PhD position: « Assistance to trajectory planning and needle guiding for percutaneous surgery »

Location: Strasbourg, France
Hosting institutes:

- Research Institute Against Digestive Cancer (IRCAD, ircad.fr)
- University of Strasbourg, ICube CNRS lab, IMAGeS group (icube.unistra.fr)

PhD advisor: Caroline Essert (essert@unistra.fr)
Co-advisor: Alexandre Hostettler (alexandre.hostettler@ircad.fr)
Starting: as soon as possible
Duration: 3 years
Salary: 1400 € per month

Description:

In this PhD, we propose to study methods to automatically assist needle insertion for percutaneous surgery. To achieve this, we will work on improving computation times of multi-objective optimization of multiple needle placement and treatment simulation methods. 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. When planning multiple trajectories, the task is even more complex as there are possible interactions between the surgical tools. Moreover, 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.

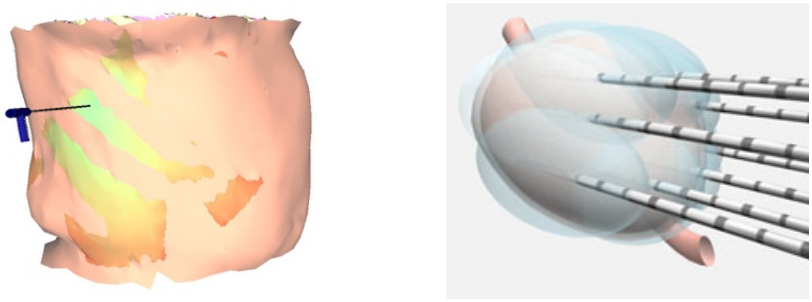
In this work, several approaches to accelerate optimization computations will be studied, using GPU, code optimization, or hybrid methods with precomputations reducing parameters or iterations. A particular attention will be given to the convergence of the methods. Acceleration of the computation of thermal propagation for simulating thermal ablations will also be studied. Moreover, for a more efficient replanning, methods accounting for the previous computations will be considered to avoid complete re-computation.

The second challenge in this thesis will be the intraoperative guidance. Initial work 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. Finally, approaches 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.

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 two teams that have a high expertise and track record in their respective fields: The IMAGeS group of ICube lab for trajectory optimization, and IRCAD for augmented reality and real time tracking.



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

The methods proposed during this PhD will be implemented and integrated in a software framework. Particular attention will be given to the presentation of the results in an intuitive and ergonomic way. A rigorous experimental validation will be performed, in collaboration with clinicians from the University Hospital of Strasbourg.

Work environment:

The PhD student will be hosted in the Surgical Data Science team of IRCAD Strasbourg for three years, and will benefit from existing software, infrastructure, agile management, support from experts in computer graphics and the possibility of testing the results in a clinical setting. Part of the research time during the thesis will also be spent in the ICube lab of the University of Strasbourg with researchers from the IMAGeS group.

The IRCAD Surgical Data Science team has been researching and developing augmented surgery software for 20 years that is intended to assist surgeons, interventional radiologists and gastroenterologists. The complexity and multiplicity of challenges associated with augmented surgery naturally require a team of suitable size. Consequently, in addition to its collaborations with the University of Strasbourg, the Surgical Data Science team is developing and forging international partnerships thanks to twin IRCAD institutes, and in particular IRCAD Africa, located in Kigali. The growth of the IRCAD Africa Surgical Data Science team has been carefully planned. The team now has 9 members, reaching 40 members within 5 years. To achieve this ambitious goal, IRCAD Africa is supporting the most deserving African computer scientists to receive funding enabling them to complete their doctoral training in Strasbourg. This is in collaboration with the best research teams of the University of Strasbourg. The best post-graduates will then have the opportunity to help lead, mentor and train new talents in IRCAD Africa in a virtuous cycle.

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, the Master's thesis, and names/addresses of at least two references to:

Caroline Essert: essert@unistra.fr
Alexandre Hostettler alexandre.hostettler@ircad.fr

Applications will be considered until the position is filled.