National Aeronautics and Space Administration

Pose Estimation for Rover-to-Lander Mars Sample Tube Transfer

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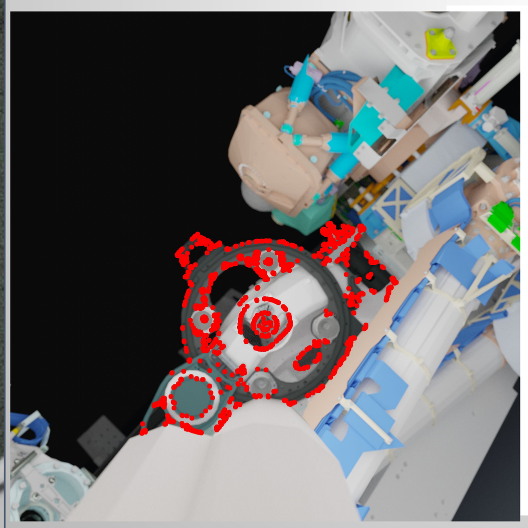
Objectives

- The MSR campaign[1] requires sample tube transfer from M2020 rover to the Sample Return Lander (SRL)
- SRL's robotic arm camera needs to visually locate both the M2020 Bit Carousel (BC) and SRL Orbital Sample compartment (OS) for successful transfer
- Localization needs to be within strict limits and robust to martian environment
- We have implemented a feature-based visual localization algorithm for the BC

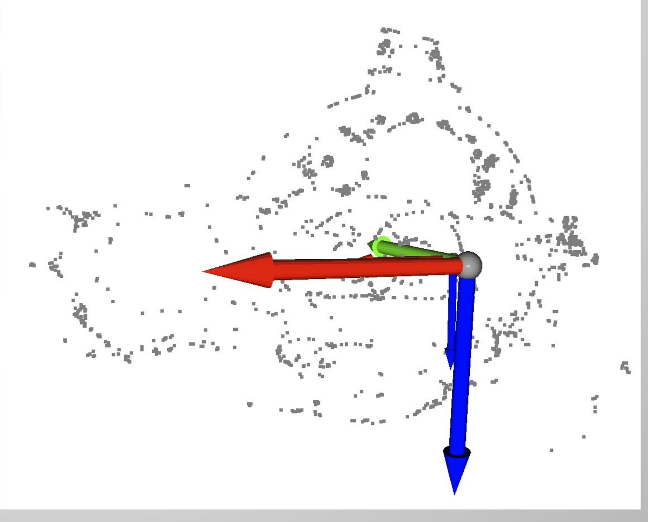
M2020 Bit Carousel

Methodology (1)

- We extract color (RGB) and depth images from a photorealistic simulated environment
- We calculate 2D features on the RGB image and their 3D coordinates (*offline features*)
- The Bit Carousel pose is found from the 2D-3D correspondences
- We build a repository of 2D-3D features and corresponding poses



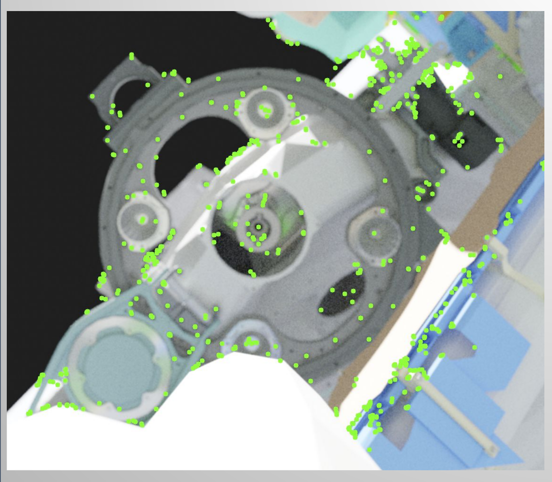
Offline feature detection



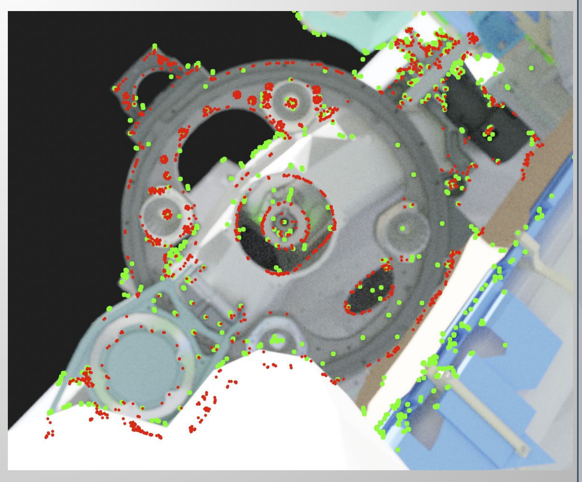
3D coordinates

Methodology (2)

