Paper ID: 66961
student

19th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Operations in Space Debris Environment, Situational Awareness - SSA (7)

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CISLUNAR OBJECT TRACKING AND NAVIGATION VIA OPTICAL SENSORS ON THE LUNAR SOUTH POLE

Abstract

Missions such as NASA's Artemis program and the Chinese Lunar Exploration Program have rejuvenated interest and activities in cislunar space. Each subsequent mission to the moon increases the number of objects left in cislunar space. For example, the Artemis 1 mission will be carrying with it several CubeSats to be put in lunar orbit. Just as space domain awareness (SDA) and space traffic management are becoming important parts of mission planning for Earth-bound satellites, cislunar object tracking is also becoming important for cislunar mission planning and safety. Satellites ranging from LEO to GEO are routinely tracked by hobbyists to international agencies using optical telescopes and radars; however, objects near the moon are too distant to observe from Earth. Studies have been done to extend the range of GPS such that cislunar objects with GPS receivers can navigate in cislunar space with some precision, however these passive receivers still require power and expensive electronics. Moreover, non-payload objects such as debris and rocket bodies will not communicate back their location. A third-party solution such as an optical telescope on the lunar surface will be able to track all types of objects around the moon. Many aspects of a cislunar orbit makes it attractive for a sensor viewing from the lunar surface. For example, the near-rectilinear halo orbit proposed for the Lunar Gateway will spend majority of its orbital period south of the moon and therefore away from the Sun. Because of this, stray light from solar irradiance is less of an issue, a problem that often plagues terrestrial sensors. The lack of atmosphere will remove atmospheric distortions and path loss. In this paper we analyze the viability of object tracking in cislunar orbits from the lunar surface. A prototype sensor is created on a mobile phone as a proof of concept, which can extract astrometric information of a space object from its camera and perform orbit determination and compare it against an existing orbital catalog. The nature of cislunar orbits will mean 3rd body dynamics will need to be considered during initial orbit determination. Detection threshold for various object types ranging from small debris to the Gateway are modeled. This prototype also demonstrates the possibility of creating a portable navigation solution via star matching. Next steps include integrating the sensor to a controllable gimbal for a fully standalone SDA sensor whether on Earth or on the moon.