IN PARTNERSHIP WITH:
CNRS

Université de Lorraine

Activity Report 2012

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 Understanding

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Project-Team MAGRIT

Keywords: Computer Vision, Tracking, Modeling, Augmented Reality, Medical Images

Creation of the Project-Team: April 03, 2006 .

1. Members

Research Scientists
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Faculty Members
Gilles Simon [Associate Professor, Université de Lorraine]
Frédéric Sur [Associate Professor, Université de Lorraine]
Pierre-Frédéric Villard [Associate Professor, Université de Lorraine]
Brigitte Wrobel-Dautcourt [Associate Professor,Université de Lorraine]

External Collaborator
René Anxionnat [Medical Doctor, PhD, Professor CHRU Nancy]

Engineer
Christel Leonet [Engineer, Inria, until July 2012]

PhD Students
Srikrishna Bhat [Inria, since December 2008]
Ahmed Yureidini [Inria, since January 2010]
Nazim Haouchine [Inria, since January 2012, co-supervised by M.O. Berger and S. Cotin (EPI Shacra)]

Post-Doctoral Fellow
Matthieu Loosvelt [CNRS, Since October 2012]

Administrative Assistant
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2. Overall Objectives

2.1. Augmented reality

Augmented reality (AR) is a field of computer research which deals with the combination of real world and computer generated data in order to provide the user with a better understanding of his surrounding environment. Usually this refers to a system in which computer graphics are overlaid onto a live video picture or projected onto a transparent screen as in a head-up display.

Though there exist a few commercial examples demonstrating the effectiveness of the AR concept for certain applications, the state of the art in AR today is comparable to the early years of Virtual Reality. Many research ideas have been demonstrated but few have matured beyond lab-based prototypes.

Computer vision plays an important role in AR applications. Indeed, the seamless integration of computer generated objects at the right place according to the motion of the user needs automatic real-time detection and tracking. In addition, 3D reconstruction of the scene is needed to solve occlusions and light inter-reflexion between objects and to make easier the interactions of the user with the augmented scene. For fifteen years, much work has been successfully devoted to the problem of structure and motion, but these works are often formulated as off-line algorithms and require batch processing of several images acquired in a sequence. The challenge is now to design robust solutions to these problems with the aim to let the user free of his motion during AR applications and to widen the range of AR application to large and/or unstructured environments. More specifically, the Magrit team aims at addressing the following problems:

- On-line pose computation for structured and non structured environments: this problem is the cornerstone of AR systems and must be achieved in real time with a good accuracy.
- Long term management of AR applications: a key problem of numerous algorithms is the gradual drifting of the localization over time. One of our aims is to develop methods that improve the accuracy and the repeatability of the pose during arbitrarily long periods of motion.
- 3D modeling for AR applications: this problem is fundamental to manage light interactions between real and virtual objects, to solve occlusions and to obtain realistic fused images.

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, usability, reliability and robustness in order to widen the current application field of AR and to improve the freedom of the user during applications. Our main research directions concern two crucial issues, camera tracking and scene modeling. Methods are developed with a view to meet the expected robustness and to provide the user with a good perception of the augmented scene.

3. Scientific Foundations

3.1. Camera calibration and registration

One of the most basic problems currently limiting Augmented Reality 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, and the user should walk anywhere he pleases.

For several years, the Magrit project has been aiming at developing on-line and marker-less methods for camera pose computation. We have especially proposed a real-time system for camera tracking designed for indoor scenes [1]. The main difficulty with on-line tracking is to ensure robustness of the process. For off-line processes, robustness is achieved by using spatial and temporal coherence of the considered sequence through move-matching techniques. To get robustness for open-loop systems, we have developed a method which combines the advantage of move-matching methods and model-based methods by using a piecewise-planar model of the environment. This methodology can be used in a wide variety of environments: indoor scenes, urban scenes .... We are also concerned with the development of methods for camera stabilization. Indeed, statistical fluctuations in the viewpoint computations lead to unpleasant jittering or sliding effects, especially when the camera motion is small. We have proved that the use of model selection allows us to noticeably improve the visual impression and to reduce drift over time.