- The robot then extracts an *online* image
- The precalculated offline features are projected onto the *online* image
- A matching algorithm matches the online 2D features to their offline 2D-3D correspondences
- The new 2D-3D correspondences are used to calculate the final pose



Online feature detection



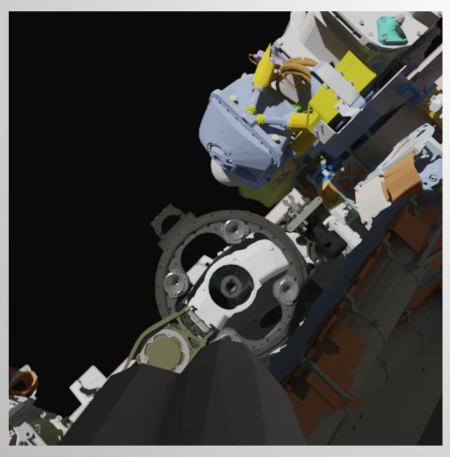
Feature matching

Conclusions

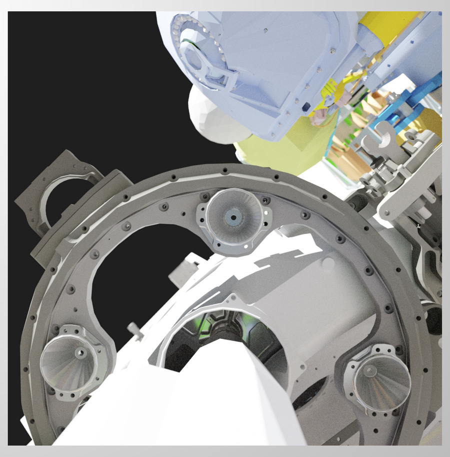
- The results suggest that an accurate pose estimation can be conducted in a reasonable time
- Lighting conditions do not significantly affect the estimation and good overall performance is retained
- Small variations from the initial standoff distance and angle do not drastically affect performance
- Evaluation with larger test image dataset will follow. OS and real testbed image tests to be ran as well
- We will also test the algorithm for the detection of the sample tube after dropped by the Sample Fetch Helicopter

Evaluation

- We test the method with 3 standoffs on the BC case (50cm, 10cm, 1cm)
- We use an initial dataset of 36 test images with varying illumination and target pose variance
- We measure average rotation and translation difference between ground truth and estimation



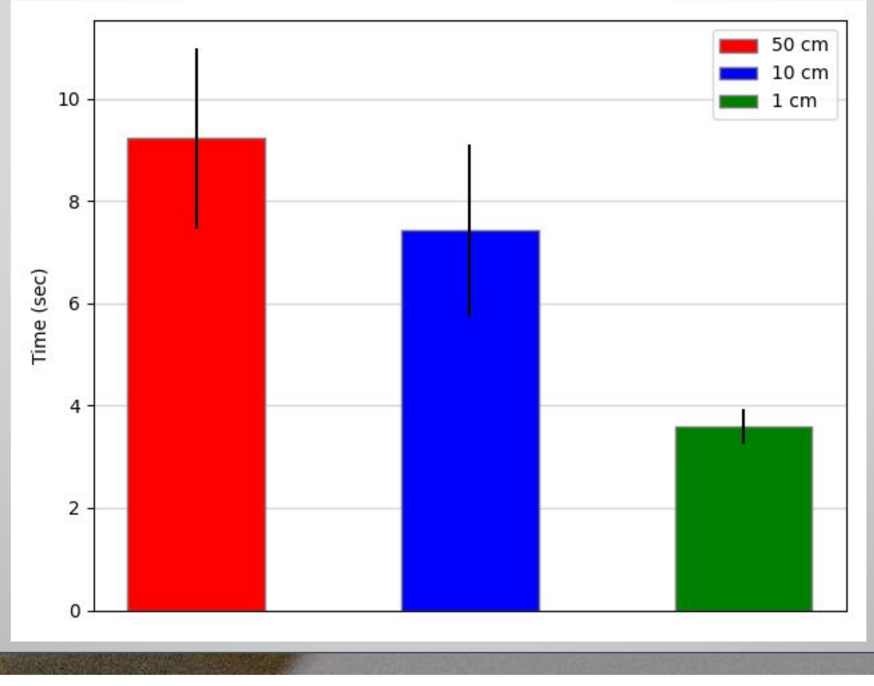
50cm (partial shadow)



