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MATERIAL CHARACTERIZATION WHILE DRILLING ON MOON:RESULTS OF THE ATMOSPHERIC DRILLING TESTS

Abstract

The LCROSS mission proved the presence of water in the lunar craters and the presence of shallow water in the mid-latitude region on Mars was detected recently through SHARAD instruments. This water-ice present on the Moon and Mars can significantly bring down the cost of space exploration, fueling the colonization of the solar system. The biggest obstacle in designing the mining and refining instruments is the variability of the estimated quantity and characteristics of the water-ice. With low-resolution orbital data available, the next step is to acquire ground-truth information by drilling and analyzing samples from the Moon and Mars. This work details the results of the atmospheric drilling tests conducted in analogous lunar formation to extract geotechnical information from real-time high-frequency drilling data. An auger based rotary drilling system was designed, taking inspiration from the heritage drill systems developed for lunar and Martian environment. The drill unit contains a high-frequency data acquisition system, measuring all essential drilling parameters. Lunar regolith simulant was used as an aggregate to cast analog concrete blocks with varying properties to replicate different subsurface geotechnical properties in the lunar polar craters. The drill was tested on samples with different geotechnical properties to account for the varying properties expected in the lunar poles. The drilling parameters like rotary rate, torque, penetration rate, weight on bit (WOB) and mechanical specific energy (MSE) were used to develop an advanced machine learning algorithm capable of processing and analyzing the real-time high-frequency drilling data to estimate a sample's geotechnical properties and water content. The evolving algorithm was developed based on drilling responses on initial tests conducted on homogeneous and heterogeneous analogs. The pattern recognition algorithm was tested on samples with varying heterogeneity to estimate the geotechnical properties accurately. With some modifications, this algorithm can be applied in the Lunar and Martian missions to estimate the geotechnical properties in real-time. This can result in a cost-effective exploration of water-ice resources on Moon and Mars, kick starting the space resources industry and the human colonization on those planetary bodies. This work details the analysis of high-frequency real-time drilling data to evaluate geotechnical properties and water content at lunar polar conditions. The techniques developed here might pay a vital role in understanding the extent and composition of water-ice on the Moon, leading to efficient colonization of the solar system.