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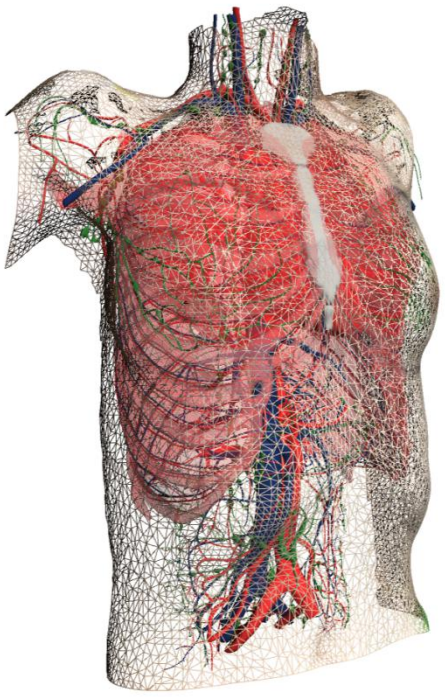
BIO-MECHANICAL BREAST SIMULATION (M/W)

General context

A lumpectomy (removal of the tumour and some surrounding tissues) is divided into two principal phases. First, a MRI in prone position (face to the ground) in order to localize the tumour in the position where the breast is the most expended. The day before the surgery, a radioactive marker or a hook is placed on the patient tumour in order to be able to remove it during the surgery. The next day, the surgery will be effectuated in supine position (the back of the patient is facing the ground easier for the surgeon) and thanks to the previous marker, the surgeon is able to remove the tumour.

Using these kind of markers is on one hand dangerous for the patient (radioactivity or infection risk) and on the other hand inaccurate during the surgery. Indeed, even if a marker is placed, detect radioactivity areas precisely or cut exactly the right amount of tumour around a hook is impossible for the moment. To overcome this problem surgeons usually cut more healthy tissues to be sure to completely remove the growth.

Specific context



To solve this problem, the University of Luxembourg and Anatoscope (french company) are working together to simulate the displacement of the tumor from prone to supine position. All the simulations were made with SOFA (Simulation Open Framework Architecture), they can be run in real-time with a high graphic render. These results can only be obtained through efficient structure for calculation and model reduction techniques.
Some experiments are conducted to confirm SOFA simulations but it is impossible to just be limited to these results. To enhance SOFA's simulation, a comparative study will be run on another open-source software : FEniCS.

Figure 1 : Registration of the patient with the underneath anatomy

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The simulation will use finite element methods applied to hyper-elastic problems with large deformations and rotations. The trainee will have to take into account the complex anatomy of the breast and the different constitutive tissues.

Tasks to complete

The main achievements are the following :

- First getting acquainted with SOFA and FEniCS environment by running simple elastic simulations on simple geometries. Then increasing the difficulty to have more complex hyper-elastic problems associated with complex geometries.

- Build a patient-specific model of the breast. This task will be effectuated in collaboration with Anatoscope specialized in patient modelling through registration technique.

- Run simulations with FEniCS[1] accorIn this internship, a first step will be to. Once the model is obtained, the simulation will be rding to SOFA's mechanical parameters and behavior, boundary conditions, loading, etc..

- Compare his own simulations with the existing one in SOFA[2] and draw the associated conclusions.

Competences : applied mathematics, numerical methods, FEM,

informatics programming, mechanics

Profile

- Master 2 or 3rd year of engineering school
- Education in applied mathematics or mechanical engineering
- Solid basis in informatics programming (Python and all its scientific libraries e.g : numpy, scipy)
- Some basic knowledge on hyper-elastic problem as well as biological apprehension is appreciate
- Knowledge of C++, SOFA architecture or FEniCS code is a real plus

[1] https://fenicsproject.org/
[2] https://www.sofa-framework.org/

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Conditions

- Duration : 6 months starting March/April 2020
- Wage : Competitive salary
- Place : University of Luxembourg, Belval campus in Computational Science department (Maison du Nombre)
- Contacts : Professor Stéphane Bordas : stephane.bordas@uni.lu and Arnaud Mazier : arnaud.mazier@uni.lu

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