1cm (direct light)

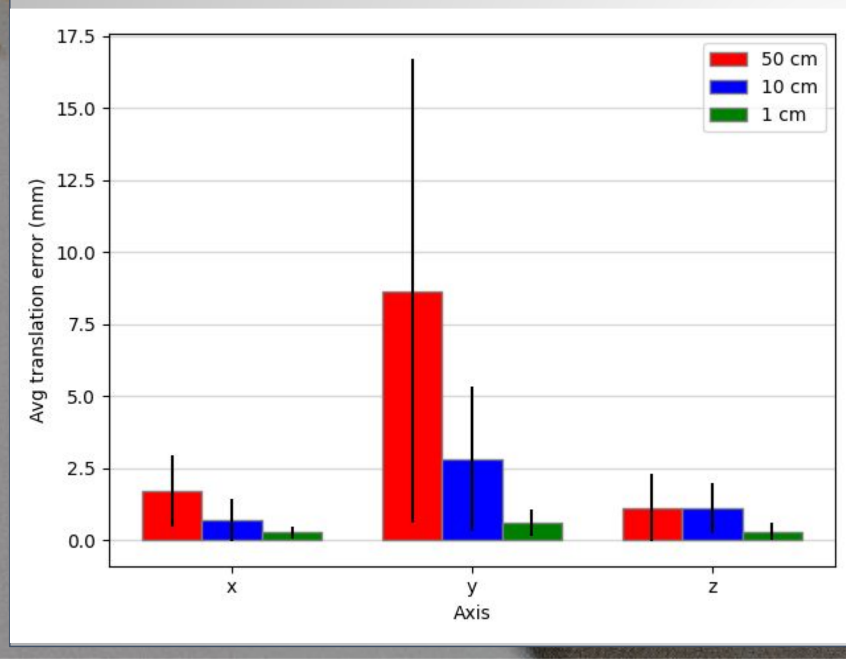
Results (2)

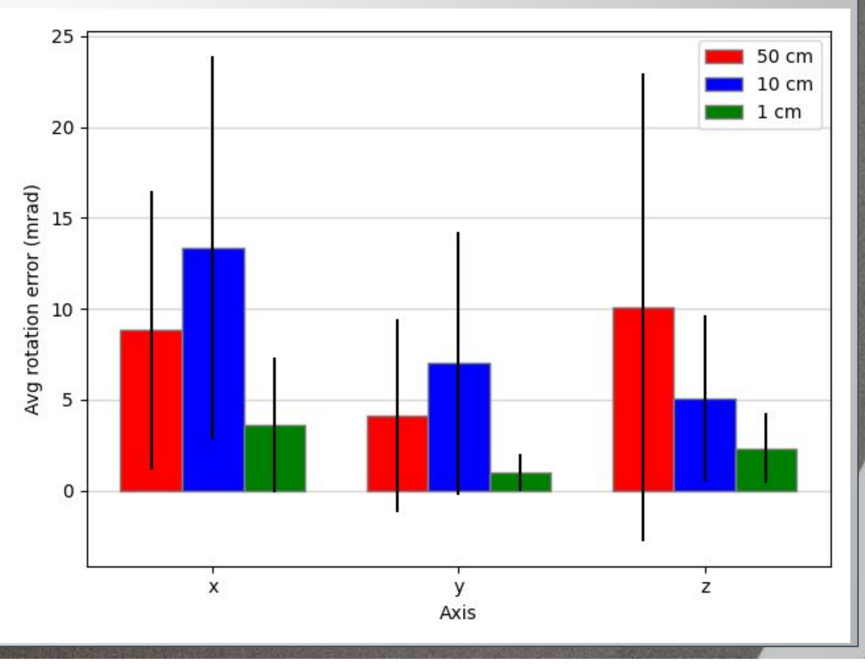
- The execution time reduces as the standoff distance decreases. The estimation converges faster as the viewpoint increases and feature search is restricted
- Executed on an Intel® Core™ i9-11950H @ 2.60GHz × 16, 64 GB memory. The on-board processor is expected to have a timing multiplier of 13.1



Results (1)

- The algorithm successfully estimates the pose within the rotation and translation limits for all standoffs
- The performance is varying with changing illumination but overall within the limits. The y error is of lesser significance as it corresponds to the axis towards the target





[1] The decision to implement Mars sample return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.

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