DLO Manipulation in Real-Time

The University of Texas at Arlington

Bardia Mojra

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Notes and Task List

Notes: I need to create a more developed Gantt chart, routinely brainstorm new ideas, and dedicate time to the progress of the project. Below is a brief initial task list:

- Create Gantt chart
- Write paragraphs on separate ideas and edit later
- Real dataset:
  - Design, discuss and build a data collection and test rig
  - Define DLO classes and specs
  - Purchase DLO samples for data collection
  - Create data collection pipeline with capture, preprocessing, annotation, and storage modules.
  - Develop a series of easy-to-perform standard dynamic tests for system identification of DLO's.
- Unity dataset:
  - Recreate virtual duplicates of physical test material
  - Model dynamics and deformity
- Develop "Optimal Real-Time Dynamic Model and Control" theory:
  - Definition: Define what is to be optimized, over what domain, and with respect to what parameters and constraints. A robust ranking system or method is needed for almost all parameters.
  - Define "Unit Segment" for deformable objects: define clearly with literature review.

  - Estimated Parameters: estimated parameters of the object of interest which may *slowly* change over time, permanently or temporarily' i.e. DLO stiffness due to repetitive bending or ambient temperature.
  - Estimated Features: These are estimated constant features of the objects that do not change over time i.e. estimated length of a relatively short DLO in an environment with stable ambient temperature.
  - Fundamental Features: These are the known characteristic parameters of a DLO that in some cases would be given to the system. These fundamental factors will not change over time, i.e. length of the DLO, cross-section thickness, and other known constant physical and dynamic characteristic features. If one fundamental parameter of an object changes (with specifics to be defined), we will treat it as a new object.
  - Limiting Factors: These would be imposed or assumed constraints that limit the control state solution space i.e. unstable and impossible configurations, self-occlusion, and controller real-time compute time and real-time performance metric (for real-time and online self-evaluation).
  - Other constraints such as external forces, lighting, DLO variations.
  - Online Control Performance Self-Evaluation: This is needed for accurate evaluation and optimization of control performance in real-time.

- Problem setup and reformulation: closed-loop geometric control system for real-time and stable feedback of the physical system.

- Optimization of dynamic system model for the most accurate real-time state estimation, control, and object manipulation.

- DLO parameter initialization on first sight: The nonlinear nature of DNN's could be exploited to train an adaptive model that predicts object parameters from a single image. Such quick estimation of the system's characteristic parameters (i.e. unknown spring and damping constants) could enable quick and precise control of DLO's. Moreover, these parameters will be tuned online using adaptive learning and control.

Abstract

Abstract goes here

Dedication

To mum and dad

Declaration

I declare that.

Acknowledgements

I want to thank.

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Chapter 1

Proposal

Chapter 2

Introduction

I set up a thesis latex project where I briefly describe the scope of the project. The project can be best described as quasi-static manipulation of elastic rods. There is a subtle difference between elastic rods and deformable linear objects (DLO's). Elastic rods can be described as a subset of DLO's and exhibit deformation and elasticity in fewer degrees of freedom. For my thesis, I will focus on solving elastic rod manipulation as it would be sufficient to resolve many existing bottlenecks in the industry. The thesis will be divided into five major sub-systems where each could be comprised of smaller research projects and papers. The five main systems are perception, tracking, chaos estimator, control and planning, and manipulation. The perception module is responsible for receiving, preprocessing and fusing raw data from RGB and depth sensors to provide rich, concise and persistent features to tracking and chaos estimator modules. The tracking module uses observation metadata such as the pose and velocity of each segment of the elastic rod. Moreover, it deploys a EKF estimator with a known dynamic model to accurately track the object in space. Chaos estimator module acts as a central and responsive node where it selectively picks what observations to tune into which ones to react to. Its output has priority over the control and planning module and it outputs directly to manipulation module. My current research project aims to start with a simple double pendulum simulation in python and gradually extend its degrees of freedom. Moreover, I will spring terms to the dynamic equations to simulate elasticity. I am currently working on a 2D simulation of a double pendulum and I am almost done. I am having trouble saving the animation but I should be able to resolve it very soon. A double pendulum can be extended and held stationary at the other end to form a quasi-static configuration. The more 'particles' or 'nodes' that are added to the model the smoother the elasticity of the object becomes. Additionally, to simulate kirchhoff's elastic rod, we need to add a degree of freedom on the roll axes to each edge with its own rotational spring force. In a 3D space and with the elastic rod placed on a planar workbench, we form the R^6 configuration space mentioned in Dr. Bretl's paper that can express quasi-static configurations sufficiently, [**?**].

Chapter 3

Related Work

This is related work section.

Chapter 4

Design Requirements

This is design requirements section.

Chapter 5

System Architecture

Chapter 6

Experiments

Chapter 7

Conclusion

Appendix A

Appendix Title