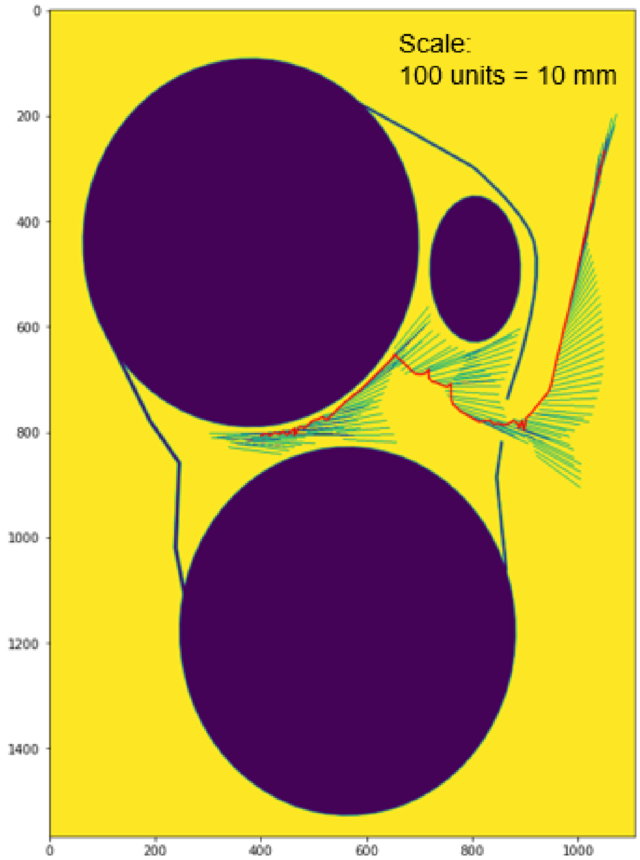
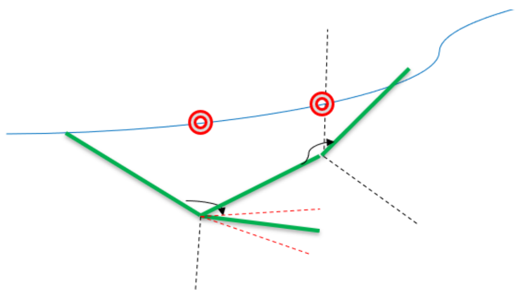
University of Basel

Department of
Biomedical Engineering

Path Planning for Planar Hyper-Redundant Surgical Robots



A 2D depiction of the path planning problem in human knee (Image by Tarun Prasad)



Fitting the configuration space solution to generated task space trajectory (Image by Tarun Prasad)

Internship by Tarun Prasad (Indian Institute of Technology Madras) at BIROMED-Lab.

The goal of the project is to perform path planning for a hyper redundant robotic endoscope addressing the narrow passage problem in human knee. Reviewing the literature and previous work on this problem, strongly indicated that approaches alternative to sampling-based algorithms need to be developed. Previous work [1] work on TSRRT BIROMED served as the start point for my work as it showed the effectiveness of task space trajectory synthesis for the end-effector while also showing the complications in using top-down approaches such as IK and null space search in generating configuration space solutions. The approach taken here is to develop an intuitive bottom-up approach for the configuration space solution while leveraging the effectiveness of a RRT -based task space planner in generating the end-effector trajectory.

A planar abstraction of the problem was taken up to visualise and analyse the various bottlenecks in configuration space planning in an intuitive manner. A 2D image of an abstraction of the knee was the simulation environment and Python was the framework. A pixel-based collision checker was implemented. The task space trajectory planner from previous work [1] was reconstructed for the 2D environment. For each end-effector task space solution along the trajectory the joint angles were chosen such that the links best fit the trajectory line. This was used as the initial configuration space planner with discretisation between consecutive instants for finer collision checking. Based on the different solutions generated using this concept, the visuals suggested different methods to overcome collision bottlenecks. Some of the solutions involved pre-validating whether a given configuration space solution will face collision in the next consecutive instant and rejecting the ones which fail. Another method was to use different permutations of trajectory lines for configuration space planning to evaluate, which one better represented collision free zone. The task space planner had a success rate of 79% on 400 cases while the configuration space planner had only a success rate of 42%. A more sustainable solution would be to develop a configuration space planner which optimises between generating the instantaneous best fit to collision free zone and exploring collision free zone by sampling.

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References:
[1] Z. Kalotay, “Path Planning for Hyper-Redundant Surgical Robots”, Master’s thesis, University of Basel, Switzerland, 2020.