PhD position: « Real-time replanning of trajectories for percutaneous surgery in deformable environment »

Location: ICUBE/IMAGeS, Université de Strasbourg (https://icube.unistra.fr)
PhD advisor: Caroline Essert (http://dpt-info.u-strasbg.fr/~essert)
Starting: Sept. 1st, 2020
Duration: 3 years
Salary: gross salary approx. 1680€ per month
Possibility of teaching (extra 400€ per month)

Description:

In this PhD, we propose to study methods to automatically assist needle insertion for percutaneous surgery, with a real-time correction of possible deviations from the trajectory of a tracked tool in a deformable environment. To achieve this, we will work on improving computation times of multi-objective optimization and treatment simulation methods. We will also work on communication between the tracking system and replanning algorithms. The objective being to help the interventional radiologist, not only in preparing the intervention preoperatively, but in guiding the insertion intraoperatively as well.

Nowadays, the clinician relies mostly on medical image to plan an intervention. A few days before the surgery, CT or MR images of the patient are acquired, then the physician elaborates his intervention plan from these sets of preoperative 2D slices. It is a difficult task, as the physician has to build a mental representation of a 3D model of the anatomy of the patient and the position of pathologies. In the case of an intervention involving the planning of a path for a needle or electrode, the surgeon has to estimate a secure tridimensional path that will ensure a maximal efficiency. However, most of currently existing methods stop the assistance when the preoperative planning is finished and leave to the surgeon the task to insert the needle according to the initial plan without any further guidance. Even if computer-assisted guidance methods have been proposed in the fields of robotics or augmented reality, these methods don't propose replanning according to the situation captured in real-time, but most often a simple guidance towards the initially planned trajectory, without accounting for possible modifications of the anatomy due to deformations (patient's breathing, movements, change of position, …).

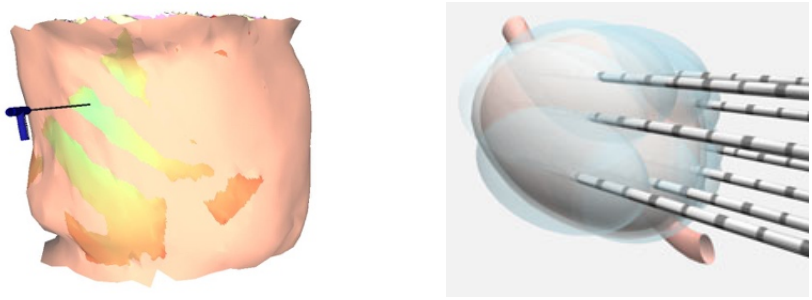
In this work, several approaches to accelerate computations will be studied, using GPU, code optimization, or hybrid methods with precomputations reducing parameters or iterations. More particularly, accelerating the computation of thermal propagation for simulating thermal ablations, that constitute one of the most time-consuming parts of the algorithms, will be studied. Moreover, for a more efficient replanning, methods accounting for the previous computations will be considered to avoid complete re-computation. Besides this, other methods for the simulation of deformation, real-time registration, and motion tracking will be considered to allow for the best re-evaluation of the constraints to satisfy at all times by the tool relatively to its current position.

Another challenge will be the related work that will have to be done on initial registration of the 3D model on the actual patient, the transmission of the position of the tracked tool, and an intuitive visualization and guidance using augmented reality to help correct the trajectory.

The targeted clinical application will be the percutaneous thermal ablation (RFA or cryo) of abdominal tumors (hepatic, renal, desmoid). We will nevertheless keep in mind a certain level of genericity.

This work will require an immersion of the PhD candidate in the surgical field, as well as the fields of geometric constraints modeling, formalization, multi-objective optimization, code optimization, simulation, interaction, visualization, ergonomics, which makes it a highly multidisciplinary topic.

This work will rely on previous results of IMAGeS group in ICUBE that has a high expertise and track record on trajectory optimization. It will be conducted in collaboration with the Technical University of Darmstadt in Germany.



Previous works on surgical tools trajectory planning (left). Cryoablation (right)

The methods proposed during this PhD will be implemented in the planning software. Particular attention will be given to the presentation of the results in an intuitive and ergonomic way. A rigorous validation will be performed, first using experiments on phantoms, then with *a posteriori* clinical validation. They will be performed in collaboration with radiologists of the University Hospital of Strasbourg, and the GRIT research group from TU Darmstadt.

Qualification: Master / Diploma with a technical and scientific background, in Computer Science / Engineering. Strong skills in C++ programming are required. Good communication skills as well as a good level of English are expected. Expertise in computer graphics or computer vision is also expected. Expertise in Numerical methods would be a plus.

To apply: send electronically a resume, a one-page letter of motivation, graduation documents and grades **with ranking**, the Master's thesis, and names/addresses of at least two references to:

Caroline ESSERT: essert@unistra.fr

Note that incomplete applications without ranking information will not be considered.