Master's internship – 2022

Curved trajectory planning for steerable needles with controlled stiffness

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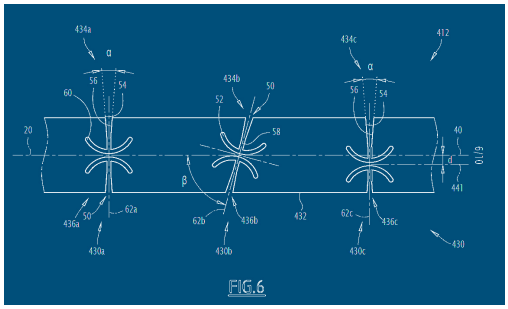
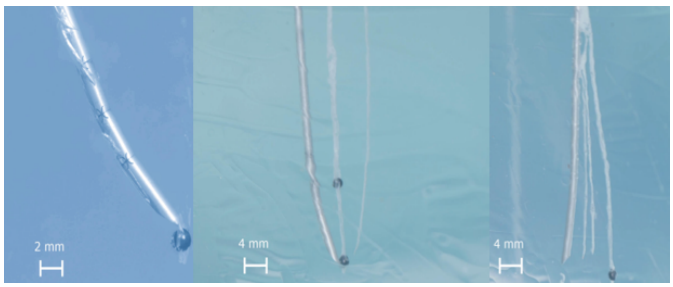
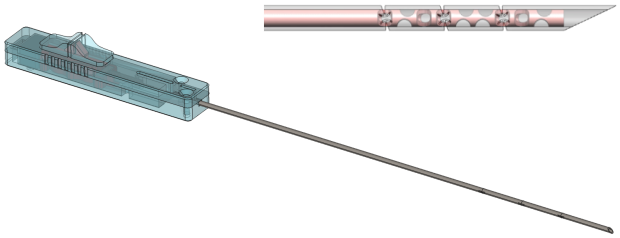
Context:



The ARC team developed a needle with controlled stiffness/flexibility, enabling passive steering, relying on the locking and unlocking of flexible joints at the needle's distal end (https://arc-needle.carrd.co/). Depending on the configuration, location, and number of joints defined, the needle's flexibility can range from a rigid-like device to a very flexible needle. Due to its capabilities, three main use cases/indications are potentially enabled: non-linear trajectories, obstacle-avoidance, and real-time trajectory adjustments with the potential of multi-targeting.

However, software-based solutions and user-friendly GUIs are needed to enable non-straight trajectory planning, and curvilinear needle insertions. In this internship, we aim at conceiving, developing, and validating a software-based solution to enable non-straight trajectory planning and insertion, while using the ARC needle as an initial use case.

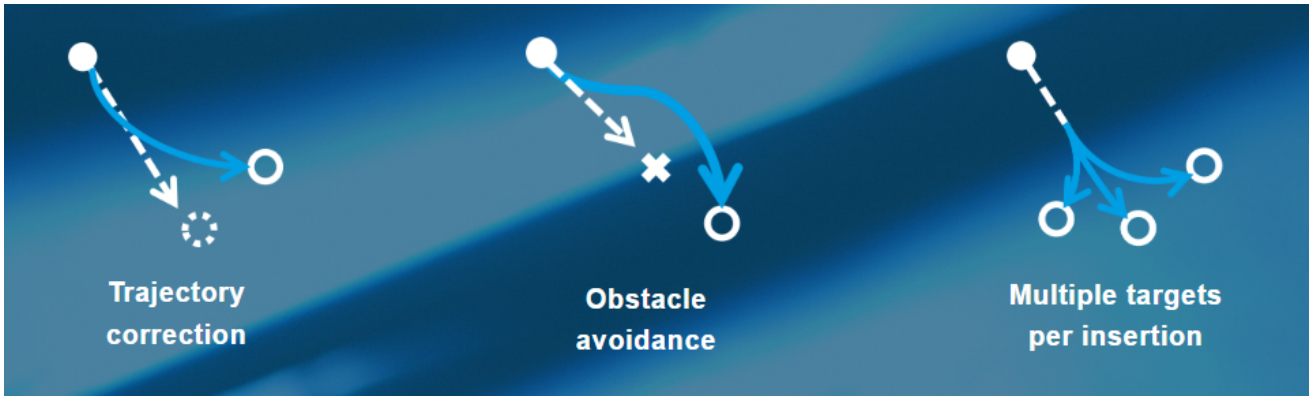




Work:

The objective is to propose **computational methods to plan curvilinear trajectories** from a specific entry point towards a specific target point, that would satisfy a set of predefined constraints such as obstacle avoidance. Our objective at the end of the project is to obtain a software prototype to validate the proof of concept and assess the effectiveness of the automatic planning on phantoms with various configurations and use-cases (trajectory correction, obstacle-avoidance, and multi-targeting).

The main tasks of the project are: definition of the experimental setup and requirements (tracking, needle modifications to host the sensor, homogeneous gel-based phantom models, 1DoF constrained deployments (mechanic arm + glide path), collect multimodal (CT/US) medical imaging and mechanical data to model the ARC needle, develop software solutions for non-linear trajectories, including obstacle-avoidance features, perform experiments (manual insertions following the planned trajectory) to validate the approaches using the ARC needle under all possible configurations (straight / curvilinear), and define the performance profile of



the ARC needle under both configurations and for the different use cases (e.g., non-linear approach, obstacle avoidance). The planning part more specifically, which is at the heart of the project, consists in several steps: define the constraints and associated cost functions, propose several alternative methods to compare - either semi-exhaustive methods, classical optimization methods, or DL/ML-based methods, implement the methods and the chosen metrics, and develop, implement, and validate a GUI aiming at intuitiveness and interoperability. Finally, time permitting, the candidate will define automated control according to planning and perform a robotic insertion and compare with manual insertions.

Team and environment:

The internship will be part of a collaboration between three disciplines and co-supervised by researchers from different research groups. Caroline Essert from the IMAGeS group will bring her computer science-based expertise in trajectory planning for surgical needles. Lennart Rubbert from the RDH team will bring his expertise in medical and surgical robotics and robot assisted interventional radiology, and more particularly in the design and mechanical understanding of the steerable needle technology. This project will be conducted in close collaboration with Dr. Juan Verde from the IHU Strasbourg, as a medical partner and additional supervisor. In addition to bringing the expertise of the medical field and facilitating the experimental setups, the involvement of Dr. Verde and IHU will allow to highlight the potential of non-linear needle insertion and its benefits thanks to the new ARC technology.

The intern will be hosted in an office at the ICube Institute, Illkirch Campus of Strasbourg, and have access to all the necessary hardware and IT resources. The experimentations including medical imaging and the validation of the software will be carried out at the preclinical platform, at the IHU Strasbourg, located in the Medical Campus of the University of Strasbourg.

Resources:

ARC needle prototypes are available and will be provided when needed. Gel phantoms, sensors and imaging devices will be provided by the IHU under the supervision of Dr. Verde.

The development will be done in C++ or python within the 3D Slicer platform and dependencies.

Internship duration: 6 months, starting January, February or March 2023.

Profile: MSc with a major in computer science, computer graphics, image processing, or related fields. Proficiency in C++ or python is required.

Funding: The intern will receive the legal stipend for trainees (around 550€ per month).

For further information and application, please contact the supervisors.