The success of pose computation largely depends on the quality of the matching stage over the sequence. Research are conducted in the team on the use of probabilistic methods to establish robust correspondences of features over time. The use of *a contrario* decision is under investigation to achieve this aim [3]. We especially address the complex case of matching in scenes with repeated patterns which are common in urban scenes. We also consider learning based techniques to improve the robustness of the matching stage.

Another way 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. Each technology approach has limitations: on the one hand, rapid head motions cause image features to undergo large motion between frames that may cause visual tracking to fail. On the other hand, inertial sensors response is largely independent from the user's motion but their accuracy is bad and their response is sensitive to metallic objects in the scene. In past works [1], we have proposed a system that makes an inertial sensor cooperate with the camera-based system in order to improve the robustness of the AR system to abrupt motions of the users, especially head motions. This work contributes to the reduction of the constraints on the users and the need to carefully control the environment during an AR application. Ongoing research on such hybrid systems are under consideration in our team with the aim to improve the accuracy of reconstruction techniques as well as to obtain dynamic models of organs in medical applications.

Finally, it must be noted that the registration problem must be addressed from the specific point of view of augmented reality: the success and the acceptance of an AR application does not only depend on the accuracy of the pose computation but also on the visual impression of the augmented scene. The search for the best compromise between accuracy and perception is therefore an important issue in this project. This research topic has been addressed in our project both in classical AR and in medical imaging in order to choose the camera model, including intrinsic parameters, which describes at best the considered camera.

3.2. Scene 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 occlusion and to compute light reflexions between the real and the virtual objects. Unlike pose computation which has to be computed in a sequential way, scene modeling can be considered as an off-line or an on-line problem according to the application. Within the team we have developed interactive in-situ modeling techniques dedicated to classical AR applications. We also developed off-line multimodal techniques dedicated to AR medical applications.

In-situ modeling
Most automatic techniques aim at reconstructing a sparse and thus unstructured set of points of the scene. Such models are obviously not appropriate to perform interaction with the scene. In addition, they are incomplete in the sense that they may omit features which are important for the accuracy of the pose recovered from 2D/3D correspondences. We have thus investigated interactive techniques with the aim of obtaining reliable and structured models of the scene. The goal of our approach is to develop immersive and intuitive interaction techniques which allow for scene modeling during the application [7].

Multimodal modeling 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 are acquired on the patient or possibly on the operating room through sensing technologies or various image acquisitions. 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's view of the environment.

Methods for multimodal modeling are strongly dependent on the image modalities and the organ specificities. We thus only address a restricted number of medical applications –interventional neuro-radiology and the Augmented Head project– 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 surgeon's training or patient's re-education/learning.

One of our main applications is about neuroradiology. For the last 15 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 a 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. An accurate definition of the target is a parameter of great importance for the success of the treatment. 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 Shacra EPI, we have proposed new methods for implicit modeling of the aneurysms with the aim of obtaining near real time simulation of the coil deployment in the aneurysm [4]. Multi-modality techniques for reconstruction are also considered within the european ASPI project, the aim of which is to build a dynamic model of the vocal tract from various images modalities (MRI, ultrasound, video) and magnetic sensors.

4. Application Domains

4.1. Augmented reality

We have a significant experience in the AR field especially through the European project ARIS (2001–2004) which aimed at developing effective and realistic AR systems for e-commerce and especially for interior design. Beyond this restrictive application field, this project allowed us to develop nearly real time camera tracking methods for multi-planar environments. Since then, we have amplified our research on multi-planar environments in order to obtain effective and robust AR systems in such environments. We currently investigate both automatic and interactive techniques for scene reconstruction/structure from motion methods in order to be able to consider large and unknown environments.

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. In particular, we aim at developing tools allowing the physicians to take advantage of the various existing imaging modalities on the brain in their clinical practice: 2D subtracted angiography (2DSA), 3D rotational angiography (3DRA), fluoroscopy, MRI,...Recent works concern the use of AR tools for neuronavigation and the development of simulation tools of the interventional act for training or planning. This last project is developed in collaboration with the EPI Shacra.

