Robotics and Embedded Systems

KI.FABRIK

Master/Bachelor Thesis – Semester Project

3D Tracking of Deformable Linear Objects with Multi-sensory Integration

Background

Manipulation of deformable linear objects (DLOs) such as cables is a crucial and widespread step in various industrial manufacturing processes. Unlike rigid bodies, the high-dimensional and nonlinear behavior of DLOs introduces difficulties in accurate modeling and real-time state estimation[1]. The lack of reliable perception methods severely hinders the existing robotic cable manipulation systems to achieve human-comparable performances. The focus in existing deformable linear object (DLO) perception research has centered on visual methodologies which capture the global shape of DLOs[2][3][4]. During manipulation, though, vision-based perception is challenged by frequent occlusions from human or robot arms. In contrast, force/torque sensors on robot wrist[5] and tactile sensors on gripper tips[6] offer local insights into DLO's shape as well as its tension and contact force when manipulated by the robot. The integration of F/T and tactile information into visual perception will hopefully improve the tracking accuracy and robustness.

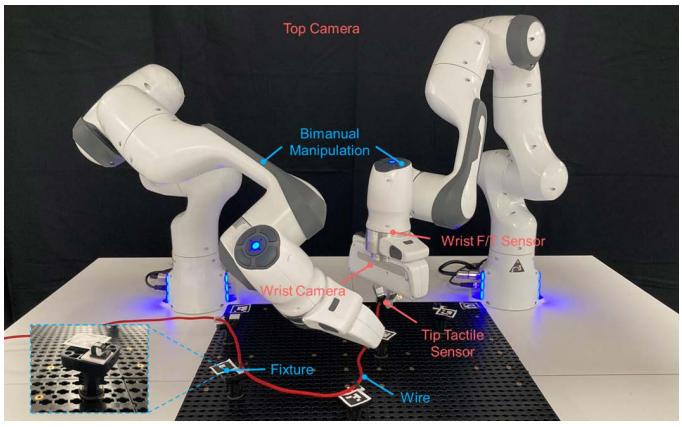
Your Tasks

In this project, you will develop a multi-sensory perception system to track the 3D shape of Deformable Linear Objects (DLOs) during robotic manipulation. Specifically, your task will include:

1. learn existing approach in visual perception and modeling of DLO,
2. track DLO status using individual F/T and tactile information,
3. fuse multi-sensory data with visual perception to update the DLO model in simulation during manipulation.

Requirement

- Basic knowledge of computer vision;
- At least six-month working time;
- Python and C++ (optional) programming experiences;
- Working experience with Robot Operating Systems (ROS) and/or Nvidea Isaac Sim will be a plus.



Supervisor: Prof. Alois Knoll

Advisor: Kejia Chen, Zhenshan Bing

kejia.chen@tum.de, bing@in.tum.de

Lehrstuhl für Robotik, Künstliche Intelligenz und Echtzeitsysteme,

Fakultät für Informatik, Technische Universität München

[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] Y. Wang, D. McConachie, and D. Berenson, "Tracking partially-occluded deformable objects while enforcing geometric constraints," in 2021 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2021, pp. 14 199–14 205.
[3] J. Xiang, H. Dinkel, H. Zhao, N. Gao, B. Coltin, T. Smith, and T. Bretl, "Trackdlo: Tracking deformable linear objects under occlusion with motion coherence," IEEE Robotics and Automation Letters, 2023.
[4] K. Lv, M. Yu, Y. Pu, X. Jiang, G. Huang, and X. Li, "Learning to estimate 3-d states of deformable linear objects from single-frame occluded point clouds," in 2023 IEEE International Conference on Robotics and Automation (ICRA), 2023, pp. 7119–7125.
[5] F. S¨uberkr¨ub, R. Laezza, and Y. Karayiannidis, "Feel the tension: Manipulation of deformable linear objects in environments with fixtures using force information," in 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2022, pp. 11 216–11 222
[6] A. Wilson, H. Jiang, W. Lian, and W. Yuan, "Cable routing and assembly using tactile-driven motion primitives," in 2023 IEEE International Conference on Robotics and Automation (ICRA), 2023, pp. 10 408–10 414.