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eHealth

Monthly Focus

PASSPORT

PAtient-Specific Simulation and PreOperative Realistic Training for liver surgery

European Commission
Information Society and Media

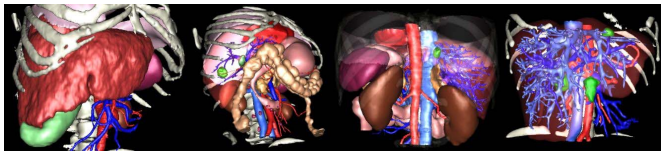
Surgery has the best survival rate in liver pathologies. However, the eligibility is limited due to a bad knowledge of each patient's hepatic specificities. PASSPORT will provide new models and tools to overcome such limits.

Clinical challenge

In 2006, over 45.000 European citizens died of cirrhosis of the liver and 44,000 additional citizens of liver cancer, knowing that the same year 48,700 new liver cancer cases were declared. Surgical procedures remain the options that offer the foremost success rate against such pathologies. Regretfully, surgery is not so frequent due to several limitations. Indeed, eligibility for liver surgery is based on anatomical and biological parameters that vary over time and from one patient to another. PASSPORT for Liver Surgery aims at increasing surgical eligibility by offering preoperative surgical simulation based on patient-specific modelling that combines anatomical, mechanical, appearance and biological preoperative modelled information. PASSPORT also aims at developing software allowing to use these models for hepatic surgical planning and education.

Geometrical and anatomical modelling

After two years, PASSPORT has already reached several of its objectives. The first task (workpackage, in short WP) of the project has thus led to a new automated and fast segmentation of thoraco-abdominal CT-scan images and a new liver and surrounding organs segmentation from US. It also provided a new mesh generation algorithm providing topologically correct meshes of segmented organs. In the same way, it allowed the integration of a mesh refinement algorithm in a framework dedicated to mesh and also the automatic quality estimation thanks to dedicated metrics that will be used for instance to both estimate the quality of a mesh for visualisation and for deformation simulation.



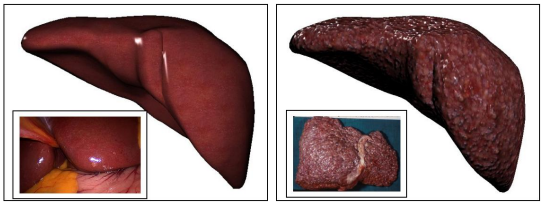
Patient-specific geometrical modelling: image segmentation followed by 3D mesh generation.

Moreover, this first WP has defined a new anatomical segmentation of the liver that avoids current anatomical mistakes and therefore improves the postoperative success of liver surgery. This new topologically correct patient-specific anatomy is based on the result of the state of the art in liver anatomy that showed that Couinaud's anatomy was correct in only 40% of cases.

Mechanic, texture, biology and dynamic models

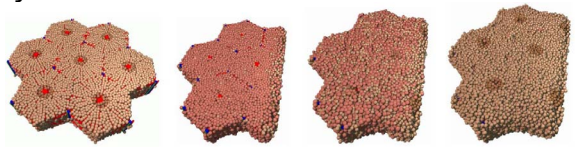
The second WP that aims at developing patient-specific mechanical modelling, has allowed to develop new MRI Elastographic (MRE) acquisition. Comparison with the Transcient US elastography clearly demonstrates greater quality of such modelling providing less errors in fibrosis detection. From an in vitro and experimental in vivo evaluation, we have also obtained a first Finite Model element of a liver that will be completed and linked to the MRE information during the upcoming last year of the project.

The third WP has provided an organ texture database from HD endoscopic views of real patients with and without liver pathologies. This database has been used to develop new high speed texture rendering techniques providing a fully realistic rendering. Moreover, an automatic texture generation from endoscopic views of patients has been developed.



Texture modelling providing high quality realism.

The fourth WP was aiming at providing biological modelling of the liver. Results achieved offer today the first effective simulation of liver cell regeneration. Moreover, MRI perfusion and diffusion image analysis developed in this WP offer the possibility to characterize liver pathologies from a MRI medical image. These results will have to be more precisely validated during the last year of the project.



Hepatic lobule regeneration simulation: cell scale.

The fifth WP is focusing on the **dynamic modelling of liver movements**. Several motion models have been derived from real-time MRI acquisitions, ultrasonic images, endoscopic images and external camera. First validations show a possible predictive simulation of liver movements during breathing cycles with a 2 mm precision.

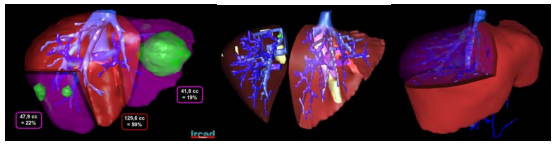
Integration

Thanks to WP6, the various models are progressively integrated in an opensource framework dedicated to surgical simulation: SOFA (www.sofa-framework.org). It allows to develop patient-specific simulation, a first educative version being already developed.

Moreover, several softwares have been developed in the integration WP7 from a new opensource framework dedicated to computer-assisted surgical software development (code.google.com/p/fw4spl). The **first one, 3D VPM 2.0, integrates new segmentation and modelling algorithms and can be used in another medical field of the Virtual Physiological Human**. The second one, VR-Render©IRCAD2010, a freeware available on the PASSPORT website, is a new DICOM viewer, integrating direct volume rendering techniques (that do not require organ modelling) and surface rendering techniques (after organ modelling). The initial patient medical image and resulting segmented organs can thus be easily visualized with this free user friendly software. The third one, VR-Render WebSurg Limited Edition ©IRCAD2010, is an educative version of VR-Render available freely on the free online virtual university WebSurg. It allows to link the patient modelling to an educative video of the surgery applied to the same patient. The last software, VR-Planning ©IRCAD2010, offers the opportunity to resect a liver with several topological components allowing thus multi segmentectomy. It then automatically computes the future liver remain rate and volumetry of each resected part.

Validation

From our results, we have created an online service providing free patient modelling to several associated European clinical teams. First results clearly demonstrate the benefits of the resulting patient-specific surgical planning based on a more precise Future Liver remain volumetry.



From the more than 300 models realized, an open anonymous database of real clinical cases has been created. This database containing medical images in DICOM and 3D models of organs is freely available to the scientific community on PASSPORT's website.

Partners

Eidgenoessische Technische Hochschule Zürich, Switzerland; Technische Universitaet Muenchen, Germany; Imperial College of Science, technology and Medicine, UK; Institut National de Recherche en Informatique et en Automatique, France ; Universitaet 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.

Timetable:	from 06/09 – to 05/11
Total cost:	5,46 million €
EC funding:	3,64 million €
Instrument:	STREP
Project Identifier:	FP7 ICT-2007.5.3

Important Link:

Project website: http://www.passport-liver.eu - VPH NoE: www.vph-noe.eu - http://www.biomedtown.org/biomed_town/VPH/

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