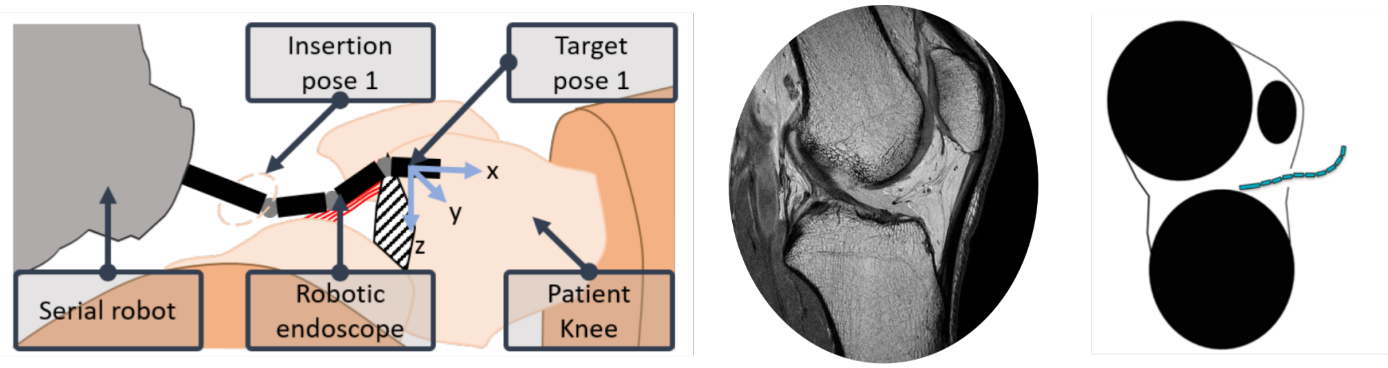
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Master Thesis: Planning paths for hyper-redundant robots using medical image data

Context: The MIRACLE project uses a hyper redundant robotic system to perform minimally invasive laserosteotomy. This robotic system can be divided into three sub-robots (macro-, milli-, and micro- robot), each operating on a different scale of motion. The macro-robot (KUKA LBR iiwa) has a large workspace with an accuracy of up to a millimeter and moves the milli-robot through desired poses. The milli-robot is a flexible robotic endoscope, which enters the human body through a natural orifice or an incision. The micro-robot is mounted at the tip of the milli-robot and manipulates the surgical tool, e.g., a laser., with submillimeter accuracy. Each of these robots has multiple DoF and must move the surgical tool as planned. Redundancy in such robots can be used to impose additional constraints (for example, avoiding obstacles or minimizing the joint motion) along with the user commands. Previously we have developed planners to compute robot motion plans in 3D (using Robot Operating System (ROS)) and in simplified 2D problem (using python) given insertion pose and target pose, but they do not always succeed.

Task description: Your task would be to find robot motion plans for a simplified 2D problem that uses medical image data (CT/MRI). The planner framework would ideally be designed such that it can re-plan motion plans as a reaction to changes in the constraints, e.g., changes of the anatomy or changes to the planned intervention on the fly. You would then extend the proposed algorithm to 3D and include the macro- and milli-robot systems together such that they satisfy the workspace constraints of the complete robot as well as anatomical constraints.



(a) (b) (c)

Figure 1: Path planning system for robotic minimally invasive knee surgery. The robotic endoscope has to reach various target locations in the knee joint to perform necessary bone cuts. An exemplary cut is visualized in (a). An example MRI image of the knee is shown in (b). A simplified problem from the MRI image in 2D with bones as obstacles (black) is shown in (c) with the endoscope (blue) reaching a target location from outside.

Workpackages:

1. Survey the literature and previous work to understand the existing path planning algorithms.
2. Extend the previous work or develop a novel planning algorithm in 2D that finds a feasible robot motion plan given initial and target poses using medical image data.
3. Evaluate the success rate of the planner with different start poses, target poses and constraints.
4. Extend the planner to a 3D scenario and include the macro-robot.

Benefits:

1. Learn and apply theory of robot kinematics to a practical problem.
2. Gain experience in building a software package from scratch.
3. Work in an open-minded and friendly team in an academic environment.

Requirements: Comfortable to code using Python or MATLAB.

Student:
Start: February 2022
Duration: 6 months
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