Chair of
Automatic Control

FAU

Master thesis

Cartesian Path-Planning for Kinematically Redundant Cooperative Dual-Arm Robots

Motivation

Path planning is a fundamental aspect of robotics, involving the computation of a path p(s) as a function of the path parameter $s \in [0,1]$. Today, sampling-based methods such as Probabilistic Roadmaps (PRMs) and Rapidly-exploring Random Trees (RRTs) are widely used. Planning paths for cooperative dual-arm robots presents a unique challenge due to closed-loop kinematics. This constraint must be satisfied for every value of s. Sampling on the constraint manifold, as explored in [1], demonstrates a promising approach. Alternatively, [2] introduces an optimization-based strategy to handle loop constraints. The use of analytical inverse kinematics algorithms, as highlighted in [3], can significantly accelerate the path-planning process.

Task description

This project begins with a comprehensive literature review on constrained path planning for kinematically redundant and coupled robotic systems. Based on these insights, the goal is to develop a Cartesian path-planning algorithm in Python. The algorithm should enable efficient path planning in the Cartesian space of the manipulated object while also considering the null space of the kinematically redundant robot.

Requirements

- Proficiency in Python and completion of the Robotics 1+2 course
- Fundamental knowledge of path planning techniques

Contact

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References

[1] Kingston, Zachary, Mark Moll, and Lydia E. Kavraki. "Sampling-based methods for motion planning with constraints." Annual review of control, robotics, and autonomous systems 1.1, 2018, pp. 159-185.

[2] A. Völz and K. Graichen, "An Optimization-Based Approach to Dual-Arm Motion Planning with Closed Kinematics," In Proc. Of IROS, 2018, pp. 8346-8351.

[3] Cohn, T., Shaw, S., Simchowitz, M., & Tedrake, R. "Constrained bimanual planning with analytic inverse kinematics," In Proc. Of ICRA, 2024, pp. 6935-6942.