Localization and Pose Estimation of Planetary Surface Assets Using Active Lighting Cues

Recently, there is renewed interest in Lunar exploration and development, both by **governments and private entities. Future plans for such initiatives includes the construction of** semi-permanent structures on the Lunar surface, and in-situ resource utilization (ISRU). These tasks are expected to be done by robots, and the coordination of multiple surface assets requires localization. However, the Deep Space Network is limited in the number of users it can support, and orbital assets may take time to reach full coverage in the area of interest. To solve this problem, we built upon our previous work in CubeSat navigation. Previously, we have used active lighting cues, inspired by navigation lights on aircraft, to estimate the attitude of CubeSats for proximity operations. Now, we apply this method for robots on planetary surfaces.

Similar to our previous work, we propose using lighting cues for the localization and the pose estimation of surface assets. Our method uses lights mounted atop towers on the Lunar surface. Such towers have been proposed as a multifunctional platform for providing support services to Lunar surface assets, such as lighting, communications, and the monitoring of activity. In this system, the user takes an image of lights mounted on towers with a camera and uses computer vision to estimate the position and pose of a user on the Lunar surface, based on *a priori* information on the placement of lights.

In this study, we put forward a design for the visual localization system. This includes the selection of appropriate cameras and the design for the placement of lights on the towers. We also develop software for identifying lighting cues and finding the user's position and pose in all six degrees of freedom (DOF). For validation, we perform hardware experiments using a scaled down model, in a sandbox we have constructed as a testbed for Lunar construction operations. We then compare our results with pose estimation results obtained from fiducials, such as those proposed for pose estimation during in-orbit servicing. We expect that the method we propose can reduce the cost of hardware required for localization of surface assets on the moon.