Toward Real-Time State Estimation and Tracking of Elastic Rods

Bardia Mojra

***Abstract*—Manipulation of deformable linear objects (DLO's) or Kirchhoff's elastic rods (not the same) has brought much-needed attention to a category of open problems in robotics. DLO is described as an elastic rod with relatively small diameter and large length. These objects deform along store energy bend and twist depending problem can be reframed to describe a wide range of problems with applications in automotive wiring harness manufacturing, surgical suturing, agriculture, and construction, to name a few. DLOs are a subset of all deformable objects but they are the simplest to model and analyze (compare to 2D and 3D deformable objects). Existing literature on the topic include various model-based, model-free, and hybrid approaches, where they tackle this problem at different levels. This research problem can be divided into smaller and more intuitive problems such as perception, state dynamic and shape deformity estimation, tracking and control, path planning, as well as obstacle and self-collision avoidance. In this article, I focus on modeling shape deformity and state dynamics of a DLO with both ends are held in a static configuration, forming a closed-loop geometric feedback control loop. I start by briefly reviewing relative work. Then, I provide a mathematical framework for modeling DLO curvature and torsion. Next, I present a simulation code where various configurations and motions are synthesized. The following section presents my effort to estimate and track object deformity and dynamics. Next, I present test cases and a quantified analysis of the tracker. Lastly, I discuss shortcomings, open questions and future steps.**

I. Introduction

This is the intro

cus on the gaps, the simulation exists, the dynamical models also exist, so I will focus on "minimal space representation" by forcing certain "constraints" such as "unit segment" estimation, and perception. Unity is a state of the art simulation software (game engine) with physics engine support and native ROS interface/API and there is also a DLO manipulation library that I need to look into.

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II. Related Work

This is the intro

A. Subsection Heading Here

Subsection text here.

III. Double Pendulum

This is the intro

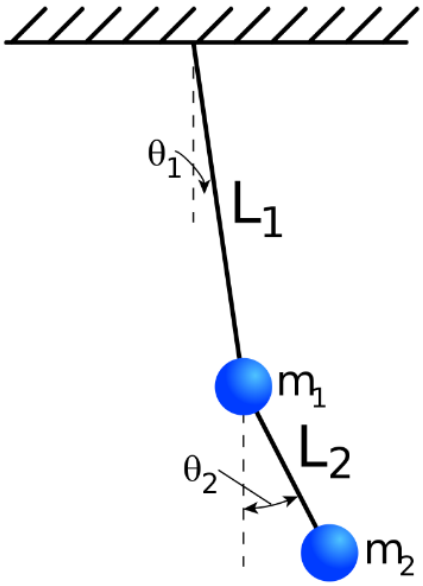

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Fig. 1. Simulation Results

A. System Model

Subsection text here.

B. State Space Representation

C.

IV. Double Pendulum

V. Conclusion

The conclusion goes here.

Acknowledgment

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References

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.