4.3. Augmented head

Visual information on a speaker, especially jaws and lips but also tongue position, noticeably improves speech intelligibility. Hence, having a realistic augmented head displaying both external and internal articulators could help language learning technology progress in giving the student a feedback on how to change articulation in order to achieve a correct pronunciation. The long term aim of the project is the acquisition of articulatory data and the design of a 3D+t articulatory model from various image modalities: external articulators are extracted from stereovision data, the tongue shape is acquired through ultrasound imaging, 3D images of all articulators can be obtained with MRI for sustained sounds, magnetic sensors are used to recover the tip of the tongue.

5. Software

5.1. Software

Our software efforts are integrated in a library called RAlib which contains our research development on image processing, registration (2D and 3D) and visualization. This library is licensed by the APP (French agency for software protection).

The visualization module is called QGLSG: it enables the visualization of images, 2D and 3D objects under a consistent perspective projection. It is based on Qt [1] and OpenScenegraph [2] libraries. The QGLSG library integrates innovative features such as online camera distortion correction, and invisible objects that can be incorporated in a scene so that virtual objects can cast shadows on real objects, and occlusion between virtual and real objects are easier to handle. The library was also ported to Mac OS and Windows and a full doxygen documentation was written.

6. New Results

6.1. Motion, scene and camera reconstruction

Participants: Marie-Odile Berger, Srikrishna Bhat, Christel Leonet, Gilles Simon, Frédéric Sur.

- **Enhancing the grid method for in-plane strain measurements**
  This work is motivated by a problem from experimental solid mechanics. The grid method permits to measure the heterogeneous strains on the surface of specimens subjected to mechanical tests. Among full-field measurement techniques, the grid method consists in transferring a regular grid on the surface of the specimen and in taking images of the grid before and after deformation. Windowed Fourier analysis then gives an estimate of the surface displacement and strain components. In a collaboration with Institut Pascal (Université Blaise Pascal, Clermont Ferrand), we have shown that the estimations obtained by this technique are approximately the convolution of the actual values with the analysis window. We have also characterized how the noise in the grid image impairs the displacement and strain maps [18]. This study has allowed us to improve the metrological performance of the grid method with deconvolution algorithms. A numerical and experimental study can be found in [17].
- **Visual words for pose computation**
  Visual vocabularies are standard tools in the object/image classification literature, and are emerging as a new tool for building point correspondences for pose estimation. Within S. Bhat's PhD thesis, we have proposed several methods for visual word construction dedicated to point matching, with structure from motion and pose estimation applications in view. The three dimensional geometry of a scene is first extracted with bundle adjustment techniques based on keypoint correspondences. These correspondences are obtained by grouping the set of all SIFT descriptors from the training images into visual words using transitive closure (TC) techniques. We obtain a more accurate 3D geometry than with classical image-to-image point matching. In a second on-line step, these visual words serve as 3D point descriptors that are robust to viewpoint change, and are used for building 2D-3D correspondences on-line during application, yielding the pose of the camera by solving the PnP problem. Several visual word formation techniques have been compared with respect to robustness to viewpoint change between the learning and the test images. Our experiments showed that the adaptive TC visual words are better in many ways when compared to other classical techniques such as K-means.

[1] http://qt.digia.com
[2] http://www.openscenegraph.org/projects/osg

More specifically, the work of this year has focused on improving pose estimation from visual words with respect to strong viewpoint changes. 2D-3D correspondences are actually difficult to establish if there are too large viewpoint changes between the image whose pose is sought and the images that yielded the visual words attached to 3D points. We assessed several viewpoint simulation techniques in order to enrich the visual word description of the 3D points.

