Master Thesis Project - A collaboration between University of Gothenburg (SE), Chalmers University of Technology (SE), and Netherlands Cancer Institute (NL)

Predicting the Cancer Tumor Position in a Liver Using Finite Element Analysis (FEA) and Artificial Intelligence (AI)

Background

Real-time predictions of the deformation behavior of an organ during surgery is a big challenge, in particular when large deformations are involved. This issue is more pronounced when dealing with laparoscopic surgeries because of size of the incision, loss of tactile feedback and the limited field of view of the laparoscopic camera. Physics based models (based on continuum mechanics and using Finite Element Method) are becoming more and more popular for making accurate connections between pre-operative anatomical models and intraoperative data.

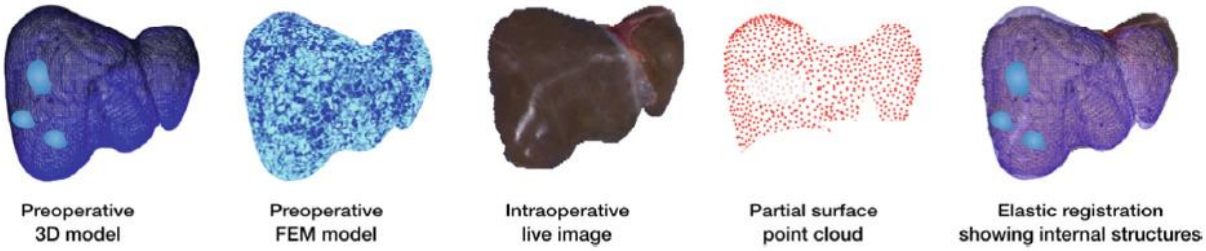

Figure 1. Representation of obtaining tumor position from pre-operative data using FEA [J.N. Brunet et al. (MICCAI 2019)]

Purpose and project description

The idea in this master thesis project is to develop an initial framework, using FEA and AI, for predicting cancer tumor position in a liver once the liver position is changed from its initial configuration. The problem can be described as:

- The surgeons have this information: the initial configuration of the liver; the tumor position in the initial configuration; the surface of the deformed liver;
- The surgeons need to know: where is the tumor position when the liver is deformed (during surgery).

To achieve the aforementioned goal, we proceed as follows. A large number of FEA will be conducted, and the deformed configuration (both at the outer surface, and also the internal structure) will be obtained. Thus, from these analyses, we will obtain the tumor position after deformation. Having this information at hand, we will develop a Deep Neural Network (DNN) model to replace the FEA and enable the surgeons to have real-time feedback from the model. To train the model:

- As input: the initial 3D configuration of the liver (from preoperative CT/MRI), and the outer surface cloud points of the liver after deformation (from stereoscopic endoscope or RGBD camera));
- As output: the internal structure of the liver after deformation and the tumor position (as a real-time feedback to surgeons during surgery).

In order to avoid mesh generation complexities and large computation times, we start with simple structures to develop the framework. Once a DNN model is developed and working well for a simple structure, the next phase of the project would be extending the model to real liver structures (considering the remained time).

Student background

This project is suitable for one or two students who are familiar and interested in Finite Element Analysis. Strong programming skills (Python), and interest in Artificial Intelligence are required.

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