Progress Report

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1 Specific Research Goals

- VPQEKF (IROS - Mar. 1st): Work on the paper.
- DLO Manipulation Proposal: Work on a personal statement.

2 To Do

- Fellowship: No update.
  - Develop a well-written personal statement. — On-going.
  - Seek other graduate fellowship opportunities. — On-going.
  - Develop multiple versions of research and personal statements for submission to different opportunities.
- ICRA 2022 Paper Review: Done.
- PVQEKF:
  - Read over Quest and Vest.
  - Write daily. — On-going.
  - Kitti tutorial. — On-going.
  - Kitti and Hilti dataset: low priority, use as control.
  - Develop object tracking and robust-to-truncation feature.
  - Get ROS environment up and running. I need to install Armadillo (C++) with a certain dependency configuration.

3 Progress

The following items are listed in the order of priority:

- Fellowship: No update.
- VPQEKF: I finished the debugging of the QEKF code and ran all test sets again. Dr. Gans and I reviewed the results and he confirmed we have good EKF results. I am working on a Kitti implementation tutorial.

- DLO: 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 $\mathbb{R}^6$ configuration space mentioned in Dr. Bretl's paper that can express quasi-static configurations sufficiently, [1].

- NBV-Grasping Project: No update.

- PyTorch Tutorials: Transfer learning.

- Pose Estimation: I will need it for DLO segment localization.

4 Intermediate Goals - Fall 2021:

- QEKF: Finish paper.
- Active Learning.
- UR5e: Do the tutorials.

References

[1] T. Bretl and Z. McCarthy, "Quasi-static manipulation of a kirchhoff elastic rod based on a geometric analysis of equilibrium configurations," *The International Journal of Robotics Research*, vol. 33, no. 1, pp. 48–68, 2014.