- **Acquisition of 3D calibrated data**
  Christel Leonet joined the team in October 2010 as an Inria assistant engineer with the aim of building an integrated 3D acquisition system. More specifically, the objective of her work is to combine an IMU (Inertial Measurement Unit), a GPS receiver, a laser rangefinder and a video camera for ground truth data acquisitions of camera movements and scene structures. These data will be useful to validate several algorithms developed in our team. This year, a new visual pan tracking method has been designed and implemented. We considered spherical environments made of sparse video images instead of fully-covered environment maps which often suffer from geometric and photometric misalignments. The scanning process has been improved in order to increase the accuracy of the recovered polygons and allow for visual assessments of this accuracy. The 3D laser pointer has been validated in several indoor environments. Finally, the GPS has been integrated to the system and preliminary results have been obtained in outdoor environments.

6.2. Medical imaging

Participants: René Anxionnat, Marie-Odile Berger, Nazim Haouchine, Erwan Kerrien, Pierre-Frédéric Villard, Brigitte Wrobel-Dautcourt, Ahmed Yureidini.

- **Vessel reconstruction with implicit surfaces**
  This research activity is led in collaboration with Shacra project-team from Inria Lille-Nord Europe and the Department of Interventional Neuroradiology from Nancy University Hospital. It was pursued this year in the context of the SOFA-InterMedS Inria Large-Scale Initiative (http://www.sofa-framework.org/).

  Our objective is to offer the interventional radiologists with a patient-based interactive simulator [16]. The medical applications are training to endovascular procedures, planning the intervention, and augmenting the intra-operative images with 3D simulated data. Our contributions address vasculature modeling from patient data, namely 3D rotational angiography (3DRA) volumes. The segmentation should be both user friendly and generate a vascular surface model that is compliant with the computing constraints set in interactive simulation. Within A. Yureidini's PhD thesis, a new model was developed consisting of a tree of local implicit blobby models. The algorithm consists of two steps: first, a vessel tracking step to extract the vessel topology and, second, fitting local surface data points with implicit blobby models at each node point on the vessel centerline.

  An extensive validation of our RANSAC-based vessel tracking algorithm was performed [14], by comparison with state of the art Multiple Hypothesis Testing [19] on 10 patient data. Fitting the implicit model to patient data relies on the minimization of a multi-termed energy. A closed form solution was derived, and a blob selection and subdivision heuristic was described to implement an efficient energy minimization algorithm. Both the geometric accuracy and compactness of the resulting vascular models were shown to be excellent [15].

  Our current goals are: first, to further enhance model compactness by relying on the robustness and versatility of the modeling algorithm and using sparser vascular centerline trees; second, to mathematically ensure the continuity between neighboring local implicit models; and third, to reintroduce the raw image data for a more accurate energy computation, with the aim to design a blobby deformable model.

This model was implemented in Sofa simulation platform, enabling interactive simulation time and thereby showing an impressive realism during tool navigation. On-going preliminary medical evaluation is being carried on by our fellow interventional radiologist in the framework of intervention planning.

- **Designing respiration models for patient based simulators**
  The work presented here has been done within a collaboration with Imperial College of London, Bangor University and Inria Aviz team.

  Respiratory models could be a key component in increasing realism in medical simulators. We have previously developed such kind of model. However finding the good parameters to tune the model so that it corresponds to a real patient behavior is not an easy task.

  This year, we have studied methods to automatically tune the elasticity of soft-tissues and the respiratory model parameters based on patient data. The estimation is based on two 3D Computed Tomography scans of the same patient at two different time steps. The parametrization of the model is considered as an inverse problem. Optimization techniques have then been deployed to solve the problem.

  In [13], we used a random search algorithm to generate a given number of sets of 15 random parameters. The set of parameters that provides the lowest fitness is extracted and corresponds to the solution of the optimization problem.

  In [9], we have made use of an ad-hoc evolutionary algorithm that is able to explore a search space with 15 dimensions. Our method is fully automatic and auto-adaptive. A compound fitness function has been designed to account for various quantities that have to be minimized. The algorithm efficiency was experimentally analyzed on several real test-cases: i) three patient datasets have been acquired with the “breath hold” protocol, and ii) two datasets corresponds to 4D CT scans. The performance was compared with two traditional methods (downhill simplex and conjugate gradient descent), our random search method and a basic real-valued genetic algorithm. The results showed that our evolutionary scheme provides more significantly stable and accurate results.

