machine learning and generative AI: a high entropy superalloy case study, May 2025, Thierry Belmonte and Alexandre Nominé (Institut Jean-Lamour), and Frédéric Sur.
- PhD in progress: Alexander Koch, Machine learning models for amino acid PET imaging to guide clinical routine decisions in neuro-oncology, Antoine Verger (IADI, CHRU Nancy) and Erwan Kerrien.
- HDR completed: Pierre-Frédéric Villard, Some Contributions to the Modeling of Organ Deformations, defended in April 2025, [29].

#### 9.2.3 Juries

- Marie-Odile Berger was president of the PhD committee of Asma Brazi (Ecole Nationale des Ponts et Chaussées) and Ricardo Espinosa Loera (Université de Lorraine). She was external reviewer for the HdR of Ewelina Rupnik (IGN) and Claire Dune (Université de Toulon), and for the PhD thesis of Idris Hamoud (Université de Strasbourg).
- Gilles Simon served as external reviewer for the PhD theses of Iad Abdul Raouf (Mines Paris), Gaétan Landreau (Université Paris-Saclay), and Stefan Larsen (Université Côte d'Azur), and as jury member for the PhD of Asma Brazi (École Nationale des Ponts et Chaussées).
- Frédéric Sur was an invited member of the PhD committee of Mehran Adibi Sedeh (Georgia-Tech Lorraine).
- Erwan Kerrien served as external reviewer for the PhD thesis of Juliette Moreau (Université Lyon 1), and was an invited member of the PhD committee of Pierre Rougé (Université Reims Champagne Ardennes) and Mbaimou Auxence Ngremmadji (Université de Lorraine).

#### 9.2.4 Educational and pedagogical outreach

Erwan Kerrien was a member of the steering committee of the National Education Program (*Programme National de Formation - PNF*) for Computer Science. Supervised by the French Ministry of Education and DGESCO (*Direction Générale de l'Enseignement Scolaire*), and with the support of Inria and SIF (*Société Informatique de France*), this committee is in charge of lifelong learning for the executive staff of the ministry. 4 webinars and a 2-day event in Nancy were organized this year.

### 9.3 Popularization

#### 9.3.1 Specific official responsibilities in science outreach structures

- Pierre-Frédéric Villard is the scientific godfather of the secondary school of Champigneulles (France) as a "Collège Pilote" of "La Main à la pâte" foundation.

- Erwan Kerrien is Chargé de Mission for scientific mediation at Inria research center at Université de Lorraine, 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", and member of the IREM Lorraine (Institut de Recherche sur l'Enseignement des Mathématiques - Research Institute for Teaching Mathematics) steering council.
- Erwan Kerrien shares the local coordination of MATh.en.JEANS in the Lorraine area with Samuel Tapie (until June 2025) and Aline Kurzmann (from June 2025) from the IECL lab (mathematics).
- Erwan Kerrien organized, with Samuel Tapie and Louisette Hiriart, the regional conference where all MATh.en.JEANS participants get together. Around 430 participants from Grand Est region, Luxembourg and Belgium, mainly middle and high schools students, gathered from April 23 to 25 in Nancy to present their work.

#### 9.3.2 Productions (articles, videos, podcasts, serious games, ...)

- Vincent Gaudilliere participated in the Loria's podcast presenting new permanent members (link).
- Erwan Kerrien published an article for Inria.fr institutional website: "Using AI to help diagnose brain aneurysms"
- Erwan Kerrien helped in the design and evaluation of a module for MediaGames, that is related to the PreSPIN PRC ANR project. MediaGames is a serious game designed and developed by the scientific mediation department at Inria, and is funded by ANR.

#### 9.3.3 Participation in Live events

- Pierre-Fredéric Villard animated workshops on image recognition with deep learning during an outreach days for high school teachers in computer science.
- Pierre-Frédéric Villard presented deep learning techniques for automatic character recognition at the "Fête de la Science" in St-Dié-des-Vosges.
- Erwan Kerrien was an associate researcher to a MATh.en.JEANS workshop within Henri Loritz high school in Nancy, and Pierre Mendès France high school in Contrexéville.
- Erwan Kerrien did presentations to high school students in the context of the "Chiche!" initiative.

# 10 Scientific production

## 10.1 Major publications


[1] Y. Assis, L. Liao, F. Pierre, R. Anxionnat and E. Kerrien. 'Aneurysm Pose Estimation with Deep Learning'. In: *MICCAI, Lecture Notes in Computer Science book series (LNCS)*. Medical Image Computing and Computer Assisted Intervention (MICCAI). Vol. 14221. Vancouver, Canada, 1st Oct. 2023. DOI: 10.1007/978-3-031-43895-0_51. URL: https://hal.univ-lorraine.fr/hal-04207337.

