Projects

The MSLab at URJC Madrid will participate in 4 exciting projects in the network of RAINBOW. All 4 projects will share some common grounds:

- Research on fundamental simulation methods for interaction with anatomical models.
- Tight connection between applied research at a high-innovation industrial setting and scientific research in the academic setting at URJC.
- Participation in training activities of the RAINBOW network, including travel to in-person courses at other institutions.
- Additional research stays at other institutions within the network.
- Doctoral supervision by Prof. Miguel Otaduy at URJC, with co-supervision by a research lead at a collaborating company.

Spine Inverse Modelling for Scoliosis Brace Design

Academic partner: URJC

Industrial partner: Anatoscope

Objectives

Scoliosis impacts 1% to 4% of children between 6 and 14. While braces are commonly used to prevent or delay surgery, their design lacks precision since their effect on spine is indirect and hard to predict, as it occurs through soft tissue and the rib cage, and depends on material parameters of bones, ligaments and connective tissue, which cannot be measure in-vivo. The goal of this project is to identify these parameters to improve brace design. The scientific challenge is to produce a novel Inverse Method to compute these using imaging of the patient in different postures: bi-planar radiographs, optical scans, videos. A Finite Element model of the patient will be computed based on available CT or MRI imaging. The method will then compute the most appropriate material parameters to match the imaging produced in different poses.

Expected Results

An imaging protocol for spine mechanical characterization (type of images, number of necessary poses, etc.). Inverse methods to identify spine material parameters from optical images. A validation study to compare predicted vs. measured spine configuration, in patients wearing a scoliosis brace.

Interactive Optimization-Based Design of Cardiovascular Devices

Academic partner: URJC
Industrial partner: Next Limit

Objectives

Starting from medical imaging data of specific patients, the first objective will be to design automatic discretization methods for fluid mechanics with fuzzy boundaries. This objective will be then refined to accommodate spatio-temporal adaptive interface tracking. The second objective will be the design of interactive shape optimization methods for cardiovascular devices, using reduced data-driven approximations of the fluid mechanics simulations designed in the first objective. The third and final objective will address the creation of device editing tools for experts, relying on the interactive optimization methods for intuitive exploration of the design space. We will design novel methods to map design-space and biomechanical constraints to the space of intuitive visual handles, using interactive evaluation of sensitivity analysis.

Expected Results

Innovative tools for intuitive editing of cardiovascular devices, relying on interactive evaluation of fluid mechanics constraints. The editor will be initialized automatically from patient-specific medical images.

Optimization-Based Fusion of Surgical Planning Data for Intraoperative Navigation

Academic partner: URJC
Industrial partner: GMV

Objectives

This ESR will enable intelligent fusion of preoperative planning data with real patient anatomy in an intraoperative setting. The first objective will consist of a novel automated methodology to design a compact deformation model from a patient's medical image, using numerical coarsening methods. This compact model will be used to deform preoperative simulation data, navigation markers, etc. in an efficient manner. The second objective will consist of a novel variational formulation to match the input anatomy to intraoperative tracking data. The task will be formulated as a constrained optimization problem, which will be efficiently solved thanks to the compact deformation model resulting from the first objective. The third and final objective will comprise novel metaphors for the intuitive specification of objective functions and constraints for the optimization problem. This will allow clinicians to work directly on the patient data, without interacting with technical details. The fusion methods will be tested on an intraoperative radiotherapy planning and navigation tool.

Expected Results

An optimization tool for fusion of preoperative planning data into intraoperative navigation, built on top of novel compact deformation models of medical images, variational solvers for medical image fusion, and interface metaphors for problem specification. Intraoperative radiology will be selected as clinical test case.

Surgical Planning through Hands-on Medical Image Editing

Academic partner: URJC
Industrial partner: GMV

Objectives

Given a medical image of the anatomical region of interest, the first objective will consist of setting up, in an automated manner, an efficient yet reliable deformation model. This will be achieved through a novel approach that will combine segmentationfree meshing with ground-breaking nonlinear homogenization methods. Inclusion of support for topological changes in the homogenized deformation model. Finally, a third objective will consist of the design of novel natural interaction techniques for the manipulation and deformation of medical images. The target scenario will take the form of an intuitive clinical design application executed on a touch screen (e.g., a tablet PC), where the clinical expert will manipulate the anatomical image directly.. Novel interaction methods will enable the mapping of natural 2D gestures to the manipulation and deformation of the underlying 3D anatomy. The intuitive planning methods will be tested on an intraoperative radiotherapy planning tool.

Expected Results

Surgical planning tools that allow direct tangible interaction with medical image data on touch screens, built on top of novel deformation models based on nonlinear homogenization and natural interaction techniques for the manipulation and deformation of medical images.

Conditions

We seek candidates that can demonstrate excellent training on computational sciences, numerical methods, simulation methods and/or computer graphics, and who wish to develop highly innovative research in these areas, applied to medical settings.

We offer 3 positions for 3-year PhD contracts starting October 1, 2018

The economic conditions are set by the MSCA European Training Network program, with a gross annual pay of 32,221€.
In case of elegibility for family allowance, the gross annual pay increases to 34,437€.

The application process is open and ends on May 8, 2018

Requirements:

- Candidates must have carried out their undergraduate and/or master studies in one of the following areas: Computer Science, Engineering, Mathematics, Physics (or similar).
- Since the scholarship is part of the MSCA European Training Network program, candidates must - at the date of the recruitment - be “Early Stage Researchers” (i.e. in the first 4 years of their research career and not have a doctoral degree).
- Candidates cannot have resided in the country of their host organization (Spain) for more than 12 months in the three years immediately before the recruitment.
- Candidates must be, at the date of the recruitment, eligible for enrolment in the PhD program at URJC. This means that they must have completed an undergraduate degree and a Master program, granting no less than 300 ECTS (European Credit Transfer and Accumulation System). Completion of the Master studies is not a requirement to apply, but it is a requirement to start the contract (October 1, 2018). Candidates who have completed their studies outside the European system will have to certify their degrees by the date of recruitment.

Application data:

- CV, including if suitable: list of degrees, summary of grades and ranking among peers, research experience, professional experience, publications, portfolio.
- Personal statement.
- 2 letters of recommendation.
- Confirmation of being fluent in English (written and oral).
- Sort your preference for the research topic among:

1. Spine inverse modeling for scoliosis brace design.
2. Interactive optimization-based design of cardiovascular devices.
3. Surgical planning through hands-on medical image editing.