PASSPORT

PAtient Specific Simulation and PreOperative Realistic Training for liver surgery

PASSPORT aims at developing a dynamic liver modelling, which thanks to a preoperative surgical planning simulator, will allow to predict a surgery's feasibility and thus increase the rate of surgical treatment so as to save patients suffering from liver pathologies.

Objectives of the Project

The liver is one of the major organs in the human body and is in charge of more than 100 vital functions. Because of its many functions, its pathologies are also varied, numerous and unfortunately often lethal. In 2006, over 45,000 European citizens died of liver cirrhosis and 44,000 additional citizens of liver cancer, knowing that the same year 48,700 new liver cancer cases were declared and that the 5-year survival rate of liver cancer is 10%. The eligibility of a patient for a tumour resection is linked to a large set of parameters provided by clinical examination, medical imaging and biological analysis.

PASSPORT aims at offering the first patient-specific modelling that combines anatomical, mechanical, appearance and biological preoperative modelled information in a unified model of the patient so as to propose the first complete "Virtual Liver". To reach this objective, **PASSPORT** will:

- develop an innovative open-source and multi-level patient-specific model combining anatomical, mechanical, functional and biological liver properties
- develop novel dynamic modelling, integrating predictive liver regeneration, organ motion and deformation and providing the patient-specific minimal safety standardized FLR
- generate a highly realistic simulation environment for liver surgery planning and training
- validate all simulation models with internationally renowned medical experts.

Project Description

A 3-year work schedule will help to reach the scientific and technological objectives of **PASSPORT**.

The first step will consist in defining the 4 anatomical, mechanical, appearance and biological models on all information available on liver pre-operative images and surrounding anatomical and pathological structures. It includes anatomical information extracted from CT-scan, MRI or US, mechanical properties extracted from elastographic imaging, functional and biological information extracted from biopsy and blood analysis. These first 4 research orientations will each be dedicated to the development of one specific model.

Then, dynamics will have to be added to this static modelling through the development of organ motion and deformation modelling. All these 5 models will then be integrated in an open-source framework allowing to exploit them in a unified patient-specific modelling, which is the "heart" of the **PASSPORT** project.

As a result of all this data, the next step will consist in developing patient-specific pre-operative liver surgery planning, not only limited to liver volume and geometry, but also integrating the previous unified modelling by providing the minimal safety standardized Future Liver Remain (FLR). In parallel to this development, the project will develop patient-specific simulators for liver surgery allowing:

- the education of such procedures
- pre-operative simulation.

The described models will be integrated for simulation on an international open-source platform allowing both a better dissemination of results and a possible extension of results in other areas of the human body as well as other types of pathologies.

All these research developments will lead to a demonstration software which will be evaluated and tested by medical experts in liver surgery.

CASE STUDY / PRACTICAL EXAMPLE / SCENARIO

A patient undergoes a CT-scan and an elastography depicting 2 tumours and a hepatic fibrosis. From these images the PASSPORT software provides a geometrical, topological, mechanical, anatomical and appearance model of the liver and neighbouring organs. From a microscopic biopsy image combined with a diffusion image of the liver another PASSPORT software provides a biological modelling of the liver defining thus the minimal safety standardized FLR of the patient. All these models are then used in a preoperative surgical simulator allowing to plan the surgical intervention and train surgeons demonstrating the feasibility of the gesture that initially seemed impossible.

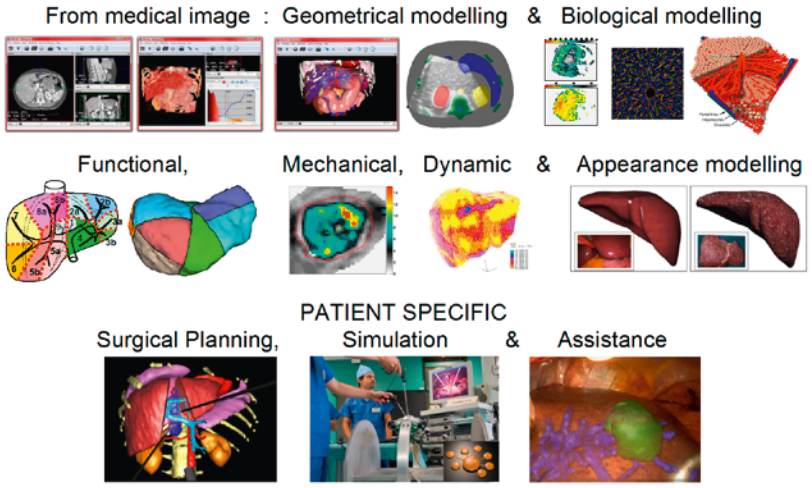
Due to the large number of static or dynamic models, **PASSPORT** is based on a large number of renowned partners or associated partners; each specialized in one or two modelling techniques or providing a clinical validation of the result. Each hospital and surgical team will be directly involved, as associated partner, in the validation of project outcomes which is vital for the development and success of that kind of technology.

Expected Results & Impacts

Eligibility for surgical resection is not only based on geometrical information (total liver volume) or topological information (vascular networks), but also on the physiological and biological state of patients (due to chemotherapy or pathology such as fibrosis). The resulting minimal safety standardized FLR is therefore a dynamic patient-specific value. The current evaluation of this value remains approximate and is very generic, reducing surgical eligibility. **PASSPORT** proposes to solve this complex limitation by developing the first patient-specific virtual liver, which will be composed of several integrated models providing all required information: anatomy, mechanics, appearance, and microbiology. By integrating these models in a unified virtual liver, **PASSPORT** allows the development of regeneration simulation and patient-specific preoperative surgical planning and simulation. This contributes to realize safe, controlled and predictable liver surgeries and thus, potentially increases the rate of operative solutions which will heal and save patients with serious liver diseases.

Realizing safe, controlled and predictable liver interventions.

PASSPORT also helps reinforcing the European competitiveness and market perspectives. Indeed, the international market in surgical simulation is currently changing due to the involvement of the surgical industry. **PASSPORT** will offer Europe's leading company in surgical instrumentation a real and efficient competitive tool on the surgical market against its international competitors.



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- Technische Universität München (Germany)
- Imperial College of Science, Technology and Medicine (UK)
- Institut National de Recherche en Informatique et en Automatique (France)
- Universität Leipzig (Germany)
- University College London (UK)
- Université de Strasbourg (France)
- KARL STORZ GmbH & CO. KG (Germany)
- Institut National de la Santé et de la Recherche Médicale (France)

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KEYWORDS
Liver, 3D Mesher, Segmentation,
Anatomical modelling, Elastography, Texture,
Biological, Dynamic, Vertical integration