[2] S. Boukhtache, K. Abdelouahab, F. Berry, B. Blaysat, M. Grediac and F. Sur. 'When Deep Learning Meets Digital Image Correlation'. In: *Optics and Lasers in Engineering* 136 (Jan. 2021), p. 106308. DOI: 10.1016/j.optlaseng.2020.106308. URL: https://hal.archives-ouvertes.fr/hal-02933431 (cit. on p. 7).

[3] A. Fond, M.-O. Berger and G. Simon. 'Model-image registration of a building's facade based on dense semantic segmentation'. In: *Computer Vision and Image Understanding* 206 (May 2021), p. 103185. DOI: 10.1016/j.cviu.2021.103185. URL: https://hal.inria.fr/hal-03204477.

[4] V. Gaudillière, G. Simon and M.-O. Berger. 'Perspective-1-Ellipsoid: Formulation, Analysis and Solutions of the Camera Pose Estimation Problem from One Ellipse-Ellipsoid Correspondence'. In: *International Journal of Computer Vision* (9th June 2023), p. 24. DOI: 10.1007/s11263-023-01794-x. URL: https://inria.hal.science/hal-04132261 (cit. on p. 6).

[5] E. Kerrien, A. Yureidini, J. Dequidt, C. Duriez, R. Anxionnat and S. Cotin. 'Blood vessel modeling for interactive simulation of interventional neuroradiology procedures'. In: *Medical Image Analysis* 35 (Jan. 2017), pp. 685–698. DOI: 10.1016/j.media.2016.10.003. URL: https://hal.inria.fr/hal-01390923 (cit. on pp. 7, 14).

[6] N. Khaledian, P.-F. Villard and M.-O. Berger. 'Capturing Contact in Mitral Valve Dynamic Closure with Fluid-Structure Interaction Simulation'. In: *International Journal of Computer Assisted Radiology and Surgery* (2022). DOI: 10.1007/s11548-022-02674-4. URL: https://inria.hal.science/hal-03708218.

[7] G. Simon. 'Jan Van Eyck's Perspectival System Elucidated Through Computer Vision'. In: *Proceedings of the ACM on Computer Graphics and Interactive Techniques* 4.2 (July 2021). DOI: 10.1145/3465623. URL: https://hal.univ-lorraine.fr/hal-03287031.

[8] P. Tan, F. Pierre and M. Nikolova. 'Inertial Alternating Generalized Forward-Backward Splitting for Image Colorization'. In: *Journal of Mathematical Imaging and Vision* 61.5 (Feb. 2019), pp. 672–690. DOI: 10.1007/s10851-019-00877-0. URL: https://hal.archives-ouvertes.fr/hal-01792432 (cit. on p. 7).

[9] M. Zins, G. Simon and M.-O. Berger. 'OA-SLAM: Leveraging Objects for Camera Relocalization in Visual SLAM'. In: ISMAR 2022 - 21st IEEE International Symposium on Mixed and Augmented Reality. Singapour, Singapore, 17th Oct. 2022. URL: https://hal.science/hal-03837883 (cit. on pp. 6, 9).

[10] M. Zins, G. Simon and M.-O. Berger. 'Object-Based Visual Camera Pose Estimation From Ellipsoidal Model and 3D-Aware Ellipse Prediction'. In: *International Journal of Computer Vision* 130 (7th Mar. 2022), pp. 1107–1126. DOI: 10.1007/s11263-022-01585-w. URL: https://hal.science/hal-03602394.

## 10.2 Publications of the year

### International journals

[11] M. Grédiac, F. Sur, A. Vinel, T. Jailin and B. Blaysat. 'Predicting Camera Sensor Noise Propagation to Displacement and Strain Maps Retrieved from Checkerboard Patterns with Localized Spectrum Analysis'. In: *Experimental Mechanics* (2025). DOI: 10.1007/s11340-025-01207-9. URL: https://hal.science/hal-05137052. In press (cit. on p. 15).

[12] T. Jailin, B. Blaysat, A. Vinel, R. Langlois, F. Sur and M. Grédiac. 'Performing Stereo-Measurements with Optimal Patterns Processed by Localised Spectrum Analysis'. In: *Experimental Mechanics* (2025). DOI: 10.1007/s11340-025-01217-7. URL: https://hal.science/hal-05308609. In press (cit. on p. 15).

[13] R. Jilani, P.-F. Villard and E. Kerrien. 'Quasi-Static Cosserat Rods in Contact with Implicit Surfaces'. In: *IEEE Robotics and Automation Letters* 10.7 (14th May 2025), pp. 6536–6543. DOI: 10.1109/LRA.2025.3570131. URL: https://hal.science/hal-05062860 (cit. on p. 14).

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