Localization under Changing Lighting Conditions on the ISS

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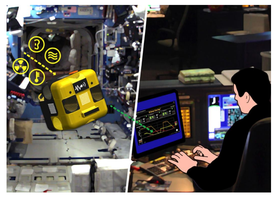
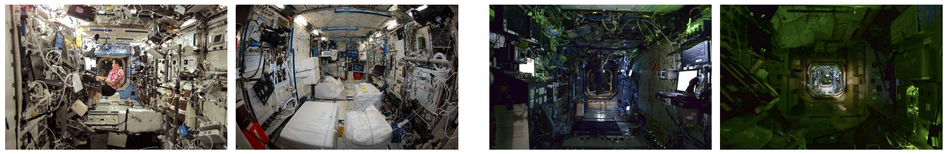
Motivation

- ***Astrobee***, a free-flying robot, is being built to autonomously navigate on the International Space Station (ISS), assisting astronauts, ground controllers, and researchers.
- The lighting conditions on the ISS change frequently, in particular they darken at night time. Currently, Astrobee's maps of the ISS are constructed in the day, but are less effective in other lighting conditions.



Concept of Astrobee

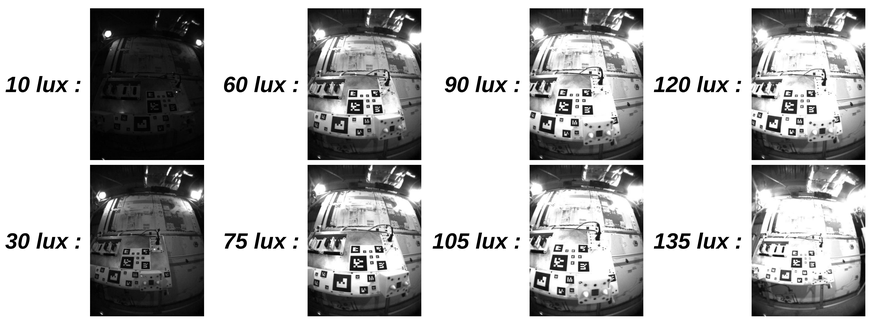


Lighting conditions at the day & night times on the ISS

- We need to investigate how the map responds to changing lighting conditions, and how to build maps that work well in multiple lighting conditions.

Methodology

- Various lighting conditions (day & night time) on the ISS are simulated realistically in the Intelligent Robotics Group (IRG) granite lab with brightness-controlled light sources.

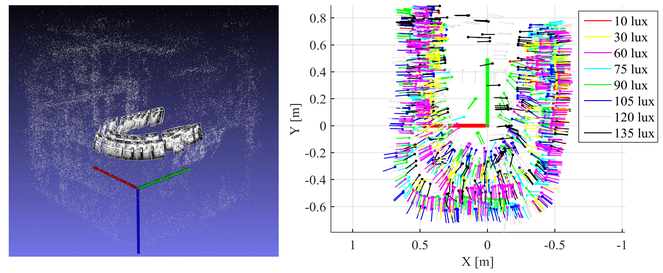


Captured images from Astrobee's navigation camera under various lighting conditions

- First, Astrobee's maps are constructed with the images captured from 105 lux to 135 lux brightness conditions, which are the most similar conditions at the day time of the ISS.
- The images taken under different lighting conditions are localized against the constructed map in the previous step. Accuracy and reliability of localization under changing lighting conditions are evaluated with various criteria. (e.g., the number of inliers, matching, etc.)

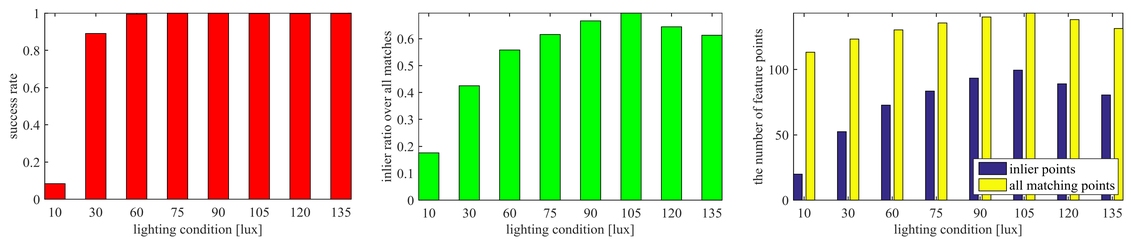
Experimental Results

- The map consisting of BRISK descriptor is constructed with 41 images taken under 105 lux lighting condition. Once the localization is performed successfully, its accuracy is reliable.



(left) Constructed map and used images with BRISK descriptor
(light) Localized images taken under various lighting conditions

- It is observed that success rate of localization with BRISK is drastically low below 30 lux lighting condition. The inlier points ratio over the all matches also decreases significantly.



Discussion & Future works

- Current Astrobee's localization system will work pretty well when the lighting condition on the ISS is over 60 lux. There is no big difference on success rate of localization, inlier points ratio over the all matches in the range of 60 to 135 lux.
- Experimental results show that the reliability of Astrobee's localization system is not good especially below 30 lux lighting condition. Hence, further studies and researches are required to make Astrobee navigate autonomously on the ISS even in the night time.
- Furthermore, more datasets consisting of the images taken at the day and night time on the ISS are also required to develop robust Astrobee's localization and mapping systems to the various lighting conditions.

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