- **Physics-based augmented reality**
  The development of AR systems for use in the medical field faces one major challenge: the correct superposition of pre-operative data onto intraoperative images. This task is especially difficult when laparospic surgery is considered since superposition must be achieved on deformable organs. Most existing AR systems only consider rigid registration between the pre and intraoperative data and the transformation is often computed interactively or from markers attached to the patient’s body. In cooperation with the Shacra team, we have introduced an original method to perform augmented or mixed reality on deformable objects. Compared to state-of-the-art techniques, our method is able to track deformations of volumetric objects and not only surfacic objects. A flexible framework that relies on the combination of 3D motion estimation obtained from stereoscopic data and a physics-based deformable model used as a regularization and interpolation step allows us to perform non-rigid and robust registration between the pre and intraoperative images [10].

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

- ANR ARTIS (2009-2013)
  Participants: M.O. Berger, E. Kerrien, M. Loosvelt.
  The main objective of this fundamental research project is to develop inversion tools and to design and implement methods that allow for the production of augmented speech from the speech sound

signal alone or with video images of the speaker's face. The Magrit team is especially concerned with the development of procedures allowing for the automatic construction of a speaker's model from various imaging modalities.

- ANR Visac (2009-2012)
  Participants: M.O. Berger, B. Wrobel-Dautcourt.
  The ANR Visac is about acoustic-visual speech synthesis by bimodal concatenation. The major challenge of this project is to perform speech synthesis with its acoustic and visible components simultaneously. Within this project, the role of the Magrit team is to build a stereovision system able to record synchronized audio-visual sequences at a high frame rate [11].
- ANR IDeaS (2012-2016)
  Participants: R. Anxionnat, M.O. Berger, E. Kerrien.
  The IDeaS Young Researcher ANR grant explores the potential of Image Driven Simulation (IDS) applied to interventional neuroradiology. IDS recognizes the current, and maybe essential, incapacity of interactive simulation to exactly superimposes onto actual data. Reasons are various: physical models are often inherently approximations of reality, simplifications must be made to reach interactive rates of computation, (bio-)mechanical parameters of the organs and surgical devices cannot but be known with uncertainty, data are noisy. This project investigates filtering techniques to fuse simulated and real data. Magrit team is in particular responsible for image processing and filtering techniques development, as well as validation.

7.1.2. AEN SOFA

Participants: R. Anxionnat, M.O. Berger, E. Kerrien, A. Yureidini.
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 Shacra Inria project-team in Lille and the Department of diagnostic and therapeutic interventional neuroradiology of Nancy University Hospital. We aim at providing in-vivo models of the patient's organs, and in particular a precise geometric model of the arterial wall. Such a model is used by Shacra team to simulate the coil deployment within an intracranial aneurysm. The associated medical team in Nancy, and in particular our external collaborator René Anxionnat, is in charge of validating our results.

7.1.3. Institut Pascal, Université de Clermont-Ferrand

Since June 2012, we are engaged in a collaboration with Pr. Michel Grédiac. The aim is to give a mathematical analysis and to help improving the image processing tools used in experimental mechanics at Institut Pascal.

7.2. European Initiatives

7.2.1. Collaborations with Major European Organizations

Partner 1: Imperial College, London.

Pierre-Frédéric Villard has a Honorary Research Fellow contract with Imperial College. The collaboration has involved 2 research visits in London in summer to mainly discuss about the ongoing work on parameters optimization. There was also a participation as an activity leader in two one-week summer schools on Haptic Technology (to give the basics of computer haptics, including visual and haptics rendering, force feedback, haptic interfaces, collision detection, collision response and deformation modelling).

