IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 2 (2B)

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# MACHINE LEARNING APPLICATIONS FOR SAFE AND EFFICIENT ROVER MOBILITY OPERATIONS AND PLANNING

## Abstract

Lunar and planetary rover driving operations are conducted by strategic path planning using orbital assets while tactically accounting for hazards and science targets within the field of view of the rover. Current approaches include a variety of automated and manual processes to plan and adapt rover driving paths while leveraging a science and operations backroom to support tactical decision making. While perception and machine learning algorithms that can improve detection of terrain hazards and science targets are increasingly being used for Mars rover missions, strategic and tactical path planning still require extensive human-in-the-loop interaction and have not been developed specifically for lunar applications.

This paper outlines machine learning tools developed at Mission Control with the goal of safer and more efficient rover navigation and planning.

1) A data-driven approach to terramechanics modeling is increasingly being considered state-of-the-art as it can capture phenomena that are hard or impossible to capture by traditional physics-based approaches. Mission Control's Autonomous Soil Assessment System (ASAS) can update slip-slope models in real-time for a specific terrain class detected by an automated terrain classifier and can dynamically adapt to changing terrain properties. This offers greater safety in navigating through non-geometric hazards that can threaten the rover's mobility. 2) For skid-steer vehicles such as many proposed lunar rovers, power consumption is dependent on turn radius along with other factors such as terrain type and slope. Path planners that implement a power model to minimize path energy can thus increase driving efficiency. Mission Control's Skid-Steer Optimizer (SSO) technology uses a data-driven power model with a sampling-based path planner that produce lower-energy paths compared to traditional distance-optimized path planners. 3) To autonomously and dynamically predict terrain slip and power consumption on a planetary surface with different terrain types, Mission Control is developing an N-terrain visual terrain classifier that uses deep learning techniques with semantic segmentation. This classifier can also be leveraged to detect targets of interest for survey or collection.

Mission Control is developing an Intelligent Path Planner that integrates the aforementioned technologies to plan trajectories that avoid terrain hazards, reduce power consumption, and increase mission yield. Updates on these developments will be presented, along with results from a recent field test campaign to demonstrate ASAS at a natural analogue test site at White Sands National Monument.