Robotics and Embedded Systems

KI.FABRIK

Master/Bachelor Thesis – Semester Project

Collision Avoidance in Dual-arm Manipulation of Deformable Linear Objects

Background

The manipulation of deformable linear objects (DLOs) is a crucial and widespread step in various industrial manufacturing processes. However, unlike rigid bodies, deformable objects present additional challenges for manipulation, such as the need for accurate modeling and real-time state estimation. Additionally, achieving the desired shape of a DLO often requires the collaboration of multiple robotic manipulators [1] and the assistance of environmental fixtures [2]. This introduces the challenge of appropriate motion planning for all the involved robots. Firstly, the robots must actively avoid collisions with each other and with the environmental fixtures. Moreover, it is necessary to consider potential collisions between the DLO and other objects in the environment during the manipulation process. To address these challenges, recent studies commonly employ a hierarchical system, consisting of a global planner for coarse motion planning and a local controller for finer shaping[3][4]. Each level of the system relies on different levels of DLO modeling.

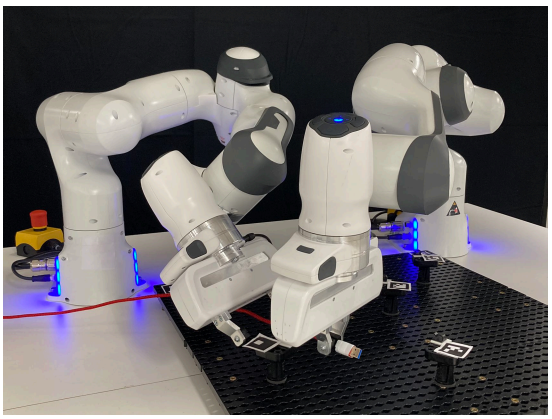
Your Tasks

In this project, you will develop the collision avoidance strategy for a dual-arm robotic cable routing system[5]. Specifically, your task will include:

1. learn basic knowledge of multi-robot motion planning and DLO modeling,
2. develop collision avoidance framework for the dual-arm cabling setup in simulation,
3. apply and further improve the framework for the same setup in the real world.

Requirement

- Self-motivation and love for robots;
- Basic knowledge of robotics and robot motion planning;
- At least six-month working time;
- Python and C++ (optional) programming experiences;
- Working experience with robotic manipulators will be a plus.



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[1] H. Yin, A. Varava, and D. Kragic, “Modeling, learning, perception, and control methods for deformable object manipulation,” Science Robotics, vol. 6, no. 54, p. eabd8803, 2021.

[2] J. Zhu, B. Navarro, R. Passama, P. Fraisse, A. Crosnier, and A. Cherubini, “Robotic manipulation planning for shaping deformable linear objects with environmental contacts,” IEEE Robotics and Automation Letters, vol. 5, no. 1, pp. 16–23, 2019

[3] McConachie D, Dobson A, Ruan M, Berenson D. Manipulating deformable objects by interleaving prediction, planning, and control. *The International Journal of Robotics Research*. 2020;39(8):957-982.

[4] Yu, Mingrui, et al. "A coarse-to-fine framework for dual-arm manipulation of deformable linear objects with whole-body obstacle avoidance." *2023 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2023.

[5] Chen, Kejia; Bing, Zhenshan; Wu, Fan; Meng, Yuan; Kraft, Andre; Haddadin, Sami; Knoll, Alois, ”Contact-aware Shaping and Maintenance of Deformable Linear Objects With Fixtures”, 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2023