8. Dissemination

8.1. Scientific Animation

- The members of the team reviewed articles for IEEE Transactions On Robotics, IEEE Transactions on Visualization and Computer Graphics, Medical Image Analysis, International Journal of Computer Vision Signal, Image and Video Processing, Signal Processing Letters.
- M.O. Berger was a member of the program committee of the following conferences: IEEE International Symposium on Mixed and Augmented Reality (ISMAR 2012), International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2012), the IEEE International Symposium on Biomedical Imaging (ISBI) 2012, International Congerence on pattern recognition (ICPR 2012).
- M.O Berger co-organized with Christian Daul (CRAN, Nancy) a one day worshop on medical imaging in Nancy. M.O Berger co-organized with Christian Linte the AE-CAI satellite MICCAI worhshop (Augmented Environments and Computer-Assisted Interventions) in Nice.
- Gilles Simon was a member of the program committee of ISMAR 2012, Mobile HCI and Computer Graphics International 2012. He was an invited speaker at the "Journées Réalité Virtuelle et Augmentée", 19-24 February 2012, Ecole Militaire Polytechnique d'Alger.
- P.F. Villard was a member of the program committee of MICCAI 2012,CGVCVIP 2012 and ISBI 2012.
- E. Kerrien was a member of the program committee of MICCAI 2012.
- Members of the team are members of local management committees (Conseil de Laboratoire and Comité de Centre), and participate on a regular basis, to scientific awareness and mediation actions.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Licence: Mathématiques (analyse complexe, distributions), 20 h, École des Mines de Nancy, France

Licence: Graphic and haptic rendering (30h), IUT Saint-Dié des Vosges, France

Licence: Image processing(30h), IUT Saint-Dié des Vosges, France

Licence: 3D programming (30h), IUT Saint-Dié des Vosges, France

Licence: Object oriented programming (110h),IUT Saint-Dié des Vosges, France

Licence: Outils informatiques et internet, 20 h, L1, Université de Lorraine, France

Licence: Programmation shell-script sous Linux, 30 h, L2, Université de Lorraine, France

Licence: Conception et programmation langage objet, 60 h, L2, Université de Lorraine, France

Licence: Introduction à la programmation objet; conception d'interfaces graphiques, 34 h, L2, Université de Lorraine, France

Licence: Programmation avancée en langage impératif classique, 14 h, L3, Université de Lorraine, France

Licence: Bases geométriques de l'imagerie, 25 h, L3, Université de Lorraine, France

Licence: Programmation et bases de données, 35 h, L3, Université de Lorraine, France

Licence: Modélisation 3D, 40 h, LP, Université de Lorraine, France

Master: Perception et raisonnement, 50 h, M1, Université de Lorraine, France

Master: Réalite augmentée, 30 h, M2, Université de Lorraine, France

Master: Réalite augmentée, 24 h, 2A, Télécom-Nancy, Université de Lorraine, France

Master: Reconnaissance des formes statistiques, 15 h, M2, Université de Lorraine, France

Master: Perception de la structure et du mouvement, 15 h, M2, Université de Lorraine, France

Master: Outils pour le traitement et l'analyse d'images, 21 h, 2A, École des Mines de Nancy, France

Master: Modélisation et prévision (régression linéaire, séries chronologiques), 48 h, École des Mines de Nancy, France
Master: Recherche opérationnelle, 59 h, École des Mines de Nancy, France
Master: Initiation au traitement du signal et applications, 21 h, Ecole des Mines de Nancy, France
Master: Méthodes et outils pour la conception informatique, 34 h, 2A, Télécom-Nancy, Université de Lorraine, France
SUPELEC: Réalite augmentée, 3 h, 3A, SUPELEC Metz, France
DIU: Robotique chirurgicale, 1 h, CHU Nancy Univ. Hospital, France.

8.2.2. Supervision

PhD in progress: S. Bhat, Learning methods for pose computation, December 2008, Marie-Odile Berger, Frédéric Sur.
PhD in progress: Ahmed Yureidini, Modélisation implicite des vaisseaux sanguins pour la simulation interactive d'actes de radiologie interventionnelle, January 2010, Erwan Kerrien, Stéphane Cotin (Shacra, Lille).
PhD in progress: Nazim Haouchine, Modèles physiques pour la réalité augmentée des organes déformables, Janvier 2012, Marie-Odile Berger, Stéphane Cotin (Shacra, Lille).

