Progress Report

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1 Specific Research Goals

- VPQEKF (—): Work on the paper.
- DLO Manipulation Dataset (ICRA - Sept. 1st)

2 To Do

- QEKF Paper - 30% extension (—): QuEst solutions!!
- Implementation (—):
  - Noise issue: noise cannot be modeled - revisit
  - SfM: RQuEst cannot find solution – under investigation - HAVOK?
- DLO Manipulation: (ICRA - Sept. 1st)
  - Work on the paper everyday – up-coming
  - ICRA 2022 RL workshops: gym, stable-baseline3, and RL zoo – on-going
  - Setup digital twin reinforcement learing setup:
    - Unity Robotics extension setup – on-going.
    - Design dynamic DLO data collection system.
    - Build work cell. – on-going
    - Collect data and create a dataset.
    - Define evaluation metrics.
    - Create a high frequency RGBD dataset with UV-frames and open-loop input control actions as the ground truth.
  - Real-Time Preception – on hold
  - Learning DLO Dynamics and System Identification
    - List feasible approached for learing DLO dynamics – done
    - Model dynamics and deformity in a latent space

3 Progress

The following items are listed in the order of priority:

- XEst (RAL —): No technical update. I have an idea for finding the correct Quaternion solution at the end of QuEst. Instead of trying to find the best 5 point correspondacnes and running a low dimensional linear decomposition, we could keep all the point correspondences and run Dynamic Mode Decomposition (DMD) [1] [2] to dilute the effect of i.i.d. noise on image pixels. Another method could be HAVOK [3] which uses DMD and Koopman operator to estimate a low dimensional linear estimate of the transform. The distribution of intermitted forcing in HAVOK could be an indication of how much noise we have bundled with selected point correspondacnes.

- DLO State Estimation (ICRA - Sept. 1st): This week, I researched Koopman operator, dynamic mode decomposition (DMD) [2] [1], extended dynamic mode decomposition (EDMD) [4], Hankel alternative view of Koopman (HAVOK) [3], and sparse identification of nonlinear dynamic systems (SiNDy) [5]. All these methods are very similar in principle as they combine principal component analysis (PCA) with frequency analysis to represent system or data dynamics with respect to both time and space. Each of the mentioned methods slightly differ from each other. For example, HAVOK and Koopman are low dimensional where DMD and EDMD are high dimensional methods. Koopman and HAVOK are continuous where SinDy is sparse. I will test all these methods and present the results in my DLO paper. I will expand more in the paper.

  Moreover, I finished setting up Refind boot manager and installed Ubuntu 18.04. My plan is to use the simulation environment provided in [6] to generate appropriate dataset for our experiments.

- Maicol (REU): He has finals and he is busy doing Unity tutorials.

- PyTorch Tutorials: Transfer learning.

- Omniverse: Apply for access. – To-Do

References

[1] P. J. Schmid, "Dynamic mode decomposition of numerical and experimental data," *Journal of fluid mechanics*, vol. 656, pp. 5–28, 2010.

[2] J. N. Kutz, S. L. Brunton, B. W. Brunton, and J. L. Proctor, *Dynamic mode decomposition: data-driven modeling of complex systems.* SIAM, 2016.

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[4] M. O. Williams, I. G. Kevrekidis, and C. W. Rowley, "A data–driven approximation of the koopman operator: Extending dynamic mode decomposition," *Journal of Nonlinear Science*, vol. 25, no. 6, pp. 1307–1346, 2015.

[5] S. L. Brunton, J. L. Proctor, and J. N. Kutz, "Discovering governing equations from data by sparse identification of nonlinear dynamical systems," *Proceedings of the national academy of sciences*, vol. 113, no. 15, pp. 3932–3937, 2016.

[6] M. Yu, H. Zhong, and X. Li, "Shape control of deformable linear objects with offline and online learning of local linear deformation models," in *2022 International Conference on Robotics and Automation (ICRA)*, pp. 1337–1343, IEEE, 2022.