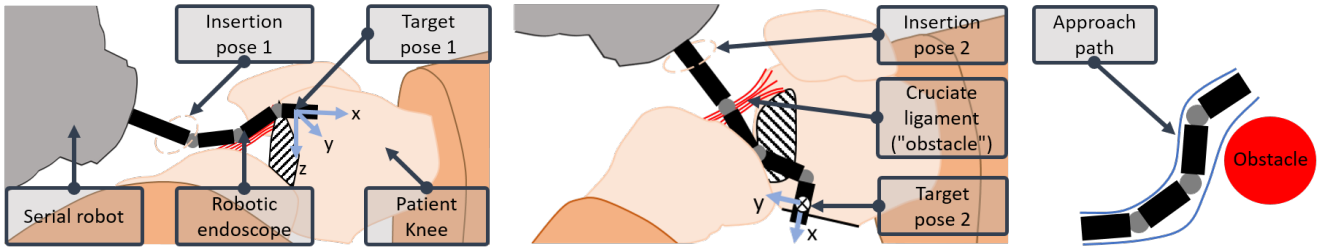
University of Basel
Department of Biomedical Engineering

BIROMED-Lab
Medical Robotics and Mechatronics

Master Thesis: Interactive Approach Path Planning System for Insertion of a Robotic Endoscope in the Human Knee

Context: We are developing a robotic endoscope with an integrated laser osteotome to combine the advantages of laser osteotomy with those of minimal invasive surgery. Given a surgical intervention that should be performed with this robotic endoscope, it is necessary to plan the approach path of the endoscope within the anatomical constraints at the surgical site and the surgeon's preferences. We designed a robotic endoscope that can reach the target pose in the human knee, but need a method to allow planning of the approach path with respect to the given constraints. In our current application, unicompartmental knee arthroplasty, damaged cartilage in the knee is replaced with an implant. During this process different bone cuts are performed, and thus the endoscope has to reach different target positions, as visualized in Fig. 1 a and 1 b.

Task description: Your task will be to develop an interactive approach path planning system for our existing robotic endoscope. Given an insertion pose of at most 5 degree-of-freedom (DoF) and a target of at most 6-DoF, you will develop an algorithm that computes a viable approach path that considers the kinematics of an articulated, rigid-link endoscope as well as anatomical and user-defined constraints. Additionally, you will develop a user interface that allows the user to inspect the endoscope configuration along the computed approach path (Fig. 1 c) during the process of insertion and to interactively update the constraints as needed. You will evaluate the functionality of your algorithm and then apply the algorithm to our setting and current endoscope design. In case a viable approach path cannot be found, you will use your algorithm to find a valid combination of insertion pose and endoscope design.



(a) (b) (c)

Figure 1: Path planning system for minimal invasive surgery using a rigid-link robotic endoscope. The first application is unicompartmental knee arthroplasty. The endoscope has to reach various target locations in the knee joint to perform the necessary bone cuts. Two exemplary cuts are visualized in (a) and (b), the distal and posterior femural cut, respectively. The algorithm computes a viable approach path that considers the kinematics of the endoscope, as well as anatomical and user-defined constraints (c).

Workpackages:

- Conduct a broad literature research on existing path planning algorithms and compare them.
- Develop an algorithm that computes a viable approach path for an articulated, rigid-link endoscope given an insertion pose and a 6-DoF target.
- Refine your algorithm to take into account both anatomical and user-defined constraints.
- Develop a user interface for the inspection and adaptation of the planned approach path.
- Evaluate the functionality of your algorithm.
- Update the insertion pose and endoscope design if needed.

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