8.2.3. Juries

- Marie-Odile Berger was reviewer of the PhD of A. Letouzey, Z. Droueche and of the HDR of E. Prados.
- Erwan Kerrien was examiner for the PhD defense of G. Pizaine.

8.3. Popularization

- Members of the team participate on a regular basis, to scientific awareness and mediation actions:
  - Several team members participated to the "Fête de la Science 2012"
  - Gilles Simon chaired a "Café Scientifique" in Nancy on the subject of augmented reality.
  - Erwan Kerrien was an associate researcher to a MATh.en.JEANS workshop, and is a member of the local Scientific Mediation Committee.
- A transdisciplinarity project has been initiated with the IUFM de Lorraine (teacher training institute), in order to assess the relevance of using augmented reality in learning astronomy at primary school. A tangible user interface has been built to allow investigation of astronomical phenomena such as the periodical renewal of the seasons, the phases of the moon, or the regular succession of day and night. The interface has been experienced in two classrooms of 20 and 19 8-year-old and 10-year-old children and compared with traditional physical and virtual models. The questions that were investigated were: is the interface approachable enough to be used by children? Does it facilitate comprehension and learning of the phenomena by direct experience? Does it facilitate children concentration? Preliminary results tend to prove that the AR model allows a better conceptualization and favors learning for younger children. This work will be continued and may lead to one or several academic papers in the education field.
- We have designed and developed a software whose aim is to support students with learning computer programming. This software, named artEoz, enables a pedagogical view of the computer memory, dynamically changing while the user program is running. Using a nice visualization helps to understand the behavior on an object oriented program. This software concerns beginners as well experimented students thanks to its facilities to draw complex data structures. This software is licensed by the APP (French agency for software protection).

9. Bibliography

Major publications by the team in recent years

[1] M. ARON, G. SIMON, M.-O. BERGER. *Use of Inertial Sensors to Support Video Tracking*, in "Computer Animation and Virtual Worlds", 2007, vol. 18, p. 57-68, http://hal.inria.fr/inria-00110628/en/.

[2] M.-O. BERGER, R. ANXIONNAT, E. KERRIEN, L. PICARD, M. SODERMAN. *A methodology for validating a 3D imaging modality for brain AVM delineation: Application to 3DRA.*, in "Computerized Medical Imaging and Graphics", 2008, vol. 32, p. 544-553, http://hal.inria.fr/inria-00321688/en/.

[3] F. CAO, J. L. LISANI, J.-M. MOREL, P. MUSÉ, F. SUR. *A Theory of Shape Identification*, Lecture Notes in Mathematics, Springer, 2008, vol. 1948, XII, 264 p., http://hal.inria.fr/inria-00319719/en/.

[4] J. DEQUIDT, M. MARCHAL, C. DURIEZ, E. KERRIEN, S. COTIN. *Interactive Simulation of Embolization Coils: Modeling and Experimental Validation*, in "Medical Imaging Computing and Computer Assisted Intervention, MICCAI Lecture Notes in Computer Science", USA, 2008, vol. 5241, p. 695-702, http://hal.inria.fr/inria-00336907/en/.

[5] N. NOURY, F. SUR, M.-O. BERGER. *How to Overcome Perceptual Aliasing in ASIFT?*, in "6th International Symposium on Visual Computing - ISVC 2010", Etats-Unis Las Vegas, Lecture Notes in Computer Science, Springer, Sep 2010, http://hal.inria.fr/inria-00515375/en.

[6] 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.

[7] 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° 9, p. 827-841, http://hal.inria.fr/inria-00565129/en.

[8] 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 Norrkoping, May 2010, http://hal.inria.fr/inria-00474324/en.

