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PERFORMANCE ASSESSMENT OF CRATER-BASED NAVIGATION FOR AUTONOMOUS MOON LANDING

Abstract

Precision landing is a key component for future robotic Moon exploration missions. The ability to reach the desired landing location with high accuracy is essential in maximizing the scientific and commercial return of the missions. A key element of precision landing is precise absolute navigation, which entails autonomously determining the Lander location above the Moon surface throughout the orbiting and descent operations.

One of the considered approaches for absolute navigation is optical crater-based navigation. This technique processes camera images during the descent, extracts craters from the images, and matches the detected craters with a pre-stored reference crater map. It outputs an estimate of the Lander location with respect to the reference map. It allows estimating the Lander absolute position in low Lunar orbit and during the descent orbit to refine the Lander position estimate and increase the accuracy at touchdown. The paper demonstrates that the technique provides a position estimation accuracy compatible with missions requiring a touchdown accuracy of 100 m or better.

One of the challenges in the design and validation of this kind of system is that it has to operate in a wide envelope of altitude and Sun illumination conditions. It is required to operate from a 100 km low-lunar orbit down to a few km of altitude prior to landing. For instance, it has to support South Pole landing missions, which face extremely low Sun elevation conditions, challenging for any vision-based navigation system.

Previous work has demonstrated system operation using a limited image data set generated from a short video sequence downloaded prior to ispace M1's hard landing. This data set only covered a small portion of the Lander's orbit with favourable Sun illumination conditions. More recent work has conducted a software simulation campaign to assess system performance over a wide range of altitudes and Sun illumination conditions. Tests were conducted to assess the performance of the image processing function alone, as well as the overall system performance with the image processing software function integrated with a navigation filter.

The paper will present the latest status of the crater-based navigation performance assessment, covering a wide range of operational altitudes and Sun illumination conditions over different regions of the Moon. It will demonstrate the robustness limits of such system and quantify the expected level of performance over the entire envelope. It will also review status of the upcoming flight demonstration on-board

the Firefly Blue Ghost Lander.