
Doctoral Dissertation

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Robotic Learning for Perception and Manipulation of Deformable Objects

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Abstract

The manipulation and perception of deformable objects, such as electrical cables, ropes, and clothes, represent a significant challenge in robotics, with critical applications in various industries such as automotive’s wiring harnesses manufacturing, textile and many more.

The research’s results are organized into three thematic sections: Perception of deformable linear objects, manipulation of deformable objects, and application of foundation models for the perception of deformable objects.

The perception of deformable linear objects (DLOs) focuses on the description of multiple state-of-the-art methods developed to enable robots to perceive and understand the properties and configurations of deformable linear objects. The section also includes a method that enables the perception of multi-deformable linear objects like wiring harnesses. Finally, it provides details on how to enable the 3D perception of thin DLOs or transparent material to overcome the limitation of the existing hardware.

The second problem addressed is related to the robotic manipulation of deformable objects. The methods proposed are based on model-based or model-free approaches to underline the multiple possibility available to solve the task from a robotic perspective. In this section, both the manipulation of linear objects and planar objects are discussed.

Finally, following the development in the field of machine learning, a discussion on how foundation models can be applied to deformable objects is introduced. The discussion considers both the straightforward application of pre-trained foundation models for the segmentation of cloth or ropes and an additional method for the grounding of text prompt for the instance segmentation of deformable linear objects.

This thesis aims to discuss the theoretical advancements and practical implementations obtained during the last years, offering a starting point for future research and development in the handling of deformable objects.

Keywords: Robotic Learning, Deformable Linear Objects, Perception of Deformable Objects, Manipulation of Deformable Objects.