Publications of the year

Articles in International Peer-Reviewed Journals

[9] F. 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° 10, p. 2942 - 2949 [*DOI :* 10.1109/TBME.2012.2213251], http://hal.inria.fr/hal-00731910.

International Conferences with Proceedings

[10] N. HAOUCHINE, J. DEQUIDT, E. KERRIEN, M.-O. BERGER, S. COTIN. *Physics-based Augmented Reality for 3D Deformable Object*, in "9th Workshop on Virtual Reality Interaction and Physical Simulation", December 2012.

[11] U. MUSTI, C. LAVECCHIA, V. COLOTTE, S. OUNI, B. WROBEL-DAUTCOURT, M.-O. BERGER. *ViSAC : Acoustic-Visual Speech Synthesis: The system and its evaluation*, in "FAA: The ACM 3rd International Symposium on Facial Analysis and Animation", Vienne, Autriche, September 2012, http://hal.inria.fr/hal-00762568.

[12] C. SAVARIAUX, P. BADIN, S. OUNI, B. WROBEL-DAUTCOURT. *Étude comparée de la précision de mesure des systèmes d'articulographie électromagnétique 3D : Wave et AG500*, in "29e Journées d'Études sur la Parole (JEP-TALN-RECITAL'2012)", Grenoble, France, ATALA-AFCP (editor), 2012, p. 513-520, http://hal.inria.fr/hal-00724682.

[13] P.-F. VILLARD, F. VIDAL, F. BELLO, N. JOHN. *A Method to Compute Respiration Parameters for Patient-based Simulators*, in "MMVR - Medicine Meets Virtual Reality 19", Newport Beach (CA), États-Unis, J. WESTWOOD (editor), IOS Press, 2012, p. 529-533, Best Poster Award [*DOI :* 10.3233/978-1-61499-022-2-529], http://hal.inria.fr/hal-00670512.

[14] A. YUREIDINI, E. KERRIEN, S. COTIN. *Robust RANSAC-based blood vessel segmentation*, in "SPIE Medical Imaging", San Diego, CA, États-Unis, D. R. HAYNOR, S. OURSELIN (editors), SPIE Press, February 2012, vol. 8314, 8314M [*DOI :* 10.1117/12.911670], http://hal.inria.fr/hal-00642003.

[15] A. YUREIDINI, E. KERRIEN, J. DEQUIDT, C. DURIEZ, S. COTIN. *Local implicit modeling of blood vessels for interactive simulation*, in "MICCAI - 15th International Conference on Medical Image Computing and Computer-Assisted Intervention", Nice, France, N. AYACHE, H. DELINGETTE, P. GOLLAND, K. MORIA (editors), Lecture Notes in Computer Science, Springer, October 2012, vol. 7510, p. 553-560 [*DOI :* 10.1007/978-3-642-33415-3_68], http://hal.inria.fr/hal-00741307.

Scientific Books (or Scientific Book chapters)

[16] Y. WEI, S. COTIN, J. DEQUIDT, C. DURIEZ, J. ALLARD, E. KERRIEN. *A (Near) Real-Time Simulation Method of Aneurysm Coil Embolization*, in "Aneurysm", Y. MURAI (editor), InTech, August 2012, p. 223-248 [*DOI :* 10.5772/48635], http://hal.inria.fr/hal-00736865.

Research Reports

[17] M. GRÉDIAC, F. SUR, C. BADULESCU, J.-D. MATHIAS. *Using deconvolution to improve the metrological performance of the grid method*, Inria, November 2012, n^{o} RR-8127, 39, http://hal.inria.fr/hal-00749812.

[18] F. SUR, M. GRÉDIAC. *Towards deconvolution to enhance the grid method for in-plane strain measurement*, Inria, November 2012, n^{o} RR-8126, 37, http://hal.inria.fr/hal-00749804.

References in notes

[19] O. FRIMAN, M. HINDENNACH, C. KÜHNEL, H.-O. PEITGEN. *Multiple hypothesis template tracking of small 3D vessel structures*, in "Medical Image Analysis", 2010, vol. 14, n^{o} 2, p. 160 - 171.