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SYSTEMATIC ROBOTIC EXPLORATION FOR SPATIAL ESTIMATION OF SHALLOW LUNAR WATER ICE DEPOSITS

Abstract

Shallow ice deposits in the small peripheral lunar permanently shadowed regions (PSRs) are the most interesting potential target for near-term space resource utilization (SRU). This is due to a combination of factors: high-quality remote sensing data, upcoming exploration ground truth through scientific missions like the VIPER rover, and relatively low-cost access through commercial lander missions in the vein of the NASA CLPS (Commercial Lunar Payload Services) program. Accessing these surface deposits will both build out the basic technologies needed to operate in and around the lunar PSRs and allow the use of ISRU as a building block for more ambitious operations on both the lunar surface and near-Earth asteroids.

As things stand, however, we do not have sufficient information about the spatial distribution of water on the lunar surface to select a site or conduct mine planning. We propose a set of robotic missions to explore high-priority PSRs with a focus on spatial resolution. To understand the concentration of water ice in the first meter of regolith, drilling is performed. This is repeated at a range of locations across the surface to build up a spatial estimate of the water concentration within the PSR.

To explore the effectiveness of this approach, we generate hypothetical water distributions underneath candidate PSRs, based off experimental data from the LCROSS and LRO missions. We then model robotic exploration of these PSRs, and estimate the resulting water concentration from sparse samples. To minimize the need for large-scale power infrastructure, we explore a range of drilling topologies. These minimize the depth of incursions into the PSR while still allowing high-quality estimates of the total water distribution within the crater.

Using these search topologies combined with standard geostatistical kriging techniques, we show that the distribution of water in small PSRs can be readily determined to an accuracy within 10

Through this approach, we aim to identify high-priority targets for development missions. Rather than developing a general-purpose approach for lunar SRU, by careful mapping of a range of promising PSRs, we aim to identify unusually high-yield, easy-to-access sites. These locations will serve as candidate locations for SRU pathfinder projects.