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: Need finish my personal statement.
  - EERE (DoE-AMO) - 1/25/22
  - Maverick Merit - 2/11/22
  - TACC - 2/18/22
  - Maverick Doctoral Bridge - 4/29/22
- DLO Manipulation:
  - 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
  - Unity dataset
    - Recreate virtual duplicates of physical test material
    - Model dynamics and deformity
  - PVQEKF (Paper deadline March 1st.):
    - Finish Dead Reckoning code – ASAP
    - DON'T DO PVQEKF WITH ROS, SKIP FOR NOW, USE PYTHON
    - Setup ROS environment – (1) –
    - Replace EKF with QEKF – (2) –
    - Feature point extraction:
    - Depth to scale
    - BigC (where we solve Q+V together) –¿ regarding depth scale issue
    - Quat: switching problem is fixed

    * 35 solutions (start here)
    * Noise issue: noise cannot be modelled
    * Chaining step: when feature points come in and out of the frame dependency configuration.

3 Progress

The following items are listed in the order of priority:

- Fellowship: I updated my resume this week and familiarized myself with EERE application process. Other opportunities, i.e. summer internships and departmental fellowships are under consideration. They are EERE summer internship (DoE-AMO-1/25/22), Maverick Merit fellowship (2/11/22), TACC fellowship (2/18/22), and Maverick Doctoral Bridge fellowship (4/29/22), with deadlines stated in parenthesis. EERE is initiated and managed by Automation Management Office (AMO), as a part Department of Energy (DoE). This opportunity seems most in line with my research and I will focus on applying this weekend. For the Maverick Merit fellowship; essentially, I need to convince the department to nominate me because my 'academic preparation and accomplishments exceed attainments of students who the program typically admits unconditionally by a significant margin." I believe I might have a chance but I don't have any publications yet. What do you think?
- Dead Reckoning (March 1st, 2022): I worked on preprocessing raw sensor data collected from an android device. I learned about Unix epoch format and used Matlab to resample interpolated measurements to create a unified-time dataset. Currently, I am working on state estimation (QEKF) part of the project by trying to integrate acceleration and gyro data.
- VPQEKF (March 1st, 2022): I need to start working on feature points extraction done by Quest+Vest code [**?**].
- DLO Manipulation: 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:
    * 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.
- 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.