PhD Thesis :
Biomechanical and Physiological Modelling of the liver : Application to liver surgery training

Thesis Description

This thesis will take place in the framework of 2 collaborative projects. The first project is the European project PassPort that started on June 2008 and gathers several leading research institutions in Europe around the topic of image guided surgery training and planning : IRCAD (Strasbourg, France), Université Louis Pasteur (Strasbourg, France), Imperial College (London, UK), ETHZ (Zurich, CH), Munich Technical University (Munich, Germany), Leipzig University (Leipzig, Germany) and one industrial partner Karl Storz (Germany). The second project is internal at INRIA and is focused on developing medical training systems based on the software SOFA. This project involves two additional research teams working on complementary topics: Alcove (Lille), and Evasion (Grenoble).

The objective of the thesis is to develop personalized biomechanical and physiological models of the liver that are well suited for therapy training and planning. The biomechanics of the liver is quite complex since it is visco-elastic, non-linear and highly perfused soft tissue. The liver mechanical behaviour has been the object of several experimental studies both ex-vivo[1] and in-vivo[2]. While several constitutive models [3] for the liver have been proposed in the literature, their complexity is not suitable for real-time or sufficiently fast computation as required for therapy training or planning. Therefore a first objective of the thesis will be to propose a visco-elastic biomechanical model of the liver parenchyma which is suitable for real-time and quasi real-time applications. To the end, several approaches will be explored and possibly combined such as developing new constitutive models based on the theory of continuum mechanics, performing model reduction on a selected basis, defining specific finite elements or meshless discretization methods, using Graphics Processing Units to speed-up computations… Several aspects of this work will be carried out in close collaboration with the INRIA team Alcove and Evasion.
The second objective of the thesis is to define and evaluate a physiological model of the regeneration of liver cells under normal and diseased conditions (hepatitis, fibrosis, cirrhosis…). Indeed, the liver cells have the ability to regenerate following a liver resection,, but this ability may be limited upon several physiopathological factors. This modelling effort will be performed in collaboration with the University of Leipzig and will aim to develop a macroscopic partial differential equation capturing macroscopically the cellular growth. Evaluation of such macroscopic models based on medical images of patient cases must be performed to test the predictive power of such models.

All software development of this thesis will be based on the SOFA platform.

Requirements

- Master in computer science or applied mathematics
- Good knowledge of image processing, numerical analysis and preferably computational mechanics
- Good Knowledge in software engineering (unix and windows) and C++ development
- Fluent in English (written and spoken)

Practical Information

The PhD student will be hired for a period of 3 years starting between September and December 2008. The PhD will take place in the Asclepios team at the INRIA Sophia-Antipolis research centre located 20 km from Nice airport.

Contact informatiom

Send a curriculum vitae and a motivation letter by email to:

Hervé Delingette
Research Team Asclepios,
INRIA Sophia-Antipolis
2004 Route des Lucioles, BP93
F-06902 Sophia Antipolis Cedex, France
Tel: 04 92 38 77 64

[1]Amy E. Kerdok, Mark P. Ottensmeyer, Robert D. Howe Effects of Perfusion on the Viscoelastic Characteristics of Liver, Journal of Biomechanics, vol. 39, pp. 2221–2231, 2006.

[2] Mazza, E., Nava, A., Hahnloser, D., Jochum, W., Bajka, M. **The mechanical response of human liver and its relation to histology: An in vivo study** [1176] 2007, Medical Image Analysis, vol. 11, p. 663-672

[3] Amy E. Kerdok, Robert D. Howe, Simona Socrate, Viscoelastic Characterization of Perfused Liver: Indentation Testing and Preliminary Modeling, Proceedings of the ASME 2007 Summer Bioengineering Conference (SBC2007), Keystone, CO, June 20-24, 2007.